Virginia Board of Housing and Community Development
CODE AND STANDARDS COMMITTEE
2021 CODE CHANGE CYCLE – BOOK 2, PART 2
October 3, 2022

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Tab 4 – USBC Proposals Recommended by Workgroups as Non-Consensus

Proposal ID	**Description**	**Page**
Proposals That Exceed the 2021 Model Codes (International Codes)		
REC-R404.2-21	Requires solar-readiness for townhouses and one- and two-family dwellings	Tab 4 – Page 3
REC-R404.4-21	Requires residential buildings to be solar-ready	Tab 4 – Page 11
EB604-21	Adds new requirements for existing energy storage systems to the VEBC	Tab 4 – Page 21
EB1102-21	Adds new requirements for existing energy storage systems to the VEBC	Tab 4 – Page 31
B433-21	Adds new requirements for Electrical Vehicle Charging Stations to the VCC, based on the Energy Storage System provisions of the 2021 IFC	Tab 4 – Page 35
P405.3.1-21	Increases the minimum required size of non-accessible water closet compartments	Tab 4 – Page 41
RB113.1-21	Adds inspection, prior to concealment, of energy conservation material to the list of minimum inspections	Tab 4 – Page 45
RB315.3-21	Requires fuel gas detectors and alarms to be installed in rooms in which combustion occurs and carbon monoxide alarms to be installed in bedrooms and each room of dwelling units in which combustion occurs.	Tab 4 – Page 49
EC-C401.2-21	Requires all new commercial buildings to be all electric	Tab 4 – Page 53
EC-C403.3-21	Requires dedicated outdoor air systems (DOAS) to provide 100% outdoor air without requiring operation of the HVAC system fans	Tab 4 – Page 63
EC-C403.4.1.6-21	Requires thermostats in commercial buildings to have demand control functionality	Tab 4 – Page 69
EC-C403.15-21	Adds minimum efficiency requirements for dehumidification systems for indoor plant growing facilities	Tab 4 – Page 73
EC-C404.11-21	Requires that certain water heaters with integrated storage tanks have demand control functionality	Tab 4 – Page 79
EC-C405.4-21	Adds minimum energy efficiency requirements for permanently installed lighting used for interior plant growing	Tab 4 – Page 85

EC-C405.10-21	Requires electric charging readiness to facilitate charging of electric vehicles (EVs)	Tab 4 – Page 89
EC-C405.11.1-21	Adds requirements for EVSE, EV Ready, and EV Capable spaces based on building type	Tab 4 – Page 97
EC-C405.13-21	Adds requirements for minimum onsite renewable energy and requires building owners to retain any renewable energy credits (RECS)	Tab 4 – Page 105
EC-C405.13(2)-21	Requires at least 10% of the parking spaces for Group R-2 occupancies to be provided with electrical vehicle supply equipment	Tab 4 – Page 115
EC-C405.13(3)-21	Adds requirements for electric vehicle capable spaces, electric vehicle ready spaces, and electric vehicle supply and equipment spaces based on occupancy classification.	Tab 4 – Page 121
EC-C405.16-21	Requires installation of electrical infrastructure to facilitate future conversion to an all-electric building, should the owners decide to do so in the future	Tab 4 – Page 129
EC-C407.6-21	Requires any buildings constructed and sold or leased as being "zero energy" or "net zero energy" or equivalent labels to comply with the IECC appendices for zero energy buildings	Tab 4 – Page 135
EC-C502.3-21	Requires additions to comply with additional energy efficiency provisions	Tab 4 – Page 141
REC-R401.2-21	Requires new residential buildings to be all-electric	Tab 4 – Page 151
REC-R401.2.5-21	Requires residential buildings to be provided with electrical infrastructure to allow for future conversion to an all-electric building, should the owners decide to do so in the future	Tab 4 – Page 163
REC-R403.1.1.1-21	Requires thermostats with demand responsive controls	Tab 4 – Page 175
REC-R403.1.4-21	Prohibits the use of on-site combustion of fossil fuels as the primary heat source in new residential construction	Tab 4 – Page 179
REC-R403.1.4(2)-21	Requires electric heat pumps to be installed as the primary space cooling and heating system in any dwelling in which central, ducted air conditioning would otherwise be installed	Tab 4 – Page 183
REC-R403.5.4-21	Requires tanked water heaters to be supplied with demand responsive controls	Tab 4 – Page 187
REC-R404-21	Requires gas water heaters, dryers, and cooking equipment in residential buildings to be provided with electrical infrastructure for potential future conversion to electric, if the owners decide to do so	Tab 4 – Page 191
REC-R503.1.2.1-21	Requires new heating and cooling equipment that are part of an alteration to be provided with controls in compliance with the IECC	Tab 4 – Page 197

REC-R1104.2-21	Requires at least one electric vehicle ready parking space for each dwelling unit or electric vehicle supply equipment space in a garage or outdoor parking area	Tab 4 – Page 203
EB805.3-21	Requires acceptance testing for new mechanical, hot water and lighting systems serving additions	Tab 4 – Page 209
EB805.3(2)-21	Requires acceptance testing for new mechanical, hot water and lighting systems serving the altered portion(s) of the building	Tab 4 – Page 213
Proposals That Exceed Existing 2018 Virginia Regulations (Amendments)		
B918.1-21	Adds a reference to the IFC for the technical requirements for in-building emergency communication systems and shifts total responsibility for the system installation to the building owner **(Conflicts with B918.1(2)-21- Consensus for Approval)**	Tab 4 – Page 219
RB313.1-21	Requires an NFPA 13D or P2904 compliant automatic sprinkler system in townhouses	Tab 4 – Page 231
RB313.1(2)-21	Requires an NFPA 13D or P2904 compliant automatic sprinkler system in townhouses and one- and two-family dwellings	Tab 4 – Page 251
RB313.1(3)-21	Requires an NFPA 13D or P2904 compliant automatic sprinkler system in townhouse buildings containing more than three townhouse units	Tab 4 – Page 263
REC-R402.1.2(1)-21	Increases the wall insulation requirements in CZ 4 and 5 to R-30 or R20 + R5ci or R13+R10ci or R0+R20ci; and to R20 or R13+5ci or R0+15ci in CZ 3	Tab 4 – Page 277
REC-R402.1.2(2)-21	Increases the wall insulation requirements in CZ 4 and 5 to R-30 or R20 + R5ci or R13+R10ci or R0+R20ci; and to R20 or R13+5ci or R0+15ci in CZ 3	Tab 4 – Page 293
REC-R402.4-21	Deletes the Virginia amendments to the air leakage testing and air leakage rate provisions, and requires compliance with the 2021 IECC	Tab 4 – Page 305
REC-R402.4.1.2-21	Deletes the Virginia amendments and requires compliance with the same envelope tightness levels as the 2021 IECC	Tab 4 – Page 319
B105.1.1-21	Requires building officials and technical assistants to have general knowledge of the principles and requirements of floodplain and high-velocity wind construction	Tab 4 – Page 331
B113.3-21	Requires the building official to inspect the elevation of the lowest floor (of structures located in flood hazard areas and special flood hazard areas) at two different construction stages	Tab 4 – Page 335
RB302.13-21	Requires protection on the underside of floor systems with ½” drywall, 5/8” wood structural panels, or equivalent, if the floor systems are not required to be fire-resistance rated by other sections of the code	Tab 4 – Page 341

RM1601.4.11-21	Prohibits the installation of diffusers, registers and grilles in the floor or its upward extension within toilet and bathing rooms	Tab 4 – Page 347
EC-C1301.1.1.1-21	Deletes the existing Virginia amendments to the IECC and requires compliance with the 2021 IECC in its entirety	Tab 4 – Page 355
EC-C1301.1.1.1(2)-21	Deletes the existing Virginia amendments to the IECC, except those related to existing buildings, and requires compliance with the 2021 IECC	Tab 4 – Page 379
EB805.2-21	Requires existing ductwork serving new equipment in additions and alterations to be tested	Tab 4 – Page 401
FP906.1-21	Deletes existing Virginia amendment which exempts groups A, B and E occupancies from the requirements to provide portable fire extinguishers, if the buildings are equipped throughout with quick response sprinklers **(USBC Portion of Proposal Only)**	Tab 4 – Page 405
Other Proposals		
EC-C1301.1.1(2)-21	Exempts buildings with occupancy classifications of F, S or U from complying with the energy code provisions	Tab 4 – Page 911
EC-Appendix CB-21	Adds Appendix CB to be used as an alternative to the building thermal envelope provisions of the IECC for Groups F, S, and U	Tab 4 – Page 917
B903.2.3-21	Deletes the new IBC occupant load threshold for requiring an automatic sprinkler Group E fire area, maintaining the state amended fire area threshold	Tab 4 – Page 937
B1006.3.4-21	Allows up to 5 stories of Group R-2 occupancy to be served by a single exit	Tab 4 – Page 941
B1010.2.8-21	Intends to comply with SB 333 and HB 670 by adding "public buildings" to the list of uses/occupancies already allowed to be provided with ESH. The proposal was generated as a result of discussions during the Active Shooter and Hostile Threats in Public Buildings - Study Group **(USBC Portion of Proposal Only)**	Tab 4 – Page 967
RB326-21	Removes the habitable attic technical provisions from the definition of Habitable Attic and places the requirements in the body of the code, with the intent of maintaining the existing Virginia technical amendments	Tab 4 – Page 973
PM103.2-21	Simplifies the unsafe building provisions of the VMC	Tab 4 – Page 977

Tab 5 – IBSR Base Document

Tab 6 – IBSR Proposals Recommended by Workgroups as Consensus for Approval

Proposal ID	Description	Page
IB20-21	Editorial change related to approval of intermodal shipping containers as building modules or components of an industrialized building	Tab 6 – Page 1
IB60-21	Editorial change related to the issuance of notices of violations under the IBSR	Tab 6 – Page 3
IB115-21	Clarifies that the local building official may approve a change of occupancy of a registered industrialized building	Tab 6 – Page 5
IB120-21	Clarifies options for approval of unregistered industrialized buildings	Tab 6 – Page 7
IB140-21	Clarifies that the report to the SBCO is for moved buildings with active violations	Tab 6 – Page 9
IB160-21	Incorporates the new ICC/MBI 1200-2021 and ICC/MBI 1205-2021 Offsite Construction Standards	Tab 6 – Page 11

Tab 7 – VADR Base Document

Tab 8 – VADR Proposals Recommended by Workgroups as Consensus for Approval

Proposal ID	Description	Page
AD20-21	Adds definition for "serious injuries/illnesses"	Tab 8 – Page 1
AD30-21	Clarifies that non-mechanized playground equipment is not considered an amusement device	Tab 8 – Page 3
AD40-21	Updates the ASTM referenced standards with the most current editions	Tab 8 – Page 5

Tab 9 – VADR Proposals Recommended by Workgroups as Consensus for Disapproval

Proposal ID	Description	Page
AD75-21	Requires riders, parents or guardians of riders, and operators to comply with Chapter 45 of Title §59.1 of the Code of Virginia, "The Amusement Device Rider Safety Act"	Tab 9 – Page 1

Tab 4
USBC Proposals Recommended by Workgroups as Non-Consensus

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Proposals That Exceed the 2021 Model Codes (International Codes)		
REC-R404.2-21	Requires solar-readiness for townhouses and one- and two- family dwellings	Tab 4 – Page 3
	Staff Summary	Tab 4 – Page 5
REC-R404.4-21	Requires residential buildings to be solar-ready	Tab 4 – Page 11
	Staff Summary	Tab 4 – Page 17
EB604-21	Adds new requirements for existing energy storage systems to the VEBC	Tab 4 – Page 21
	Staff Summary	Tab 4 – Page 25
EB1102-21	Adds new requirements for existing energy storage systems to the VEBC	Tab 4 – Page 31
	Staff Summary	Tab 4 – Page33
B433-21	Adds new requirements for Electrical Vehicle Charging Stations to the VCC, based on the Energy Storage System provisions of the 2021 IFC	Tab 4 – Page 35
	Staff Summary	Tab 4 – Page 39
P405.3.1-21	Increases the minimum required size of non-accessible water closet compartments	Tab 4 – Page 41
	Staff Summary	Tab 4 – Page 43 Page
RB113.1-21	Adds inspection, prior to concealment, of energy conservation material to the list of minimum inspections	Tab 4 – Page 45
	Staff Summary	Tab 4 – Page 47
RB315.3-21	Requires fuel gas detectors and alarms to be installed in rooms in which combustion occurs and carbon monoxide alarms to be installed in bedrooms and each room of dwelling units in which combustion occurs.	Tab 4 – Page 49
	Staff Summary	Tab 4 – Page 51

EC-C401.2-21	Requires all new commercial buildings to be all electric	Tab 4 – Page 53
	Staff Summary	Tab 4 – Page 61
EC-C403.3-21	Requires dedicated outdoor air systems (DOAS) to provide 100% outdoor air without requiring operation of the HVAC system fans	Tab 4 – Page 63
	Staff Summary	Tab 4 – Page 66
EC-C403.4.1.6- 21	Requires thermostats in commercial buildings to have demand control functionality	Tab 4 – Page 69
	Staff Summary	Tab 4 – Page 71
EC-C403.15-21	Adds minimum efficiency requirements for dehumidification systems for indoor plant growing facilities	Tab 4 – Page 73
	Staff Summary	Tab 4 – Page 76
EC-C404.11-21	Requires that certain water heaters with integrated storage tanks have demand control functionality	Tab 4 – Page 79
	Staff Summary	Tab 4 – Page 82
EC-C405.4-21	Adds minimum energy efficiency requirements for permanently installed lighting used for interior plant growing	Tab 4 – Page 85
	Staff Summary	Tab 4 – Page 87
EC-C405.10-21	Requires electric charging readiness to facilitate charging of electric vehicles (EVs)	Tab 4 – Page 89
	Staff Summary	Tab 4 – Page 94
EC-C405.11.1- 21	Adds requirements for EVSE, EV Ready, and EV Capable spaces based on building type	Tab 4 – Page 97
	Staff Summary	Tab 4 – Page 101
EC-C405.13-21	Adds requirements for minimum onsite renewable energy and requires building owners to retain any renewable energy credits (RECS)	Tab 4 – Page 105
	Staff Summary	Tab 4 – Page 112
EC-C405.13(2)- 21	Requires at least 10% of the parking spaces for Group R-2 occupancies to be provided with electrical vehicle supply equipment	Tab 4 – Page 115
	Staff Summary	Tab 4 – Page 118

REC-R403.5.4- 21	Requires tanked water heaters to be supplied with demand responsive controls	Tab 4 – Page 187
	Staff Summary	Tab 4 – Page 189
REC-R404-21	Requires gas water heaters, dryers, and cooking equipment in residential buildings to be provided with electrical infrastructure for potential future conversion to electric, if the owners decide to do so	Tab 4 – Page 191
	Staff Summary	Tab 4 – Page 194
REC- R503.1.2.1-21	Requires new heating and cooling equipment that are part of an alteration to be provided with controls in compliance with the IECC	Tab 4 – Page 197
	Staff Summary	Tab 4 – Page 199
REC-R1104.2- 21	Requires at least one electric vehicle ready parking space for each dwelling unit or electric vehicle supply equipment space in a garage or outdoor parking area	Tab 4 – Page 203
	Staff Summary	Tab 4 – Page 207
EB805.3-21	Requires acceptance testing for new mechanical, hot water and lighting systems serving additions	Tab 4 – Page 209
	Staff Summary	Tab 4 – Page 211
EB805.3(2)-21	Requires acceptance testing for new mechanical, hot water and lighting systems serving the altered portion(s) of the building	Tab 4 – Page 213
	Staff Summary	Tab 4 – Page 215
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B918.1-21	Adds a reference to the IFC for the technical requirements for in-building emergency communication systems and shifts total responsibility for the system installation to the building owner **(Conflicts with B918.1(2)-21- Consensus for Approval)**	Tab 4 – Page 219
	Staff Summary	Tab 4 – Page 222
RB313.1-21	Requires an NFPA 13D or P2904 compliant automatic sprinkler system in townhouses	Tab 4 – Page 231
	Staff Summary	Tab 4 – Page 238
RB313.1(2)-21	Requires an NFPA 13D or P2904 compliant automatic sprinkler system in townhouses and one- and two-family dwellings	Tab 4 – Page 251
	Staff Summary	Tab 4 – Page 254

RB313.1(3)-21	Requires an NFPA 13D or P2904 compliant automatic sprinkler system in townhouse buildings containing more than three townhouse units	Tab 4 – Page 263
	Staff Summary	Tab 4 – Page 268
REC- R402.1.2(1)-21	Increases the wall insulation requirements in CZ 4 and 5 to R- 30 or R20 + R5ci or R13+R10ci or R0+R20ci; and to R20 or R13+5ci or R0+15ci in CZ 3	Tab 4 – Page 277
	Staff Summary	Tab 4 – Page 285
REC- R402.1.2(2)-21	Increases the wall insulation requirements in CZ 4 and 5 to R- 30 or R20 + R5ci or R13+R10ci or R0+R20ci; and to R20 or R13+5ci or R0+15ci in CZ 3	Tab 4 – Page 293
	Staff Summary	Tab 4 – Page 301
REC-R402.4-21	Deletes the Virginia amendments to the air leakage testing and air leakage rate provisions, and requires compliance with the 2021 IECC	Tab 4 – Page 305
	Staff Summary	Tab 4 – Page 312
REC- R402.4.1.2-21	Deletes the Virginia amendments and requires compliance with the same envelope tightness levels as the 2021 IECC	Tab 4 – Page 319
	Staff Summary	Tab 4 – Page 323
B105.1.1-21	Requires building officials and technical assistants to have general knowledge of the principles and requirements of floodplain and high-velocity wind construction	Tab 4 – Page 331
	Staff Summary	Tab 4 – Page 333
B113.3-21	Requires the building official to inspect the elevation of the lowest floor (of structures located in flood hazard areas and special flood hazard areas) at two different construction stages	Tab 4 – Page 335
	Staff Summary	Tab 4 – Page 338
RB302.13-21	Requires protection on the underside of floor systems with ½” drywall, 5/8” wood structural panels, or equivalent, if the floor systems are not required to be fire-resistance rated by other sections of the code	Tab 4 – Page 341
	Staff Summary	Tab 4 – Page 344

RM1601.4.11-21	Prohibits the installation of diffusers, registers and grilles in the floor or its upward extension within toilet and bathing rooms	Tab 4 – Page 347
	Staff Summary	Tab 4 – Page 348
EC-C1301.1.1.1- 21	Deletes the existing Virginia amendments to the IECC and requires compliance with the 2021 IECC in its entirety	Tab 4 – Page 355
	Staff Summary	Tab 4 – Page 369
EC- C1301.1.1.1(2)-21	Deletes the existing Virginia amendments to the IECC, except those related to existing buildings, and requires compliance with the 2021 IECC	Tab 4 – Page 379
	Staff Summary	Tab 4 – Page 394
EB805.2-21	Requires existing ductwork serving new equipment in additions and alterations to be tested	Tab 4 – Page 401
	Staff Summary	Tab 4 – Page 403
FP906.1-21	Deletes existing Virginia amendment which exempts groups A, B and E occupancies from the requirements to provide portable fire extinguishers, if the buildings are equipped throughout with quick response sprinklers **(USBC Portion of Proposal Only)**	Tab 4 – Page 405
	Staff Summary	Tab 4 – Page 412
	Other Proposals	
EC- C1301.1.1(2)-21	Exempts buildings with occupancy classifications of F, S or U from complying with the energy code provisions	Tab 4 – Page 911
	Staff Summary	Tab 4 – Page 915
EC-Appendix CB-21	Adds Appendix CB to be used as an alternative to the building thermal envelope provisions of the IECC for Groups F, S, and U	Tab 4 – Page 917
	Staff Summary	Tab 4 – Page 927
B903.2.3-21	Deletes the new IBC occupant load threshold for requiring an automatic sprinkler Group E fire area, maintaining the state amended fire area threshold	Tab 4 – Page 937
	Staff Summary	Tab 4 – Page 939

B1006.3.4-21	Allows up to 5 stories of Group R-2 occupancy to be served by a single exit	Tab 4 – Page 941
	Staff Summary	Tab 4 – Page 943
B1010.2.8-21	Intends to comply with SB 333 and HB 670 by adding "public buildings" to the list of uses/occupancies already allowed to be provided with ESH. The proposal was generated as a result of discussions during the Active Shooter and Hostile Threats in Public Buildings - Study Group **(USBC Portion of Proposal Only)**	Tab 4 – Page 967
	Staff Summary	Tab 4 – Page 970
RB326-21	Removes the habitable attic technical provisions from the definition of Habitable Attic and places the requirements in the body of the code, with the intent of maintaining the existing Virginia technical amendments	Tab 4 – Page 973
	Staff Summary	Tab 4 – Page 975
PM103.2-21	Simplifies the unsafe building provisions of the VMC	Tab 4 – Page 977
	Staff Summary	Tab 4 – Page 984

Tab 4

USBC Non-Consensus Proposals That Exceed the 2021 Model Codes (International Codes)

REC-R404.2-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Energy Conservation Code

Add new text as follows:

R404.2 SOLAR-READY CONSTRUCTION FOR DETACHED ONE- AND TWO-FAMILY DWELLINGS AND TOWNHOUSES. New detached one- and two-family dwellings, and townhouses with not less than 600 square feet (55.74 m^2) of roof area oriented between 110 degrees and 270 degrees of true north shall comply with Appendix RA Solar Ready Provisions--Detached One- and Two-Family Dwellings and Townhouses. [NOTE: denominated Appendix RB in 2021 IECC].

Exceptions:

1. New residential buildings with a permanently installed on-site renewable energy system.

2. A building with a solar-ready zone that is shaded for more than 70 percent of daylight hours annually.

2018 Virginia Construction Code

Add new text as follows:

N1104.2 Solar Ready Construction for Detached One- And Two-Family Dwellings and Townhouses. New detached one- and two-family dwellings, and townhouses with not less than 600 square feet (55.74 m^2) of roof area oriented between 110 degrees and 270 degrees of true north shall comply with Appendix RA Solar Ready Provisions--Detached One- and Two-Family Dwellings and Townhouses. [NOTE: denominated Appendix RB in 2021 IECC].

Exceptions: .

1. New residential buildings with a permanently installed on-site renewable energy system.

2. A building with a solar-ready zone that is shaded for more than 70 percent of daylight hours annually.

Reason Statement: This proposed addition to the body of the building code is designed to require builders to make new one- and two-family dwellings and townhouses "solar ready", subject to certain specific exceptions. The proposal does not require builders to install solar. However, it would enable buyers to arrange for cheaper, easier installation of rooftop solar if they choose to do so in the future. It is a low-cost measure that will reduce the cost of adding solar at a later date. The proposal is based up on the Appendix RA in the 2018 Virginia building code, which has been updated as Appendix RB in the 2021 IECC. Since the Appendix is in the current code and has not been modified from the 2018 code, it will presumptively follow the 2021 IECC's equivalent appendix, Appendix RB.

Rooftop solar energy production will reduce occupants' utility bills by reducing the quantity of energy they need to purchase for heating, lighting and other purposes. That will tend to stabilize and reduce their annual energy costs. Further, distributed generation will reduce the quantity of energy that utilities need to generate or purchase, the generation and transmission facilities to be constructed, and the line losses that would result from transmitting energy to markets from central power stations. Distributed energy production will help to save overall energy costs.

Distributed zero-carbon generation will also reduce greenhouse gas emissions, which are the primary driver of climate change and its many harmful impacts, including rising seas, flooding, dangerous high temperatures, agricultural disruption and threats to infrastructure.

Cost Impact: The code change proposal will increase the cost of construction

There will be a small increase in the initial cost of construction, which will be offset by encouraging building owners to install money-saving, GHG-reducing rooftop solar in the future. (Obviously, builders decide to install and profitably market the dwelling with rooftop solar if they desire to do so.) The principal material cost would be a 1-inch electrical conduit, which can be purchased for $2.00/foot or less, i.e., less than $100 from the roof to the electrical panel. During construction, the cost of installation will be a small increment given that the walls will be open and tradesmen will be installing similar conduits and/or wiring in the building. The costs of retrofitting are likely to be much higher after walls are closed and construction completed. Reopening and repairing walls could be required.

The small upfront costs will have little impact on a resident's annual mortgage costs, particularly when compared to the savings that will result from self-generated solar energy and from the much higher cost of retrofitting.

Resiliency Impact Statement: This proposal will increase Resiliency

This low-cost proposal will increase resiliency for residential customers who install solar and for the utility system. Residential customers with solar will generate energy on-site, which will lower energy and total occupancy costs, reducing risks of lease and mortgage defaults. In combination with on-site battery storage, the on-site solar can power the house during periods of power outages. Distributed solar can also support utility's regional reliability when power outages occur at remote central generating stations.

Solar generation is zero-carbon, which makes it a necessary measure to mitigate worsening climate impacts which harms Virginia and its residents generally. The most recent IPCC report confirms that rapid reductions of greenhouse gas emissions is essential to avoid catastrophic climate impacts around the world. *IPCC Sixth Assessment Report* (February 2022), https://www.ipcc.ch/report/ar6/wg2/

Substantial harm has already occurred nationally and locally from global warming and much worse will follow without rapid reductions of greenhouse gases (particularly CO2 and methane associated with fossil fuel production and combustion). Virginia's coastal areas are among the most vulnerable to sea level rise and destructive storms. The most recent report from NOAA indicates that Virginia may face 2 feet of sea level rise by 2050 due to worsening climate change from human greenhouse gas emissions. https://www.noaa.gov/news-release/us-coastline-to-see-up-to-foot-of-sea-level-rise-by-2050

Growing climate dangers include harms to communities, infrastructure, people (e.g., heat-related illnesses, disease vectors and ability to work), agriculture, property (inland and coastal) and the economy. These result from many climate-driven forces, including rising temperatures and seas, wildfires, worsening storms, more severe rainfall events and damage to crops and infrastructure. In addition, by cutting greenhouse gas emissions, solar generation will help to mitigate the growing impacts that warming seas and ocean acidification have on sea life and Virginia's fisheries. Even if Virginia were not directly endangered, its residents, economy and access to resources would be endangered by the growing harms to the rest of the nation and the world.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: REC-R404.2-21

Discussion by Richard Potts
Jun 3, 2022 23:43 UTC

Attached are two public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.
Attachments:
https://va.cdpaccess.com/proposal/1015/discuss/143/file/download/730/HBAV_Clarifying%20ACEEE%20Report%20on%20Virginia%27s%20Residenti
https://va.cdpaccess.com/proposal/1015/discuss/143/file/download/729/HBAV_DoE%20Data%20on%20New%20Construction%20EE%20Improvemen

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REC-R404.2-21 – Staff Summary

Proponent: William Penniman, Sierra Club – Virginia Chapter

Brief Description:

The proposal requires one- and two-family dwellings, and townhouses with not less than 600 square feet of roof area oriented between 110 degrees and 270 degrees of true north, to comply with the Solar-Ready provisions in the 2021 International Energy Conservation Code, Appendix RB.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March, 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- Brian Clark: Habitat for Humanity
- Eric Lacey (Laura Baker alternate): Responsible Energy Codes Alliance
- K.C. Bleile: Viridiant
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- William Penniman: Sierra Club - Virginia Chapter

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)
    - Our concerns are similar to what we expressed last year. Again, to my earlier point, allowing the consumers to make the personal financial decisions to incorporate these provisions instead of making it a baseline requirement is more beneficial.
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter*. Note*: partial attendance. Not in attendance during REC-R404.2-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during REC-R404.2-21 discussion and voting.
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)

- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter

Other stakeholders in attendance and supporting the proposal:

- Linda Baskerville (in response to Andrew Clark's comments above)
    - What Andrew is saying is only relevant to the first owner of a home and does not provide an ability to less expensively incorporate solar into their home.
- Ben Rabe, New Buildings Institute (NBI)
    - Just to piggy-back off of previous commentary, this is another proposal where it is way more cost effective to do these readiness provisions on the front end than incorporating them later on. It makes it easier for people who want to add solar later and would not cost much on the front end.

Other stakeholders in attendance and opposing the proposal:

- John Ainslie

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Ben Rabe, NBI

- Ben Rabe, NBI, expressed support for the proposal and noted that he is the proponent of a similar proposal (REC-R404.4-21). He is willing to continue the conversation and is open to making adjustments to the proposal if consensus could be reached.

Opposition:

Names: Andrew Clark, HBAV

- Andrew Clark, HBAV, expressed opposition to the proposal and stated that something that may never be used should not be mandated. It should be up to the consumer if they want that as an option, or to buy a home that is already equipped. He also noted concerns with the second exception of the proposal which would apply to buildings with a solar-ready zone that is shaded for more than 70 percent of daylight hours annually. He stated that it would seem to be almost impossible to determine when that would apply.

  Note: the proponent responded that he is willing to strike out the exception, which was meant to allow some flexibility for buildings surrounded by tall buildings or in the middle of the woods. He does not anticipate for the exception to come into play very often and opined that it is not that difficult to make the determination.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 43; Tab 10 - Page 83; Tab 11 - Page 15.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

Clarifying the *American Council for an Energy-Efficient Economy's* Report on Virginia's Energy Policy and Building Codes

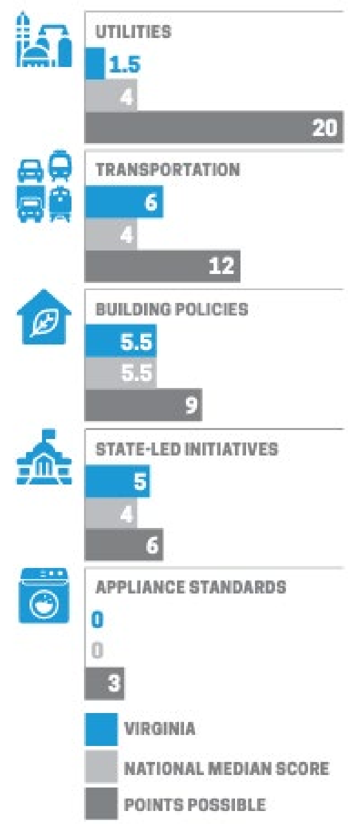
The American Council for an Energy-Efficient Economy (ACEEE) periodically releases a report ranking each state's energy efficiency policies and programs. This report is *widely* cited by energy efficiency stakeholders as justification for additional advancements in Virginia's energy codes – particularly, the report's ranking of Virginia as 25th in the country for energy efficiency[1].

Although the Home Builders Association of Virginia has partnered with these stakeholders during the 2015 and 2018 code cycles (which resulted in several significant advancements) and has continued to do so during the 2021 cycle, we felt it important to clarify the ACEEE's findings on Virginia's energy codes.

While the ACEEE report is a helpful resource for policymakers and regulatory boards, a state's ***overall ranking*** in the report is not particularly informative when evaluating the "strength" or "weakness" of a state's residential and commercial energy codes or specific energy code proposals. A deeper analysis of the ACEEE report shows that Virginia's ***overall ranking*** distorts the fact that Virginia receives extremely high scores for residential and commercial energy codes.

Virginia loses nearly half (24.5 points) of its points in categories *unrelated* to building codes

The ACEEE report ranks states based on five categories: (i) utility and public benefits programs and policies; (ii) transportation policies; (iii) building energy efficiency policies; (iv) state government initiatives; (v) appliance efficiency standards.



A state can only earn a certain number of points in each category:

- Utility and public benefits programs and policies (20 pts)
- Transportation policies (12 pts)
- Building energy efficiency policies (9 pts)
- State government initiatives (6 pts)
- Appliance efficiency standards (3 pts)

In the ACEEE's most recent report (2020), Virginia earned 18 out of 50 points – which is 25th in the nation.

However, a deeper analysis of the ACEEE's findings shows that Virginia lost nearly 50% of its points (24.5) in categories that are *unrelated* to energy efficiency building codes. Specifically, Virginia only earned 1.5 out of 20 pts for "Utility and Public Benefits Programs and Policies" and only received 6 out of 12 points for "Transportation Policies". *(See figure to the right)*

Due to the report's scoring system, it is inaccurate to claim that Virginia's 25th-in-the-Nation ranking in this report is the result of the Commonwealth's "weak energy code".

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[1] American Council for an Energy-Efficient Economy – 2020 State Energy Efficiency Scorecard

Virginia receives a near-perfect score for residential code stringency and perfect score for commercial code stringency.

In the "Building Energy Efficiency Policy" category, Virginia receives 5.5 out of 9 points – by comparison, Virginia is only .5 points behind Maryland and 2 points behind California, which are the two states most frequently described by energy efficiency stakeholders as "leaders" in energy efficiency.

The "Building Energy Efficiency Policy" category consists of 8 sub-categories, including "residential code stringency" and "commercial code stringency". Contrary to statements made during several sub-workgroup and workgroup meetings, Virginia receives a near perfect score for "residential energy efficiency" (1.5 points out of 2) and a perfect score for "commercial energy efficiency" (2 points out of 2).

It is HBAV's understanding that these rankings were determined while Virginia was in the middle of the last code development cycle. While Virginia received exemplary scores for residential and commercial energy code stringency in ACEEE's report, the rankings only reflect a *portion* of the progress which was made in Virginia's energy codes during the last code cycle. During the last code cycle, the Home Builders Association of Virginia and other organizations reached consensus with energy efficiency stakeholders on several proposals, including:

1. Removed visual option for verifying building envelope air tightness and required blower door testing for all new residential buildings. Also added requirement that all new homes pass the blower door test with 5 air changes per hour;
2. Require an "energy certificate" in all new residential buildings to inform current and future homeowners about the key energy characteristics of their home;
3. Increase minimum ceiling insulation requirements (R-38 to R-49) for all new residential buildings;
4. ResCheck compliance updated to 2018 IECC, without Virginia amendments. Previously, a work around had been created for VA amendments that weakened the current IECC;
5. Increased fenestration requirements.

While the ACEEE has yet to release an updated report, it is highly likely that Virginia will receive further recognition for the full scope of energy efficiency code proposals that were adopted during the last code cycle – and possibly for the energy efficiency code proposals which are likely to be forwarded to the Board as "consensus" during the current code development cycle.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

U.S. Department of Energy Data Shows Significant Advancements in Residential Energy Efficiency and Reduction in Energy Cost Burdens in New Construction

"The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs."

Building code regulations were first established – and are continually revised – to ensure a *baseline standard* of quality, safety, and efficiency in new residential structures. For example, they provide assurance for consumers that they are residing in safe structures, guidelines for builders/design professionals as to what constitutes a safe and durable structure, and certainty for lenders of the value and quality of structure.

Similarly, energy efficiency standards were first adopted by the U.S. Housing and Home Finance Agency in the 1950's to address a concerning *public health and welfare* issue at the time: the rising number of mortgage defaults on federally insured loans on homes with high utility bills.

While increasing the efficiency of new residential structures is a laudable objective, it is critically important for policymakers to balance that objective with the growing concerns over the cost of housing in Virginia and the dramatic undersupply of housing that is attainable for households across the income spectrum. Furthermore, it is important for policymakers to distinguish between building code requirements that are essential to providing that baseline standard of quality, safety, and efficiency, and code requirements that are "aspirational".

Consumers can make a personal financial decision to purchase or build a home that is constructed to a higher energy efficiency standard, if that is an amenity that they are willing and able to afford. While energy efficiency requirements can reduce negative environmental externalities, promote high-quality housing stock, and protect consumers from soaring energy costs over time, the ability to afford the **upfront costs** of additional energy efficiency code requirements will vary widely by income.

The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs.

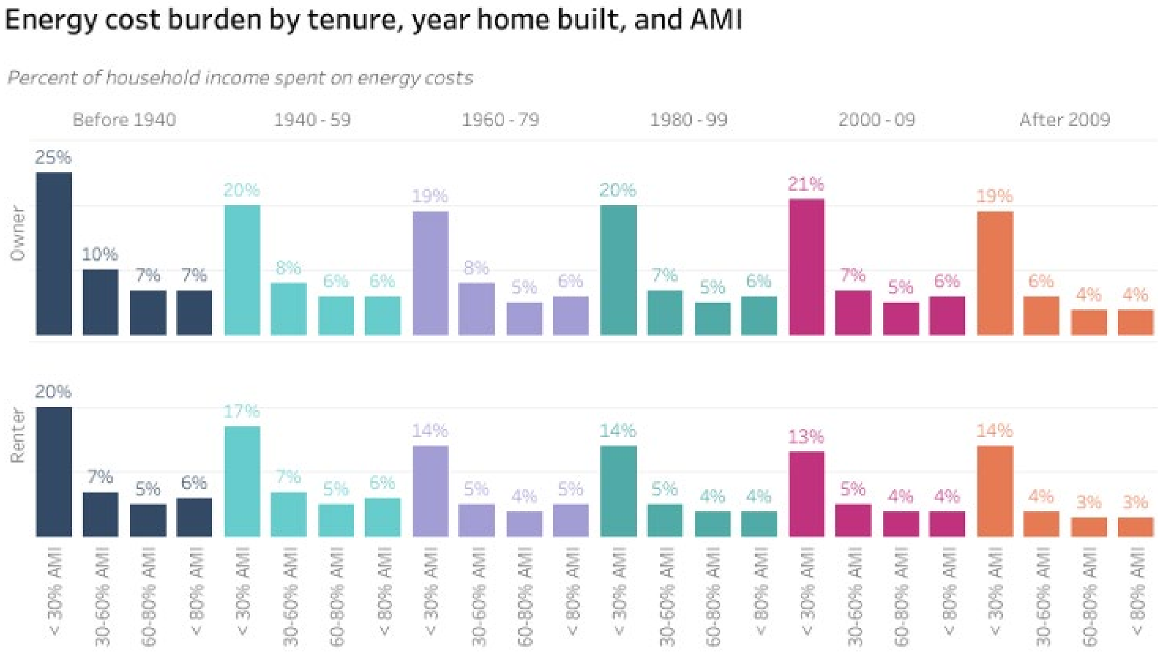
U.S. Department of Energy Data

Data from the U.S. Department of Energy's *Low-Income Energy Affordability Data (LEAD) Tool* validates the claim that Virginia *has* made vast improvements in residential energy efficiency over the last 80 years and has significantly reduced household energy costs to a level considered sustainable for individuals and families across the income spectrum.

A household is considered "energy cost burdened" when over 6% of the household income is dedicated to covering energy bills – this calculation includes all costs associated with energy used by the house (e.g., electricity and natural gas). When a household is "energy cost burdened", it impacts their ability to use electricity and heat or cool their home – and forces households to choose between paying utility bills, paying a mortgage or rent, or other essential expenses. In short, high energy cost burdens results in higher levels of housing instability, including evictions and foreclosures.

The chart below was compiled using data from the U.S. Department of Energy and included in a recent report released by Virginia Housing (formerly, Virginia Housing Development Authority) and the Department of Housing and Community Development[1].

[1] HB 854 Statewide Housing Study Report (January 2022)



Source: National Renewable Energy Laboratory, Low-Income Energy Affordability Data (LEAD) Tool, 2018.

The data from the U.S. Department of Energy (chart above) provides several important insights:

First, renters and owners residing in residential structures built since 2000 are below the 6% "energy cost burdened" threshold, with two exceptions: (i) Owner households in structures built between 2000 and 2009 are slightly over the 6% energy cost burdened threshold; (ii) Owners and renters with incomes below 30% of AMI residing in structures built between 2000 and 2019 are experiencing extremely high energy cost burdens. More analysis is needed to understand the latter - there are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Second, the highest "energy cost burdened" households (owner and renter) are residing in structures built prior to 1980's/1990's. The most "energy cost burdened" demographic – regardless of age of structure – are households earning under 30% AMI. Again, more analysis is needed to understand this dynamic. There are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Conclusion:

Data from the U.S. Department of Energy shows that residential structures constructed in the last 20 years are significantly more energy efficient than older homes, which has reduced household energy costs to levels considered sustainable for individuals and families across the income spectrum. The data also reflects the reality that efforts to reduce household energy cost burdens would be best focused on older, existing structures occupied by individuals and families at the lower end of the income spectrum.

Several energy proposals submitted during the 2021 code cycle seek to impose stricter energy efficiency requirements on all new homes, thus increasing the upfront cost of all new homes and exacerbating an issue raised by the Virginia Joint Legislative Audit and Review Commission's recent report on housing affordability: "Rising prices make it more difficult for low- and middle-income households to afford to purchase homes because of the increased monthly mortgage costs, as well as the increased upfront costs associated with purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes.[2]"

[2] Joint Legislative Audit and Review Commission: Affordable Housing in Virginia (2021)

REC-R404.4-21

Proponents: Ben Rabe (ben@newbuildings.org); Diana Burk (diana@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

R103.2.3 Solar-ready system . . The construction documents shall provide details for dedicated roof area, structural design for roof dead and live load, and routing of conduit or pre-wiring from *solar-ready zone* to electrical service panel or plumbing from *solar-ready zone* to *service water heating* system for the *solar-ready zone* shall be represented on the construction documents.

Revise as follows:

R105.2.3 Plumbing rough-in inspection. Inspections at plumbing rough-in shall verify compliance as required by the code and *approved* plans and specifications as to types of insulation and corresponding *R*-values and protection, and required controls. Where the solar-ready zone is installed for solar water heating, inspections shall verify pathways for routing of plumbing from solar-ready zone to service water heating system.

Add new text as follows:

R105.2.5 Electrical rough-in inspection.. Inspections at electrical rough-in shall verify compliance as required by the code and the approved plans and specifications as to the locations, distribution, and capacity of the electrical system. Where the solar-ready zone is installed for electricity generation, inspections shall verify conduit or pre-wiring from solar-ready zone to electrical panel.

Revise as follows:

~~R105.2.5~~ **R105.2.6 Final inspection.** The *building* shall have a final inspection and shall not be occupied until *approved*. The final inspection shall include verification of the installation of all required *building* systems, equipment and controls and their proper operation and the required number of high-efficacy lamps and fixtures.

SOLAR-READY ZONE. A section or sections of the roof or building overhang designated and reserved for the future installation of a solar photovoltaic or solar thermal system.

R401.3 Certificate. A permanent certificate shall be completed by the builder or other *approved* party and posted on a wall in the space where the furnace is located, a utility room or an *approved* location inside the *building*. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory *label*, service disconnect *label* or other required labels. The certificate shall indicate the following:

1. The predominant *R*-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, *basement walls*, *crawl space walls* and floors and ducts outside *conditioned spaces.*
2. *U*-factors of fenestration and the *solar heat gain coefficient* (SHGC) of fenestration. Where there is more than one value for any component of the building envelope, the certificate shall indicate both the value covering the largest area and the area weighted average value if available.
3. The results from any required duct system and building envelope air leakage testing performed on the building.
4. The types, sizes and efficiencies of heating, cooling and service water-heating equipment. Where a gas-fired unvented room heater, electric furnace or baseboard electric heater is installed in the residence, the certificate shall indicate “gas-fired unvented room heater,” “electric furnace” or “baseboard electric heater,” as appropriate. An efficiency shall not be indicated for gas-fired unvented room heaters, electric furnaces and electric baseboard heaters.
5. Where on-site *photovoltaic panel* systems have been installed, the array capacity, inverter efficiency, panel tilt and orientation shall be noted on the certificate.
6. For buildings where an Energy Rating Index score is determined in accordance with Section R406, the Energy Rating Index score, both with and without any on-site generation, shall be listed on the certificate.
7. The code edition under which the structure was permitted and the compliance path used.
8. Where a *solar-ready zone* is provided, the certificate shall indicate the location, dimensions, and capacity reserved on the electrical service panel.

Add new text as follows:

R404.4 Renewable energy infrastructure. The building shall comply with the requirements of R404.4.1 or R404.4.2
R404.4.1 One- and two- family dwellings and townhouses. One- and two-family dwellings and townhouses shall comply with Sections R404.4.1.1 through R404.4.1.4.

Exceptions:

1. A *building* with a permanently installed on-site renewable energy system.

2. A *building* with a solar-ready zone area that is less than 600 square feet (55 m^2) of roof area oriented between 110 degrees and 270 degrees of true north.

3. A *building* with a solar-ready zone area that is shaded for more than 70 percent of daylight hours annually.

R404.4.1.1 Solar-ready zone area. The total area of the *solar-ready zone* shall not be less than 300 square feet (28 m^2) and shall be composed of areas not less than 5.5 feet (1676 mm) in width and not less than 80 square feet (7.4 m^2) exclusive of access or set back areas as required by the International Fire Code.

Exception: Townhouses three stories or less in height above grade plane and with a total floor area less than or equal to 2,000 square feet (186 m^2) per dwelling shall be permitted to have a solar-ready zone area of not less than 150 square feet (14 m^2).

R404.4.1.2 Obstructions . Solar-ready zones shall be free from obstructions, including but not limited to vents, chimneys, and roof-mounted equipment.

R404.4.1.3 Electrical service reserved space . The main electrical service panel shall have a reserved space to allow installation of a dual pole circuit breaker for future solar electric installation and shall be labeled “For Future Solar Electric.” The reserved space shall be positioned at the opposite (load) end from the input feeder location or main circuit location.

R404.4.1.4 Electrical interconnection. An electrical junction box shall be installed within 24 inches (610 mm) of the main electrical service panel and shall be connected to a capped roof penetration sleeve or a location in the attic that is within 3 feet (914 mm) of the *solar ready zone* by one of the following:

1. Minimum ¾-inch nonflexible conduit

2. Minimum #10 Metal copper 3-wire

Where the interconnection terminates in the attic, location shall beno less than 12” (35 mm) above ceiling insulation. Both ends of the interconnection shall be labeled “For Future Solar Electric”.

R404.4.2 Group R occupancies. Buildings in Group R-2, R-3 and R-4 shall comply with Section C405.13.

Revise as follows:

TABLE R405.2 REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE

SECTION[a]	TITLE
General	
R401.2.5	Additional energy efficiency
R401.3	Certificate
Building Thermal Envelope	
R402.1.1	Vapor retarder
R402.2.3	Eave baffle
R402.2.4.1	Access hatches and doors
R402.2.10.1	Crawl space wall insulation installations
R402.4.1.1	Installation
R402.4.1.2	Testing
R402.5	Maximum fenestration U-factor and SHGC
Mechanical	
R403.1	Controls
R403.3, including R403.3.1, except Sections R403.3.2, R403.3.3 and R403.6	Ducts
R403.4	Mechanical system piping insulation
R403.5.1	Heated water circulation and temperature maintenance systems
R403.5.3	Drain water heat recovery units
R403.6	Mechanical ventilation
R403.7	Equipment sizing and efficiency rating
R403.8	Systems serving multiple dwelling units
R403.9	Snow melt and ice systems
R403.10	Energy consumption of pools and spas
R403.11	Portable spas
R403.12	Residential pools and permanent residential spas
Electrical Power and Lighting Systems	
R404.1	Lighting equipment
404.2	Interior lighting controls
R404.4	Renewable Energy Infrastructure

a. Reference to a code section includes all the relative subsections except as indicated in the table.

TABLE R406.2 REQUIREMENTS FOR ENERGY RATING INDEX

SECTION[a]	TITLE
General	
R401.2.5	Additional efficiency packages
R401.3	Certificate
Building Thermal Envelope	
R402.1.1	Vapor retarder
R402.2.3	Eave baffle
R402.2.4.1	Access hatches and doors
R402.2.10.1	Crawl space wall insulation installation
R402.4.1.1	Installation
R402.4.1.2	Testing
Mechanical	
R403.1	Controls
R403.3 except Sections R403.3.2, R403.3.3 and R403.3.6	Ducts
R403.4	Mechanical system piping insulation
R403.5.1	Heated water calculation and temperature maintenance systems
R403.5.3	Drain water heat recovery units
R403.6	Mechanical ventilation
R403.7	Equipment sizing and efficiency rating
R403.8	Systems serving multiple dwelling units
R403.9	Snow melt and ice systems
R403.10	Energy consumption of pools and spas
R403.11	Portable spas
R403.12	Residential pools and permanent residential spas
Electrical Power and Lighting Systems	
R404.1	Lighting equipment
404.2	Interior lighting controls
R404.4	Renewable Energy Infrastructure
R406.3	Building thermal envelope

a. Reference to a code section includes all of the relative subsections except as indicated in the table.

Reason Statement: In 2020, renewable energy sources were responsible for 21% of U.S. electricity generation. In order to cost-effectively achieve a Biden's goal to create a carbon-free power sector by 2035, we must make sure our buildings are capable of cost effectively installing renewable energy now. According to a recent study entitled "A New Roadmap for the Lowest Cost Grid", the least expensive grid involves a large amount of centralized renewables and a large amount of distributed renewables located on the building site. More renewables placed on site enables more clean utility-scale renewables to be deployed efficiently. It is therefore crucial for new residential buildings to be solar-ready so that the U.S. can reach its 100% carbon-free electricity goal by 2035 in the most cost-effective manner. Installing renewables on-site will also allow homeowners to economically benefit from the transition towards a low-carbon economy and benefit from additional resiliency during disruptions in centrally supplied power.

In addition, this solar-ready requirement would help grow good paying jobs. According to the Bureau of Labor Statistics, the two fastest growing occupations in the US are solar PV and wind turbine service technician. The Interstate Renewable Energy Council estimates that to reach Biden's target of 100% renewable energy by 2035, the industry will need to employ three times the number of workers employed in 2020.

The proposed revisions and additions to the code have been moved from the 2021 IECC Appendix RB Solar-Ready Provisions to the most appropriate place in the base code. The amendments would require all new homes to be solar ready by requiring a designated 300 square foot minimum "solar ready zone" on the roof. Conduit and wire from this zone must be installed and space in the electrical panel must be reserved for a future solar array. Homes where solar is not feasible due to shading or not enough solar exposure due to orientation are exempt. Information on compliance with this requirement must be placed on the construction documents to improve compliance and so that future homeowners know their home is solar-ready. Revisions to Table R405.2 and R406.2 make this a mandatory requirement in the energy code. This amendment points multifamily buildings (Group R-2 and R-3 occupancies) to a similar amendment in the commercial energy code. If the residential committee chooses to accept this amendment but the commercial solar amendment is not accepted by the commercial committee, this amendment should be revised accordingly.

References:

Renewables Became the Second-Most Prevalent U.S. Electricity Source in 2020 , U.S. Energy Information Administration, https://www.eia.gov/todayinenergy/detail.php?id=48896.

Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies, The White House, 22 Apr. 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/.

Why Local Solar For All Costs Less: A New Roadmap for the Lowest Cost Grid, Vibrant Clean Energy, Dec. 2020, www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_ES_Final.pdf.

The National Solar Job Census 2020, Interstate Renewable Energy Council, May 2021, https://irecusa.org/wp-content/uploads/2021/07/National-Solar-Jobs-Census-2020-FINAL.pdf.

Richardson, Jake. *Solar and Wind Tech Are the Fastest Growing Jobs in US*, Red, Green, and Blue, 28 Jan. 2019, http://redgreenandblue.org/2019/01/27/solar-wind-tech-fastest-growing-jobs-us/.

Cost Impact: The code change proposal will increase the cost of construction
Recent analysis by NBI and partners using cost data from RSMeans indicates that adding the infrastructure to make a home solar ready would cost $216 or $0.09 per square foot for a typical home at the time of construction. According to an NREL report, if a home is not made solar ready but chooses to add solar at a later date, the cost of the retrofit (if the retrofit is feasible) is $4,373 or $1.84 per square foot, assuming a 2,376 s.f. home. Therefore, adding the infrastructure to make a home solar ready now saves $4,157 or $1.75 per square foot for homeowners who choose to add solar at a later date.

References:

Solar Ready: An Overview of Implementation Practices, National Renewable Energy Laboratory, Jan. 2012, www.nrel.gov/docs/fy12osti/51296.pdf.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. As we see increasing number of severe weather events, the electric grid's ability to withstand these events will become increasingly important. Community resilience will be increasingly dependent on distributed generation, and more localized production can help buildings and communities keep power when other areas of the grid may be offline. This local production of power can support critical functions and provide life supporting functions of small/at home medical devices that require on power, allowing for needed cell phone charging to stay in touch during an emergency, and literally keeping the lights on for safety and security.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: REC-R404.4-21

This proposal doesn't have any public comments.

Proposal # 1061

REC-R404.4-21 – Staff Summary

Proponent: Ben Rabe (New Buildings Institute); Diana Burk (New Buildings Institute)

Brief Description:

The proposal requires new one- and two-family dwellings and townhouses to be solar-ready.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- William Penniman: Sierra Club - Virginia Chapter
    - Expressed support based on statements made earlier (while introducing his proposal REC-R404.2-21, which has a similar scope), reproduced here for convenience:
        - The 2021 IECC includes a solar ready appendix for detached 1-and 2- family dwellings and townhouses. Since VA doesn't allow localities to adopt and enforce appendices, the only way to activate the appendix and make it relevant is to include it in the body of the code, which is what this proposal would do. The solar ready provisions are very simple, basically requiring a conduit from a location on the roof to the panel. It doesn't require the installation of solar, but it makes it easier to install solar.

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)
    - Opposed the proposal based on comments made earlier in the meeting during REC-R404.1-21 discussions. Comments reproduced here for convenience:
        - Our concerns are similar to what we expressed last year. Again, to my earlier point, allowing the consumers to make the personal financial decisions to incorporate these provisions instead of making it a baseline requirement is more beneficial.
- Brian Clark: Habitat for Humanity
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- Laura Baker (alternate for Eric Lacey): Responsible Energy Codes Alliance
- K.C. Bleile: Viridiant

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note*: partial attendance. Not in attendance during REC-R404.4-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during REC-R404.4-21 discussion and voting.
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter

Other stakeholders in attendance and opposing the proposal:

- John Ainslie

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club - Virginia Chapter

- William Penniman, Sierra Club - Virginia Chapter, expressed support for the proposal and noted that this is just another way, maybe a better one, to require solar-readiness. (*Note:* he was referring to his own proposal: REC-R404.2-21)

Opposition:

Names: Andrew Clark, HBAV; Jimmy Moss, representing self.

- Andrew Clark, HBAV, wanted to go on record as opposing the proposal.
- Jimmy Moss, representing self, wanted to go on record as opposing the proposal.

DHCD Staff Notes: The proposal seeks to achieve a very similar outcome, requiring solar-readiness compliance, with proposal REC-R404.2-21. Given this, stakeholders appeared to limit their comments on this proposal and rested on the statements made for REC-R404.2-21, reproduced here for convenience:

REC-R404.2-21 comments:

Support:

Names: Ben Rabe, NBI

- Ben Rabe, NBI, expressed support for the proposal and noted that he is the proponent of a similar proposal (REC-R404.4-21). He is willing to continue the conversation and is open to making adjustments to the proposal if consensus could be reached.

Opposition:

Names: Andrew Clark, HBAV

- Andrew Clark, HBAV, expressed opposition to the proposal and stated that something that may never be used should not be mandated. It should be up to the consumer if they want that as an option, or to buy a home that is already equipped. He also noted concerns with the second exception of the proposal which would apply to buildings with a solar-ready zone that is shaded for more than 70 percent of daylight hours annually. He stated that it would seem to be almost impossible to determine when that would apply.

  Note: the proponent responded that he is willing to strike out the exception, which was meant to allow some flexibility for buildings surrounded by tall buildings or in the middle of the woods. He does not anticipate for the exception to come into play very often and opined that it is not that difficult to make the determination.

Meeting summaries and proposal related information: Tab 10 - Page 43; Tab 10 - Page 83; Tab 11 - Page 15; Tab 11 - Page 20.

EB604-21

Proponents: Shahriar Amiri (samiri@arlingtonva.us)

2018 Virginia Existing Building Code

Add new text as follows:

604 Energy Storage Systems. Proponents: Shahriar Amiri (samiri@arlingtonva.us)
4/24/2021
2021 Virginia Existing Building Code

Section 604

Energy Storage Systems

604.1 Retrofits. Retrofitting of an existing ESS shall comply with the following:

1. A construction permit shall be obtained in accordance with Section 105.6.5 of VCC.
2. New batteries, battery modules, capacitors and similar ESS components shall be *listed* .
3. Battery management and other monitoring systems shall be connected and installed in accordance with the manufacturer's instructions.
4. The overall installation shall continue to comply with UL 9540 listing requirements, where applicable.
5. Retrofits shall be documented in the service records log.

Exceptions:

1. Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for DC power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and locations outdoors or in building spaces used exclusively for such installations shall not be required to comply with this Section.
2. Detached one- and two-family dwellings and townhouses.

604.1.1 Retrofitting lead acid and nickel cadmium. This section shall not apply to retrofitting of lead-acid and nickel-cadmium batteries with other lead-acid and nickel-cadmium batteries at facilities under the exclusive control of communications utilities that comply with NFPA 76 and operate at less than 50 VAC and 60 VDC.

604.2 Replacements. Replacements of ESS shall be considered new ESS installations and shall comply with the provisions of Section 432 as applicable to new ESS. The ESS being replaced shall be decommissioned in accordance with Section 432.2.3.

604.3 Reused and repurposed equipment. Equipment and materials shall only be reused or reinstalled as permitted in Section 112.4. Storage batteries previously used in other applications, such as electric vehicle propulsion, shall not be reused in applications regulated by Chapter 4 unless *approved* by the *code official* and unless the equipment is refurbished by a battery refurbishing company *approved* in accordance with UL 1974.

604.4 Deployment documents. The following information shall be provided with the permit applications for mobile ESS deployments:

1. Relevant information for the mobile ESS equipment and protection measures in the *construction documents* required by Section 432.1.3 of VCC.

2. Location and layout diagram of the area in which the mobile ESS is to be deployed, including a scale diagram of all nearby exposures.

3. Location and content of signage, including no smoking signs.

4. Description of fencing to be provided around the ESS, including locking methods.

5. Details on fire suppression, smoke and automatic fire detection, system monitoring, thermal management, exhaust ventilation and explosion control, if provided.

6. For deployment, the intended duration of operation, including anticipated connection and disconnection times and dates.

7. Location and description of local staging stops during transit to the deployment site. See Section 432.10.7.5 of VCC.

8. Description of the temporary wiring, including connection methods, conductor type and size, and circuit overcurrent protection to be provided.

9. Description of how fire suppression system connections to water supplies or extinguishing agents are to be provided.

10. Contact information for personnel who are responsible for maintaining and servicing the equipment and responding to emergencies as required by Section 432.1.6.1 of VCC.

432.3.8 Replacements. Replacements of ESS shall be considered new ESS installations and shall comply with the provisions of Section 432 of VCC as applicable to new ESS. The ESS being replaced shall be decommissioned in accordance with Section 432.2.3 of VCC.

432.2.1 Commissioning. Commissioning of existing ESS that have been retrofitted, replaced or previously decommissioned and are returning to service shall be subject to *special inspection* and conducted prior to the ESS being placed in service in accordance with a commissioning plan that has been *approved* prior to initiating commissioning. The commissioning plan shall include the following:

1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.

2. A listing of the specific ESS and associated components, controls and safety-related devices to be tested, a description of the tests to be performed and the functions to be tested.

3. Conditions under which all testing will be performed, which are representative of the conditions during normal operation of the system.

4. Documentation of the owner's project requirements and the basis of design necessary to understand the installation and operation of the ESS.

5. Verification that required equipment and systems are installed in accordance with the *approved* plans and specifications.

6. Integrated testing for all fire and safety systems.

7. Testing for any required thermal management, ventilation or exhaust systems associated with the ESS installation.

8. Preparation and delivery of operation and maintenance documentation.

9. Training of facility operating and maintenance staff.

10. Identification and documentation of the requirements for maintaining system performance to meet the original design intent during the operation phase.

11. Identification and documentation of personnel who are qualified to service, maintain and decommission the ESS, and respond to incidents involving the ESS, including documentation that such service has been contracted for.

12. A decommissioning plan for removing the ESS from service, and from the facility in which it is located. The plan shall include details on providing a safe, orderly shutdown of energy storage and safety systems with notification to the code officials prior to the actual decommissioning of the system. The decommissioning plan shall include contingencies for removing an intact operational ESS from service, and for removing an ESS from service that has been damaged by a fire or other event.

Exception: Commissioning shall not be required for lead-acid and nickel-cadmium battery systems at facilities under the exclusive control of communications utilities that comply with NFPA 76 and operate at less than 50 VAC and 60 VDC. A decommissioning plan shall be provided and maintained where required by the *fire code official* .

432.10.6 Charging and storage. Installations where mobile ESS are charged and stored shall be treated as permanent ESS indoor or outdoor installations and shall comply with the applicable sections of VCC.

Reason Statement: An increased number of electrical energy storage systems (ESS) utilizing stationary storage batteries are appearing on the market to help meet the energy needs of society. This proposal does not mandate that ESS or stationary battery storage systems be provided but includes basic safety requirements and minimum safeguards for the installation that should be applied if such systems are provided.

This proposal incorporates the building related provisions from the 2021 edition of the International Fire Code into the Virginia Existing Building Code. Doing so is intended to reduce confusion and clearly define the building parameters necessary for the evolving technology, distinct from the operational needs.

Cost Impact: The code change proposal will not increase or decrease the cost of construction

The code change proposal will not increase or decrease the cost of construction. Some of the requirements in this proposal have the potential to increase the cost of providing ESS installations. However, the provisions in this proposal better address risks and owner/user needs in buildings and outdoor installations. Any increased cost addresses the hazards that were not contemplated in previous code editions due to energy storage technology advancements.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: EB604-21

Discussion by Paul Messplay
Jul 20, 2022 16:45 UTC

The following is a public comment submitted on behalf of John G. Armstrong, P.E., representing Dominion Energy:

"During the VA Existing Building Code stakeholder meeting held on Wednesday, June 8th, 2022, Mr. Shahriar Amiri (proposal proponent) recommended adding amended language to his proposal (EB-604- 21) concerning the exemption of lead acid and nickel cadmium batteries under the exclusive control of an electric utility. This language, which had been approved on June 7th for the VA Construction Code Proposal B-432(2)-21, read as follows:

Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for DC power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and locations outdoors or in building spaces used exclusively for such installations shall not be required to comply with this Section.

There were discussions concerning the best location to place the amended language, and it was ultimately decided to locate the proposed exemption language under Section 604.1. At the time, Mr. Justin Perry of Dominion Energy expressed a concern with the agreed upon location. Mr. Perry's concern is that locating the exemption language in Section 604.1 could be interpreted as applying to retrofits only, leaving mobile ESS units (see Section 604.4) to be subject to the provisions of this code section.

Dominion Energy utilizes mobile ESS units (lead acid batteries on trailers) to provide emergency backup power for our substation control batteries. These batteries are required for the safe operation of the substation and provision of power to any customer served from that substation. Without this exemption being placed in the proper location, our ability to reliably provide power would be impacted, as it would limit our ability to provide emergency power using a mobile ESS to our substation.

Recognizing that the proposal itself was non-consensus, there were no objections to the amendment to include the language requested by Dominion Energy. It is recommended that the amended language be included in a stand-alone section that precedes current Section 604.1 so that the exemption applies to the entire section of this code. Without the requested change, Dominion Energy does not support this proposal."

Attachments:
https://va.cdpaccess.com/proposal/1191/discuss/183/file/download/797/Public%20comment%20on%20VA%20Existing%20Building%20Code%20propo
21.pdf

EB604-21 – Staff Summary

Proponent: Shahriar Amiri, Arlington County

Brief Description:

The proposal introduces new code requirements that would apply when retrofitting existing energy storage systems.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: John Armstrong, Dominion Power; Allison Cook, Arlington County; Linda Hale, Virginia Fire Prevention Association (VFPA).

- John Armstrong, Dominion Power, expressed support for the proposal with the condition that an exception is added to exclude certain lead-acid and nickel-cadmium battery systems designed in accordance with IEEE C2, from the requirements imposed by the proposal. With the proponent agreeing to add the exception to the proposal, John Armstrong voiced support for the proposal.
- Allison Cook, Arlington County, expressed support for the proposal and noted that the proposal is a result of large workgroups (convened by the proponent and not DHCD) which consisted of both fire and building code officials across the (Northern Virginia) area.
- Linda Hale, VFPA, expressed support and indicated that this is something that is actually needed as the codes have not been able to keep up with the technology; we are behind the curb and need to be able to catch up with the technology.

Opposition:

Names: Steve Shapiro, Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA); Sarah Thomas, Virginia Association for Commercial Real Estate; William Penniman, representing self; David Beahm, representing self; Andrew Clark, HBAV.

- Steve Shapiro, AOBA & VAMA, expressed opposition to the proposal and stated that he is not comfortable applying these provisions to existing energy storage systems. He thinks there is still a lot to be learned about energy storage systems and much more discussion needs to be had about all the aspects of these systems.
- Sarah Thomas, Virginia Association for Commercial Real Estate, expressed opposition to the proposal and agreed with Steve Shapiro’s comments.
- William Penniman, representing self, expressed concerns that these provisions might be applied to existing energy storage systems in single family dwellings and would like to see an exception

added to the proposal to make it clear that single family dwellings are exempted from these requirements. *Note:* the proponent clarified that the provisions are not intended to apply to single family dwellings and agreed to add the exception to the proposal.

- David Beahm, representing self, expressed opposition to the exception for single family dwellings as that is already covered in the codes, and continuing to add unnecessary exceptions could create confusion.
- Andrew Clark, HBAV, expressed opposition and noted that he has concerns that the workgroup consisted of representatives from Northern Virginia only, while the requirements would apply statewide. *Note:* the proponent responded that the workgroup had participation from other parts of the state to the degree that it was feasible, he gave the examples of Norfolk and Chesterfield. Andrew also stated that he was not able to identify any representatives from the building or development community that participated in the workgroup, and when he poled those groups, this is the first time they heard about the workgroup.

DHCD Staff Notes:

- Justin Perry, Dominion Energy, indicated that the exception for lead-acid and nickel-cadmium battery systems (see supporting comment by Justin Armstrong above), if placed under Section 604.1 would only be applicable to the retrofitting of batteries, but not to the other sections of the proposal, such as replacement, deployment, etc. Subsequently, Dominion Energy reached out to DHCD staff via email and suggested that the exception should be included in a stand-alone section that precedes Section 604.1.
  DHCD staff agrees with the concern raised and that the proposed amendment suggested by Dominion Power could be a viable solution.
- While reviewing the proposal for processing, DHCD staff has identified several sections in the proposal that warrant some additional clarification or refinement. The concerns were shared with the proponent well in advance of the General Stakeholders Workgroup Meeting (GSWG), however, the proponent has not provided a response to the identified items. During the June 8th GSWG meeting, DHCD staff has shared this information with the participants and asked the proponent if he had a chance to review the comments. The proponent stated that he has reviewed them and has responses to most of the items but did not wish to take everyone's time during this meeting with those issues; and deferred to DHCD staff for the appropriate corrections. DHCD staff made the stakeholders aware that the staff will share the identified items with the Board of Housing and Community Development and could provide potential solutions while trying to maintain the intent of the proposal. See attached document "EB604-21_ Staff Notes and Comments" for more information.

Meeting summaries and proposal related information: Tab 10 - Page 70.

EB604-21

VEBC: 604 (New)

Proponents:

Shahriar Amiri (samiri@arlingtonva.us)

2018 Virginia Existing Building Code

Add new text as follows:

604 Energy Storage Systems.

Proponents: Shahriar Amiri
(samiri@arlingtonva.us) 4/24/2021

2021 Virginia Existing Building Code

Section 604

Energy Storage Systems

604.1 Retrofits. Retrofitting of an existing ESS shall comply with the following:

1. A construction permit shall be obtained in accordance with Section 105.6.5 of VCC.

2. New batteries, battery modules, capacitors and similar ESS components shall be *listed*.

3. Battery management and other monitoring systems shall be connected and installed in accordance with the manufacturer's instructions.

4. The overall installation shall continue to comply with UL9540 listing requirements, where applicable.

5. Retrofits shall be documented in the service records log.

604.1.1 Retrofitting lead acid and nickel cadmium. This section shall not apply to retrofitting of lead-acid and nickel-cadmium batteries with other lead-acid and nickel-cadmium batteries at facilities under the exclusive control of communications utilities that comply with NFPA 76 and operate at less than 50 VAC and 60 VDC.

604.2 Replacements. Replacements of ESS shall be considered new ESS installations and shall comply with the provisions of Section 432 as applicable to new ESS. The ESS being replaced shall be decommissioned in accordance with Section 432.2.3.

604.3 Reused and repurposed equipment. Equipment and materials shall only be reused or reinstalled as permitted in Section 112.4. Storage batteries previously used in other applications, such as electric vehicle propulsion, shall not be reused in applications regulated by Chapter 4 unless *approved* by the *code official* and unless the equipment is refurbished by a battery refurbishing company *approved* in accordance with UL 1974.

604.4 Deployment documents. The following information shall be provided with the permit applications for mobile ESS deployments:

1. Relevant information for the mobile ESS equipment and protection measures in the *construction documents* required by Section 432.1.3 of VCC.

Commented [MF(1]: This appears to be an IFC Section. The more appropriate VCC Section would appear to be 108.

Commented [MF(2]: Could there be a possibility that some existing installation did not comply with the UL9540 listing requirements? If so, they would be unable to "continue to" comply if they never did prior.

Commented [MF(3]: It appears that these references are to Sections contained in proposal B432(2)-21. In the event that said proposal does not get approved, but this proposal (EB604.21) does, these references would become invalid?

Commented [MF(4]: This appears to be a VCC Section. If so, it should indicate such.

Commented [MF(5]: Section 604.3 appears to be the same as the 2021 IFC Section 1207.3.9, except for the references to Section 104.8.1 (of the IFC) and Ch 12 (of the IFC). Since IFC Ch 12 covers only ESS, it would be appropriate to reference the entire Chapter. However, the IBC/VCC Ch 4 covers Special Detailed Req'ts – a much broader subject matter that Ch 12 of the IFC. As such, could there be a possibility of misinterpreting the reference to Ch 4 to only apply to those special occupancies covered by the Chapter? I.e. I, R, etc.? Should, perhaps, the reference to Ch 4 be replaced with a reference to the appropriate section number (Section 432, proposed by another proposal) as already done on other instances in this proposal?

Commented [MF(6]: VCC Section 432.1.3 [proposed by code change B432(2)-21] covers Hazard mitigation analysis, Was it meant to reference Section 432.1.2 perhaps?

2. Location and layout diagram of the area in which the mobile ESS is to be deployed, including a scale diagram of all nearby exposures.

3. Location and content of signage, including no smoking signs.

4. Description of fencing to be provided around the ESS, including locking methods.

5. Details on fire suppression, smoke and automatic fire detection, system monitoring, thermal management, exhaust ventilation and explosion control, if provided.

6. For deployment, the intended duration of operation, including anticipated connection and disconnection times and dates.

7. Location and description of local staging stops during transit to the deployment site. See Section 432.10.7.5 of VCC.

8. Description of the temporary wiring, including connection methods, conductor type and size, and circuit overcurrent protection to be provided.

9. Description of how fire suppression system connections to water supplies or extinguishing agents are to be provided.

10. Contact information for personnel who are responsible for maintaining and servicing the equipment and responding to emergencies as required by Section 432.1.6.1 of VCC.

432.3.8 Replacements. Replacements of ESS shall be considered new ESS installations and shall comply with the provisions of Section 432 of VCC as applicable to new ESS. The ESS being replaced shall be decommissioned in accordance with Section 432.2.3 of VCC.

432.2.1 Commissioning. Commissioning of existing ESS that have been retrofitted, replaced or previously decommissioned and are returning to service shall be subject to *special inspection* and conducted prior to the ESS being placed in service in accordance with a commissioning plan that has been *approved* prior to initiating commissioning. The commissioning plan shall include the following:

1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.

2. A listing of the specific ESS and associated components, controls and safety-related devices to be tested, a description of the tests to be performed and the functions to be tested.

3. Conditions under which all testing will be performed, which are representative of the conditions during normal operation of the system.

4. Documentation of the owner's project requirements and the basis of design necessary to understand the installation and operation of the ESS.

5. Verification that required equipment and systems are installed in accordance with the *approved* plans and specifications.

6. Integrated testing for all fire and safety systems.

7. Testing for any required thermal management, ventilation or exhaust systems associated with the ESS installation.

8. Preparation and delivery of operation and maintenance documentation.

9. Training of facility operating and maintenance staff.

Commented [MF(7]: If this reference was intended to refer to a Section in proposal B432(2)-21, equivalent to the IFC Section 1207.10.7.5, said proposal does not include a section for "Local Staging" (rightfully so, as that is an operational item covered under the SFPC).

Commented [MF(8]: Similar with above comment (Fire mitigation personnel, IFC Section 1207.1.6.1).

Commented [MF(9]: Section 604.2 above reads almost identical with this section. It is unclear whether Section 432.3.8 was added here in error.

Commented [MF(10]: It appears that the more appropriate section number would be 604.5? If so, all the subsections would have to be updated accordingly.

Commented [MF(11]: Are the special inspections requirements stipulated here meant to be in accordance with Chapter 17 of the VCC? If so, perhaps it should be noted as such.

10. Identification and documentation of the requirements for maintaining system performance to meet the original design intent during the operation phase.

11. Identification and documentation of personnel who are qualified to service, maintain and decommission the ESS, and respond to incidents involving the ESS, including documentation that such service has been contracted for.

12. A decommissioning plan for removing the ESS from service, and from the facility in which it is located. The plan shall include details on providing a safe, orderly shutdown of energy storage and safety systems with notification to the code officials prior to the actual decommissioning of the system. The decommissioning plan shall include contingencies for removing an intact operational ESS from service, and for removing an ESS from service that has been damaged by a fire or other event.

Exception: Commissioning shall not be required for lead-acid and nickel-cadmium battery systems at facilities under the exclusive control of communications utilities that comply with NFPA 76 and operate at less than 50 VAC and 60 VDC. A decommissioning plan shall be provided and maintained where required by the *fire code official* .

432.10.6 Charging and storage. Installations where mobile ESS are charged and stored shall be treated as permanent ESS indoor or outdoor installations and shall comply with the applicable sections of VCC.

Reason Statement:

An increased number of electrical energy storage systems (ESS) utilizing stationary storage batteries are appearing on the market to help meet the energy needs of society. This proposal does not mandate that ESS or stationary battery storage systems be provided but includes basic safety requirements and minimum safeguards for the installation that should be applied if such systems are provided.

This proposal incorporates the building related provisions from the 2021 edition of the International Fire Code into the Virginia Existing Building Code. Doing so is intended to reduce confusion and clearly define the building parameters necessary for the evolving technology, distinct from the operational needs.

Commented [MF(12]: The Resiliency Impact Statement is missing.

Cost Impact:

The code change proposal will not increase or decrease the cost of construction

The code change proposal will not increase or decrease the cost of construction. Some of the requirements in this proposal have the potential to increase the cost of providing ESS installations. However, the provisions in this proposal better address risks and owner/user needs in buildings and outdoor installations. Any increased cost addresses the hazards that were not contemplated in previous code editions due to energy storage technology advancements.

EB1102-21

Proponents: Scott Lang (scott.lang@honeywell.com); Richard Roberts (richard.roberts@systemsensor.com); Robert Davidson (rjd@davidsoncodeconcepts.com)

2018 Virginia Existing Building Code

Add new text as follows:

1102
Energy Storage Systems

1102.1 Lithium-ion technology energy storage systems. The owner of an energy storage system (ESS) utilizing lithium-ion battery technology having capacities exceeding the values in Table 1207.1.1 of the IFC and that was installed prior to the jurisdiction's adoption of the 2018 or later edition of the International Fire Code shall provide the fire code official a failure modes and effects analysis (FMEA) or other approved hazard mitigation analysis for review and approval.

Exception: Detached one- and two-family dwellings and townhouses.

1102.1.1 Detection. In addition to the requirements of Section 1207.1.4.1 and 1207.1.4.2 of the IFC, the analysis shall include an assessment of the ability of the installed protection systems to provide for detection and notification of a thermal runaway event in relation to the ability of emergency responders to safely mitigate the size and impact of a thermal runaway event.

1102.1.2 Corrective action plan. Where hazards are identified by the analysis, a plan that includes a timetable for corrective action shall be submitted to the fire code official for review and approval. The plan shall include actions and system improvements necessary for eliminating or mitigating any identified hazards, including listed methods for early detection and notification of a thermal runaway event.

Reason Statement: Note: this proposal has been accepted for the 2024 edition of the International Fire Code.
Though both the 2018 International Fire Code, 2018 NFPA 1 Fire Code received significant enhancements to provide necessary protection levels which were improved further with the provisions of the 2020 NFPA 855 Energy Storage Systems, the 2021 International Fire Code and the 2021 NFPA 1 Fire Code, there are numerous installations that do not meet the new and necessary safety requirements. Even after the printing of the 2018 International Fire Code installers continued to install systems that did not meet the new standard of care, taking advantage of earlier editions of the codes that were still being enforced locally. A glaring example of a system that did not meet the requirements of the 2018 or 2021 editions of the International Fire Code was located in Surprise, Arizona where a thermal runaway event seriously injured 4 members of the fire service.

The purpose of this proposal is to start to address potential protection shortcomings in the design, installation and maintenance of existing energy storage systems employing lithium-ion technology by requiring that a hazard analysis conforming to the requirements of Sections 1207.1.4.1 and 1207.1.4.2 of the current ESS requirements.

Proposed Section 1102.1 sets the scoping to those systems installed prior to the local adoption of the 2018 IFC or later that exceed the thresholds in Table 1207.1.1 which is the trigger for new installations. It utilizes similar language for the hazard analysis as currently exists for new systems at 1207.1.4 for consistency in application. An exception for one- and two-family dwellings and townhouses is included.

Proposed Section 1102.1.1, in addition to the requirements of Sections 1207.1.4.1 and 1207.1.4.2, requires the inclusion of an assessment of the ability of the installed protection to provide an early warning of a thermal runaway event and to provide notification of that event in relation to the ability of responders to safely mitigate the event. Early detection of a thermal runaway utilizing listed methods of early detection, such as sensing cell off-gassing or other compliant methods, is essential to mitigation efforts and the safety of responders.

Proposed Section 1102.1.2 requires the submission of a corrective action plan for the review and approval of the fire code official that includes actions and system improvements necessary for eliminating or mitigating identified hazards.

This retroactive provision is consistent with activities for a similar requirement during the current cycle of NFPA 855 Energy Storage Systems.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
The code change proposal will not increase or decrease the cost of construction. The proposed language does not address new construction. It addresses the safety of existing systems. Though there will not be a construction increase, there will be an increased operational cost to have the analysis conducted, and a cost to remedy and existing safety hazards typical of any other identified safety issue in a regulated occupancy.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal would increase the resiliency of existing ESS by requiring an assessment of potential hazards that could lead to large events

destroying the ESS and exposures. Addressing those hazards provides for increased long term resilience.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: EB1102-21

This proposal doesn't have any public comments.

Proposal # 974

EB1102-21– Staff Summary

Proponent: Scott Lang; Richard Roberts; Robert Davidson.

Brief Description:

The proposal introduces retrofit provisions for existing energy storage systems installed prior to the adoption of the 2018 International Fire Code.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Statewide Fire Prevention Code (SFPC) Sub-Workgroup at their April 18, 2022, meeting but it did not gain the support of the Sub-Workgroup.

Key comments:

- The proposal is unclear as to the potential mitigation requirements and how it will be enforced.
- What will happen if future code requirements will become even more stringent? Would existing energy storage systems have to be retrofitted yet again?
- Retrofit provisions come as a directive from the General Assembly and they tie back to legislation. Also, retrofit provisions require a one-time upgrade by a certain date which this proposal does not.
- Other retrofits require something to be done to the building. This proposal does not appear to say that. It requires that information to be given to the fire official. It makes more sense to put it into Chapter 12 of the Statewide Fire Prevention Code.

SFPC Sub-Workgroup members in attendance:

- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)
- Andrew Milliken: Virginia Fire Services Board – Codes and Standards Committee
- Andrew Milliken: Virginia Fire Chiefs Association
- Joshua Davis: State Fire Marshal’s Office, Virginia Department of Fire Programs (VDFP)
- James (Jimmy) Moss: Virginia Building & Code Officials Association
- Dustin J. Wakefield: Virginia Department of General Services/Division of Engineering & Buildings
- Linda Hale: Virginia Fire Prevention Association

Sub-Workgroup members not in attendance:

- Mike O'Connor: Virginia Petroleum & Convenience Marketers Association
- Lou Wolf: American Institute of Architects - Virginia Chapter
- Matthew Lannon: Virginia Restaurant, Lodging & Travel Association
- Jodi Roth: Virginia Retail Federation

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Justin Perry, Dominion Power; Andrew Grigsby, Viridiant.

- Justin Perry, Dominion Power, expressed concerns with the word “early” in the proposal as Honeywell sells an early detection system and they are one of the code change proponents. He indicated that he would support the proposal if the word “early” is removed from Section 1102.1.1. The proponent agreed to remove the word “early” (two instances). With the proponent agreeing to the friendly modification, Justin Perry supported the proposal.
- Andrew Grigsby, Viridiant, also expressed support for the proposal.

Opposition:

Names: Steve Shapiro, AOBA & VAMA; David Beahm, representing self.

- Steve Shapiro, AOBA & VAMA, indicated that this is a retroactive provision and he is totally opposed to that. There are very few retroactive provisions in the Uniform Statewide Building Code, and it is like that for a reason.
- David Beahm, representing self, noted that the proposed language, although it appears to have been brought over from the International Fire Code, it is not appropriate for Virginia. He also opposes the proposal due to the exception for detached one- and two-family dwellings and townhouses, which does not belong here since it is covered in the administrative portion of the code.

DHCD Staff Notes:

The proposal was originally included in the Agenda for the April 13, 2022, General Stakeholders Workgroup (GSWG) meeting. While the proposal was introduced to the stakeholders and very briefly discussed during the April 13th GSWG meeting, the proponent requested to carry over the proposal to the June 10th GSWG meeting so that it can also be discussed by the SFPC Sub-Workgroup in the interim. The notes in the “GENERAL STAKEHOLDERS WORKGROUP INFORMATION” section above represent comments made during the June 10th GSWG meeting.

Meeting summaries and proposal related information: Tab 10 - Page 10; Tab 10 - Page 32; Tab 10 - Page 33; Tab 10 - Page 74; Tab 11 - Page 49; Tab 11 - Page 50; Tab 11 - Page 108; Tab 11 - Page 118.

B433-21

Proponents: Shahriar Amiri (samiri@arlingtonva.us)

2018 Virginia Construction Code

Add new text as follows:

433 Electric Vehicle (EV) Charging Stations. Proponents: Shahriar Amiri (samiri@arlingtonva.us) 4/25/2022
2021 Virginia Construction Code

SECTION 433

ELECTRICAL VEHICLE (EV) CHARGING STATIONS

433.1 General. The provisions of this Section shall apply to installation of Electric Vehicle Charging Stations

Exception: EV CHARGING STATION in Group R-3 and R-4 occupancies shall comply with Section 433.11.

433.2 Construction documents. The following information shall be provided with the permit application:

1. Location and layout diagram of the room or area in which the EV CHARGING STATION is to be installed.

2. The quantities and types of EV CHARGING STATION to be installed.

3. Manufacturer's specifications, ratings and listings of each EV CHARGING STATION.

4. Description of energy (battery) management systems and their operation.

5. Location and content of required signage.

6. Details on fire suppression EV Charging Station, smoke or fire detection, thermal management, ventilation, exhaust and *deflagration* venting systems, if provided.

7. Support arrangement associated with the installation, including any required seismic restraint.

433.3 Installation and Listing. Where provided, electric vehicle charging stations shall be installed in accordance with *NFPA 70* . Electric vehicle charging system equipment shall be listed and labeled in accordance with *UL 2202* . Electric vehicle supply equipment shall be listed and labeled in accordance with *UL 2594* . Accessibility to electric vehicle charging stations shall be provided in accordance with Chapter 11.

433.3.1 Electrical disconnects. Where the EV CHARGING STATION disconnecting means is not within sight of the main electrical service disconnecting means, placards or directories shall be installed at the location of the main electrical service disconnecting means indicating the location of EV Charging Station(s) disconnecting means in accordance with NFPA 70.

433.3.2 Vehicle impact protection. Where EV CHARGING STATION are subject to impact by a motor vehicle, impact protection shall be provided in accordance with this code.

433.4 Location. 433.5.3 Elevation. EV CHARGING STATION shall not be located in the following areas:

1. Where the floor is located more than 75 feet (22 860 mm) above the lowest level of fire department vehicle

2. Where the floor is located more than one level below the lowest *level of exit discharge*

433.5 Fire detection. An *approved* automatic smoke detection system or radiant energy-sensing fire detection system shall be installed in EV charging station area where located in enclosed parking garages. An *approved* radiant energy-sensing fire detection system shall be installed to protect open parking garage and rooftop installations. Alarm signals from detection systems shall be transmitted to a central station, proprietary or remote station service in accordance with NFPA 72, or where *approved* to a constantly attended location.

433.5.1 System status. Where required by the fire *code official*, visible annunciation shall be provided on cabinet exteriors or in other *approved* locations to indicate that potentially hazardous conditions associated with the EV CHARGING STATION exist.

433.6 Fire suppression systems: Enclosed parking garages containing EV CHARGING STATION shall be protected by an automatic sprinkler system designed and installed in accordance with the following:

1. An *automatic sprinkler system* designed and installed in accordance with Section 903.3.1.1 with a minimum density of 0.3 gpm/ft^2 (1.14 L/min) based on the *fire area* or 2,500 square-foot (232 m^2) design area, whichever is smaller.

433.8 Exhaust ventilation. Where installed in enclosed parking garages, exhaust ventilation of areas and containing EV charging stations shall be provided in accordance with the *International Mechanical Code* and Section 433.8.1 or 433.8.2.

433.8.1. Ventilation based on LFL. The exhaust ventilation system shall be designed to limit the maximum concentration of flammable gas to 25 percent of the lower flammable limit (LFL) of the total volume of the room, area or walk-in unit during the worst-case event of simultaneous charging of batteries at the maximum charge rate, in accordance with nationally recognized standards.

433.8.2 Ventilation based on exhaust rate. Mechanical exhaust ventilation shall be provided at a rate of not less than 1 ft^3 /min/ft^2 (5.1 L/sec/m^2) of floor area of the room, area or walk-in unit. The ventilation shall be either continuous or shall be activated by a gas detection system in accordance with Section 432.6.1.2.4.

433.8.2.1 Standby power. Mechanical exhaust ventilation shall be provided with a minimum of 2 hours of standby power in accordance with Section 1203.2.5.

433.8.2.2 Installation instructions. Required mechanical exhaust ventilation systems shall be installed in accordance with the manufacturer's installation instructions and the *International Mechanical Code* .

433.8.2.3 Supervision. Required mechanical exhaust ventilation systems shall be supervised by an *approved* central station, proprietary or remote station service in accordance with NFPA 72 or shall initiate an audible and visible signal at an *approved* constantly attended on-site location.

433.9 Separation. The EV CHARGING STATION shall be separated from doors, windows, operable openings into buildings or HVAC inlets by at least 10 feet (1524 mm). 433.7 Means of egress separation from EV Charging Station. EV CHARGING STATION located outdoors and in open parking garages shall be separated from any *exit* as required by the fire *code official* to ensure safe egress from EV under fire conditions, but in no case EV Charging Station shall be separated less than 10 feet (3048 mm). EV charging stations located in enclosed parking structures shall be located no less than 25 feet from any exit.

433.10 Special installations. Rooftop and open parking garage EV CHARGING STATION installations shall comply with this section.

1. A Class I standpipe outlet shall be installed at an*approved* location on the roof level of the building or in the stairway at the top level.

2. The EV CHARGING STATION shall be the minimum of 10 feet (3048 mm) from the fire service access point on the rooftop.

433.11 Spill control and neutralization. Areas containing free-flowing liquid electrolyte or hazardous materials shall be provided with spill control and neutralization in accordance with this section.

433.11.1 Spill control. Spill control shall be provided to prevent the flow of liquid electrolyte or hazardous materials to adjoining rooms or areas.

432.11.2 Neutralization. An *approved* method that is capable of neutralizing spilled liquid electrolyte from the largest battery or vessel to a pH between 5.0 and 9.0 shall be provided.

Reason Statement: An increased number of Electric Vehicle (EV) Charging Station installations is occurring to help meet the electric vehicle charging needs of society. This proposal does not mandate that (EV) Charging Stations be provided but includes basic safety requirements and minimum safeguards for the installation of these stations that should be applied if such stations are provided.

This proposal incorporates the building related provisions from the 2021 edition of the International Fire Code into the Virginia Construction Code. Doing so is intended to reduce confusion and clearly define the building parameters necessary for the evolving technology, distinct from the operational needs.

Cost Impact: The code change proposal will not increase or decrease the cost of construction

The code change proposal will not increase or decrease the cost of construction. Some of the requirements in this proposal have the potential to increase the cost of providing ESS installations. However, the provisions in this proposal better address risks and owner/user needs in buildings and outdoor installations. Any increased cost addresses the hazards that were not contemplated in previous code editions due to energy storage technology advancements.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: B433-21

This proposal doesn't have any public comments.

Proposal # 1190

B433-21 – Staff Summary

Proponent: Shahriar Amiri, Arlington County

Brief Description:

The proposal adds requirements and restrictions applicable to Electric Vehicle (EV) Charging Stations in order to mitigate potential hazards associated with these systems.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Matthew Cobb; Matt Smolky, representing Prince William County; Gregg Karl.

- Matthew Cobb made the point that extinguishing an EV lithium ion battery fire with thermal runaway requires considerable water and personnel resources. The biggest threat to safety is underground EV charging stations.
- Matt Smolky, representing Prince William County, stated that EV charging stations must be in a manageable and readily accessible location (which this proposal would ensure).
- Gregg Karl emphasized that the extent of hazardous runoff from a lithium ion battery fire is enormous and the first responders need respirators to engage with it. Those types of fires could take up to 12 hours to extinguish. There's a very limited window from the time the fire starts getting it somewhat under control, and removing the vehicle before another flare-up. Limiting the floor levels where the EV charging stations can be located would facilitate the firefighting operations and allow for buildings to be re-occupied sooner.

Opposition:

Names: William Penniman, Sierra Club - Virginia Chapter; Andrew Clark, Home Builders Association of Virginia (HBAV); Steve Shapiro, Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA).

- William Penniman, Sierra Club - Virginia Chapter, indicated that precluding EV charging from any parking level sounds extreme. He noted that the International Code Council is moving towards charging availability for every dwelling unit in multi-family dwelling buildings. There are several code change proposals under consideration this code development cycle that require a minimum number of EV charging spaces and would allow them to be located at any level. He opposes the proposal given that it conflicts with the national initiative to move towards EV, and thinks there needs to be more discussion on this subject.

- Andrew Clark, HBAV, highlighted that the proposal does not correlate with the other EV related proposals. He agrees with William Penniman on the need for additional discussion on this topic.

- Steve Shapiro, AOBA and VAMA, indicated that he has been collaborating with William Penniman and others on achieving consensus on some of the other EV related proposals and this proposal would be in conflict with the former.

DHCD Staff Notes:

A cursory review by DHCD staff during proposal processing revealed several sections in the proposal that warrant some additional clarification or refinement. Please see attached document “B433-21_Staff Notes and Comments” for more information. The potential issues were brought up to the proponent’s attention via email on May 16, 2022. An official response, with proposed resolutions, has not been received from the proponent.

Meeting summaries and proposal related information: Tab 10 - Page 60.

P405.3.1-21

Proponents: Paula Eubank (paula.neal.eubank@gmail.com)

2021 International Plumbing Code

Revise as follows:

405.3.1 Water closets, urinals, lavatories and bidets. A water closet, urinal, lavatory or bidet shall not be set closer than 15 inches (381 mm) from its center to any side wall, partition, vanity or other obstruction. Where partitions or other obstructions do not separate adjacent water closets, urinals, or bidets, the fixtures shall not be set closer than 30 inches (762 mm) center to center between adjacent fixtures or adjacent water closets, urinals, or bidets. There shall be not less than a 21-inch (533 mm) clearance in front of a water closet, urinal, lavatory or bidet to any wall, fixture or ~~door.~~ door swinging outward. Doors swinging inward shall not encroach into the required 21 inch clearance by more than 7 inches. Water closet compartments shall be not less than 30 inches (762 mm) in width and not less than 60 inches (1524 mm) in depth for floor-mounted water closets and not less than 30 inches (762 mm) in width and 56 inches (1422 mm) in depth for wall-hung water closets.

> **Exception:** An accessible children's water closet shall be set not closer than 12 inches (305 mm) from its center to the required partition or to the wall on one side.

Reason Statement: This code proposal supports and reinforces the requirement to provide adequate knee and maneuvering clearance within the water closet compartment without users contacting the plumbing fixtures, water closet fixture, or other restroom accessories located within the water closet compartment. This code proposal allows adequate area to safely enter, rotate, maneuver, and exit the water closet compartment as necessary. Not affecting water closet compartments equipped with outward swinging doors, this code proposal would not significantly increase the minimum water closet compartment dimension/length requirements of those equipped with inward swinging doors, approximately 8 inches. The code proposal reinforces the necessity for occupant and user health and sanitation.
The majority of existing water closet compartments having water closet compartment doors swinging into water closet compartment interiors do not provide even the minimal of necessary maneuvering clearance without contact with water closet fixtures, typically 6 inches. This provision would not be applicable to or alter water closet compartment provisions for fully accessible water closet compartments in accordance with ICC/ANSI A117.1, however this provision should be applied to alternate wheelchair accessible water closet compartments.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
While potentially increasing the required water closet compartment dimensions minimally when the water closet compartment door swings into the water closet compartment interior, the code proposal reinforces the code intent to provide adequate maneuvering clearance within the water closet compartment without contacting the water closet fixture or other restroom accessories located within the water closet compartment. The code proposal reinforces the necessity for occupant health and sanitation.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: P405.3.1-21

Discussion by Paul Messplay
Aug 18, 2022 12:00 UTC

Proponents: Paula Eubank, representing Self requests As Submitted

Commenter's Reason: This code proposal supports and reinforces the requirement to provide adequate knee and maneuvering clearance within the water closet compartment without users directly contacting the plumbing fixtures, water closet fixture, or other restroom accessories located within the water closet compartment for safety, health, and sanitation purposes. This code proposal allows adequate area to safely enter, rotate, maneuver, and exit the water closet compartment as necessary. The existing code provisions do not prohibit outward swinging water closet compartment doors, and thus some percentage are presently constructed and installed in this manner. the outward swinging door generally would not affect access/egress and therefore generally would not require any increase in dimension requirements or construction costs. Although this primarily affects female restrooms and water closet compartments, this code proposal reinforces the necessity for occupant and user safety, health, and sanitation.

Proposal # 1170

P405.3.1-21 – Staff Summary

Proponent: Paula Eubank

Brief Description:

The proposal requires additional clearance in front of water closets located in stalls not required to meet the handicap accessibility provisions.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: David Beahm, representing self

- David Beahm, representing self, expressed his support for the proposal but noted that he would prefer to not have the door swing outward.

Opposition:

Names: Andrew Clark, Apartment and Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

- Andrew Clark, representing AOBA and VAMA, expressed opposition and stated that adding additional inches to the minimum dimensions drives up the cost for something that may not necessarily be an issue.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 106

RB113.1-21

Proponents: KC Bleile (kc.bleile@viridiant.org)

2018 Virgina Residential Code

Revise as follows:

113.3 Minimum inspections. The following minimum inspections shall be conducted by the building official when applicable to the construction or permit:

1. Inspection of footing excavations and reinforcement material for concrete footings prior to the placement of concrete.
2. Inspection of foundation systems during phases of construction necessary to assure compliance with this code.
3. Inspection of preparatory work prior to the placement of concrete.
4. Inspection of structural members and fasteners prior to concealment.
5. Inspection of electrical, mechanical and plumbing materials, equipment and systems prior to concealment.
6. Inspection of energy conservation ~~material~~ <u>materials, equipment, and systems</u> prior to concealment.
7. Final inspection.

Reason Statement: The intent of this proposal is to clarify existing 2018 Virginia Residential Code Minimum Inspections found in Chapter 1 to aid in Building Code Official enforcement.

Cost Impact:
None to builder as related to Building Code Official enforcement of existing code.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal will strengthen home resilience as it clarifies the minimum inspections related to energy code provisions.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: RB113.1-21

This proposal doesn't have any public comments.

RB113.1-21 – Staff Summary

Proponent: KC Bleile

Brief Description:

The proposal seeks to clarify the existing minimum inspection requirements to better encompass the scope of inspections required for compliance with the energy codes.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was first brought to the Energy Sub-Workgroup during their May 12th meeting. KC mentioned that she worked on this proposal with the building official from Montgomery County who felt the existing language for inspecting energy conservation material was limiting. The discussions from this meeting lead to the proposal being carried over until the following meeting on May 19th. A decision was not made by the sub-workgroup during the May 19th meeting.

Energy Sub-Workgroup members in attendance at the May 12th meeting:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
- K.C. Bleile: Viridiant
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)
- William (Bill) Penniman: Sierra Club; Virginia chapter

Energy Sub-Workgroup members not in attendance at the May 12th meeting:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance

Energy Sub-Workgroup members in attendance at the May 19th meeting:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
- K.C. Bleile: Viridiant
- William (Bill) Penniman: Sierra Club – Virginia chapter

Energy Sub-Workgroup members not in attendance at the May 19th meeting:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club - Virginia Chapter

- William Penniman expressed support for the proposal and indicated that the proposal makes sense.

Opposition:

Names: Andrew Clark, Home Builders Association of Virginia (HBAV); Anthony Clatterbuck, representing self; David Beahm, representing self; Richard Grace, Culpepper County Building Department.

- Andrew Clark, HBAV testified that the proposal's original language may be unnecessary or overkill.
- The proponent provided amended language in the chat based on concerns raised during the meeting about when these inspections should take place: "Inspection of energy conservation materials, equipment, and systems prior to concealment."
    - David Beahm, representing self, stated that he does not think that equipment needs to be inspected prior to concealment.
    - Andrew Clark, HBAV, testified that this language is still too open ended and adds ambiguity to the minimum inspection requirements.
    - Anthony Clatterbuck, representing self, raised concerns about having to install a complete system prior to concealment.
    - Richard Grace, Culpepper County Building Department, raised concern about this change being applicable to the Virginia Construction Code as well as the Virginia Residential Code (VRC) since there is no separate administrative chapter for the VRC.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 94; Tab 11 - Page 42.

RB315.3-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virgina Residential Code

Revise as follows:

R315.3 Location. Carbon monoxide alarms in *dwelling units* shall be installed outside of each separate sleeping area in the immediate vicinity of the ~~bedrooms.~~ bedrooms and in each room, including the basement, in which combustion occurs. Where a fuel-burning *appliance* is located within a bedroom or its attached bathroom, a carbon monoxide alarm shall be installed within the bedroom.

Add new text as follows:

R331 Gas Detectors and Alarms. Fuel gas detectors with alarms appropriate to the fuel combusted shall be installed in each room, including the basement, in which combustion occurs. Such detectors shall comply with UL1484. They shall be installed as recommended by the manufacturers and be made permanent fixtures.

Reason Statement: Indoor combustion of fuels poses serious risks to residents. (See. e.g., Rocky Mountain Institute, et al. "Health Effects from Gas Stove Pollution", https://rmi.org/insight/gas-stoves-pollution-health/ ; "Gas Stoves Can Generate Unsafe Levels of Indoor Air Pollution," https://www.vox.com/energy-and-environment/2020/5/7/21247602/gas-stove-cooking-indoor-air-pollution-health-risks ; Carbon monoxide is one of several pollutants from combustion that endanger residents' health and are potentially deadly. Indoor air pollution can be worse than permissible outdoor pollution levels.
Carbon monoxide is a direct product of combustion and can accumulate in rooms in which the combustion occurs. Gas stoves and unvented combustion devices pose the most obvious dangers. Even vented combustion systems, such as furnaces, pose dangers if they are damaged or if the vents are blocked in whole or in part.
Fuel gas leaks pose health, fire and explosion dangers. Leaks are most likely where appliances are joined to pipes and where gas leaks if the fire is put out or doesn't ignite (e.g., at a gas stove). Leaks can also occur if pipes or equipment are damaged. While an odorizer may help, it may not be adequate if people are sleeping in other rooms or out of the house.

Cost Impact: The code change proposal will increase the cost of construction
The cost impact will be minimal. Combination detectors are available on the market for $!00 or less. If combustion occurs in the utility room and kitchen, the cost could be $200 or less.

Resiliency Impact Statement: This proposal will increase Resiliency
Avoiding or at least minimizing hazards associated with indoor air pollution and potentially explosive gas leaks will help to protect residents. The risks of leaks from damage to fuel lines will be greater when storms damage buildings.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: RB315.3-21

This proposal doesn't have any public comments.

Proposal # 1192

RB315.3-21 – Staff Summary

Proponent: William Penniman, Sierra Club – Virginia Chapter

Brief Description:

The proposal requires carbon monoxide alarms to be installed in each room in which combustion occurs, including the basement. The proposal also requires fuel gas detectors in these same areas to detect gasses other than carbon monoxide.

STUDY GROUP OR SUB-WORKGROUP INFORMATION.

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Ross Shearer, representing self; Susan Stillman, representing self

- Ross Shearer, representing self, stated that he supports this proposal for the reasons given in the proposal.
- Susan Stillman, representing self, stated that requiring carbon monoxide alarms in rooms where combustion occurs would help prevent the buildup of carbon monoxide in the house.

Opposition:

Names: Anthony Clatterbuck, Home Builders Association of Virginia (HBAV); Andrew Clark, HBAV

- Anthony Clatterbuck, HBAV, stated that this proposal is "overkill" since it would require the installation of carbon monoxide alarms in multiple rooms and that the area with the most need for carbon monoxide alarms is in garages with generators.
- Andrew Clark, HBAV, indicated that one of the reasons for carbon monoxide build up is the continued increase in the levels of house tightness required by the code. He also noted that the current Virginia carbon monoxide provisions are the same as those stipulated by the International Residential Code (IRC), which have been thoroughly vetted and agreed upon by building and fire officials and builders. He also referred to an NFPA study done a few years ago which concluded that analyses of hazards should be done before new device suggestions are made. He asked whether any study was done and determined that the current IRC requirements for carbon monoxide alarms are inadequate.
  Note: the proponent answered that the issues of fuel gas leaks and carbon monoxide buildup are real. The detectors are inexpensive and give an early warning if they are placed where the leaks would occur.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 98.

EC-C401.2-21

Proponents: Ben Rabe (ben@newbuildings.org); Diana Burk (diana@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

ALL-ELECTRIC BUILDING.. A *building* that contains no *combustion equipment* , or plumbing for *combustion equipment*, installed within the *building*, or *building site.*

APPLIANCE.. A device or apparatus that is manufactured and designed to utilize energy and for which this code provides specific requirements.

COMBUSTION EQUIPMENT. . Any*equipment* or *appliance* used for space heating, *service water heating* , cooking, clothes drying, or lighting that uses *fuel gas* or *fuel oil* .

COMMERCIAL COOKING APPLIANCE. Appliances used in a commercial food service establishment for heating or cooking food and which produce grease vapors, steam, fumes, smoke or odors that are required to be removed through a local exhaust ventilation system. Such appliances include deep fat fryers, upright broilers, griddles, broilers, steam-jacketed kettles, hot-top ranges, under-fired broilers (charbroilers), ovens, barbecues, rotisseries, and similar appliances. For the purpose of this definition, a food service establishment shall include any building or a portion thereof used for the preparation and serving of food.

EQUIPMENT. Piping, ducts, vents, control devices and other components of systems other than appliances that are permanently installed and integrated to provide control of environmental conditions for buildings. This definition shall also include other systems specifically regulated in this code.

Revise as follows:

C401.2 Application. Commercial buildings shall be *all-electric buildings* and shall comply with Section C401.2.1 or C401.2.2.

C404.8.1 Heaters. The electric power to all heaters shall be controlled by an on-off switch that is an integral part of the heater, mounted on the exterior of the heater, or external to and within 3 feet (914 mm) of the heater in a location with *ready access*. Operation of such switch shall not change the setting of the heater thermostat. Such switches shall be in addition to a circuit breaker for the power to the heater. Gas-fired heaters shall not be ~~equipped with continuously burning ignition pilots.~~ permitted.

C405.5.3 Gas lighting. Gas-fired lighting appliances shall not be permitted. ~~equipped with continuously burning pilot ignition systems . systems.~~

TABLE C406.1(1) ADDITIONAL ENERGY EFFICIENCY CREDITS FOR GROUP B OCCUPANCIES

SECTION	CLIMATE ZONE																
	0A & 1A	**0B & 1B**	**2A**	**2B**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5A**	**5B**	**5C**	**6A**	**6B**	**7**	**8**
C406.2.1: 5% heating efficiency improvement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	1	1	NA	1
C406.2.2: 5% cooling efficiency improvement	6	6	5	5	4	4	3	3	3	2	2	2	1	2	2	2	1
C406.2.3: 10% heating efficiency improvement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	1	1	2	2	NA	1
C406.2.4: 10% cooling efficiency improvement	11	12	10	9	7	7	6	5	6	4	4	5	3	4	3	3	3
C406.3: Reduced lighting power	9	8	9	9	9	9	10	8	9	9	7	8	8	6	7	7	6
C406.4: Enhanced digital lighting controls	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1
C406.5: On-site renewable energy	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
C406.6: Dedicated outdoor air	4	4	4	4	4	3	2	5	3	2	5	3	2	7	4	5	3
C406.7.2: Recovered or renewable water heating	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
~~C406.7.3: Efficient fossil fuel water heater~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~
C406.7.4: Heat pumpwater heater	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.8: Enhanced envelope performance	1	4	2	4	4	3	NA	7	4	5	10	7	6	11	10	14	16
C406.9: Reduced air infiltration	2	1	1	2	4	1	NA	8	2	3	11	4	1	15	8	11	6
C406.10: Energy monitoring	4	4	4	4	3	3	3	3	3	3	2	3	2	2	2	2	2
C406.11: Fault detection and diagnostics system	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1

NA = Not Applicable.

TABLE C406.1(2) ADDITIONAL ENERGY EFFICIENCY CREDITS FOR GROUP R AND I OCCUPANCIES

SECTION	CLIMATE ZONE																
	0A & 1A	0B & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% heating efficiency improvement	NA	NA	NA	NA	1	NA	NA	1	NA	1	1	1	1	2	1	2	2
C406.2.2: 5% cooling efficiency improvement	3	3	2	2	1	1	1	1	1	NA	1	1	NA	1	1	1	NA
C406.2.3: 10% heating efficiency improvement	NA	NA	NA	NA	1	NA	NA	1	1	1	2	2	1	3	2	3	4
C406.2.4: 10% cooling efficiency improvement	5	5	4	3	2	3	1	2	2	1	1	1	1	1	1	1	1
C406.3: Reduced lighting power	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
C406.4: Enhanced digital lighting controls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.5: On-site renewable energy	8	8	8	8	7	8	8	7	7	7	7	7	7	7	7	7	7
C406.6: Dedicated outdoor air system	3	4	3	3	4	2	NA	6	3	4	8	5	5	10	7	11	12
C406.7.2: Recovered or renewable water heating	10	9	11	10	13	12	15	14	14	15	14	14	16	14	15	15	15
~~C406.7.3: Efficient fossil fuel water heater~~	~~5~~	~~5~~	~~6~~	~~6~~	~~8~~	~~7~~	~~8~~	~~8~~	~~8~~	~~9~~	~~9~~	~~9~~	~~10~~	~~10~~	~~9~~	~~10~~	~~11~~
C406.7.4: Heat pump water heater	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C406.8: Enhanced envelope performance	3	6	3	5	4	4	1	4	3	3	4	5	3	5	4	6	6
C406.9: Reduced air infiltration	6	5	3	11	6	4	NA	7	3	3	9	5	1	13	6	8	3
C406.10: Energy monitoring	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C406.11: Fault detection and diagnostics system	1	1	1	1	1	1	NA	1	1	NA	1	1	NA	1	1	1	1

NA = Not Applicable.

TABLE C406.1(3) ADDITIONAL ENERGY EFFICIENCY CREDITS FOR GROUP E OCCUPANCIES

SECTION	CLIMATE ZONE															
	0A & 1A	0B & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% heating efficiency improvement	NA	NA	NA	NA	1	1	1	1	1	2	1	2	1	2	2	3	4
C406.2.2: 5% cooling efficiency improvement	4	4	3	3	2	2	2	2	1	1	1	1	NA	1	1	1	NA
C406.2.3: 10% heating efficiency improvement	NA	NA	NA	1	1	1	1	2	3	4	3	4	3	4	3	5	7
C406.2.4: 10% cooling efficiency improvement	7	8	7	6	5	4	3	4	3	1	2	2	1	2	2	2	1
C406.3: Reduced lighting power	8	8	8	9	8	9	9	8	9	9	8	9	8	7	8	7	7
C406.4: Enhanced digital lighting controls	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
C406.5: On-site renewable energy	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5
C406.6: Dedicatedoutdoor air system	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.7.2: Recoveredor renewable water heating[a]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
~~C406.7.3: Efficient fossil fuel water heater[a]~~	~~NA~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~1~~	~~2~~	~~2~~	~~3~~	~~2~~	~~3~~	~~2~~	~~3~~	~~3~~	~~3~~	~~5~~
C406.7.4: Heat pump water heater[a]	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	1	1	NA	1	1	1	1
C406.8: Enhanced envelope performance	3	7	3	4	2	4	1	1	3	1	2	3	NA	4	3	6	9
C406.9: Reduced air infiltration	1	1	1	2	NA	NA	NA	NA	NA	NA	1	NA	NA	4	1	4	3
C406.10: Energy monitoring	3	3	3	3	3	3	3	3	3	2	2	3	2	2	2	2	2
C406.11: Fault detection and diagnostics system	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2

NA = Not Applicable.

a. For schools with showers or full-service kitchens.

TABLE C406.1(4) ADDITIONAL ENERGY EFFICIENCY CREDITS FOR GROUP M OCCUPANCIES

SECTION	CLIMATE ZONE																
	0A & 1A	0B & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% heating efficiency improvement	NA	NA	NA	NA	1	1	NA	1	1	2	2	2	2	3	2	3	4
C406.2.2: 5% cooling efficiency improvement	5	6	4	4	3	3	1	2	2	1	1	2	NA	1	1	1	NA
C406.2.3: 10% heating efficiency improvement	NA	NA	NA	1	1	1	1	2	2	4	3	4	5	5	3	6	8
C406.2.4: 10% cooling efficiency improvement	9	12	9	8	6	6	3	4	4		2	3	NA	2	2	2	1
C406.3: Reduced lighting power	13	13	15	14	16	14	17	15	15	14	12	14	14	16	16	14	12
C406.4: Enhanced digital lighting controls	3	3	4	3	4	3	4	4	4	3	3	3	3	4	4	3	3
C406.5: On-site renewable energy	8	8	8	8	8	8	8	8	8	7	7	7	7	7	7	7	6
C406.6: Dedicated outdoor air system	3	4	3	3	3	3	1	3	2	2	2	3	2	4	3	4	4
C406.7.2: Recovered or renewable water heating	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
~~C406.7.3: Efficient fossil fuel water heater~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~	~~NA~~
C406.7.4: Heat pump water heater	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C406.8: Enhanced envelope performance	4	6	3	4	3	3	1	6	4	4	4	5	4	6	5	8	9
C406.9: Reduced air infiltration	1	1	1	2	1	1	NA	3	1	1	3	2	1	7	3	6	3
C406.10: Energy monitoring	4	5	5	5	5	4	4	4	4	3	3	4	3	4	4	4	3
C406.11: Fault detection and diagnostics system	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	2	2

NA = Not Applicable.

TABLE C406.1(5) ADDITIONAL ENERGY EFFICIENCY CREDITS FOR OTHER[a] OCCUPANCIES

SECTION	CLIMATE ZONE																
	0A & 1A	0B & 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
C406.2.1: 5% heating efficiency improvement	NA	NA	NA	NA	1	1	1	1	1	2	1	2	1	2	2	3	3
C406.2.2: 5% cooling efficiency improvement	5	5	4	4	3	3	2	2	2	1	1	2	1	1	1	1	1
C406.2.3: 10% heating efficiency improvement	NA	NA	NA	1	1	1	1	2	2	3	3	3	3	4	3	5	5
C406.2.4: 10% cooling efficiency improvement	8	9	8	7	5	5	3	4	4	2	2	3	2	2	2	2	2
C406.3: Reduced lighting power	8	8	9	9	9	9	10	8	9	9	7	8	8	8	8	8	7
C406.4: Enhanced digital lighting controls	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	1
C406.5: On-site renewable energy	8	8	8	8	8	8	8	8	8	7	7	7	7	7	7	7	7
C406.6: Dedicated outdoor air system	3	4	3	3	4	3	2	5	3	3	5	4	3	7	5	7	6
C406.7.2: Recovered or renewable water heating [b]	10	9	11	10	13	12	15	14	14	15	14	14	16	14	15	15	15
~~C406.7.3: Efficient fossil fuel water heater [b]~~	~~5~~	~~5~~	~~6~~	~~6~~	~~8~~	~~7~~	~~8~~	~~8~~	~~8~~	~~9~~	~~9~~	~~9~~	~~10~~	~~10~~	~~9~~	~~10~~	~~11~~
C406.7.4: Heat pump water heater [b]	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
C406.8: Enhanced envelope performance	3	6	3	4	3	4	1	5	4	3	5	5	4	7	6	9	10
C406.9: Reduced air infiltration	3	2	2	4	4	2	NA	6	2	2	6	4	1	10	5	7	4
C406.10: Energy monitoring	3	3	3	3	3	3	3	3	3	3	2	3	2	2	2	3	2
C406.11: Fault detection and diagnostics system	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1

NA = Not Applicable.

a. Other occupancy groups include all groups except Groups B, E, I, M and R.

b. For occupancy groups listed in Section C406.7.1.

Delete without substitution:

~~**C406.7.3 Efficient fossil fuel water heater.** The combined input-capacity weighted-average equipment rating of all fossil fuel water-heating equipment in the building shall be not less than 95 percent Et or 0.95 EF. This option shall receive only half the listed credits for buildings required to comply with Section C404.2.1.~~

Reason Statement: In order to meet the state's 2045 carbon neutrality goal, Virginia must not only reduce energy use through energy efficiency and move to utility scale and on-site renewable energy, but also begin to transition away from using combustion equipment in buildings that runs on fossil fuels to electric equipment.
In 2020, combustion equipment in commercial and residential buildings accounted for 36% of the United States energy-related greenhouse gas emissions. To meet Virginia's goal, it is crucial that new buildings built today are all-electric so that emissions from these buildings are not "locked-in" by gas-dependent building infrastructure. Reduced carbon emissions was also recently cited as a priority of energy code development by the ICC in their Leading the Way to Energy Efficiency: A Path Forward on Energy and Sustainability to Confront a Changing Climate in 2021.

This proposed code amendment seeks to address the carbon impact of commercial buildings by requiring all new commercial buildings to be all-electric in Section C401.2. The amendment removes vestigial language that relates to fossil fuel systems related to pool heaters and lighting and clarifies that low-energy buildings must also be all-electric. To clarify the definition of all-electric and combustion equipment, the definition for appliance, equipment, fuel gas, and fuel oil are mirrored from 2021 IMC to be useful in defining combustion equipment.

Requiring all-electric construction as described above will result in new construction that is less expensive to construct than a building constructed with gas appliances and in the long term will result in fewer retrofit costs for building owners to meet future policy goals to eliminate all carbon emissions in the U.S. by 2050. All-electric construction will also result in lower utility costs if high efficiency heat pump technology is used. An Ecotope study of the 2017 Oregon Residential code found that homes heated by electric heat pumps use 40 percent less energy than homes heated with gas (including water heating). Even accounting for reduced efficiency in extreme cold weather, according to a study by RMI, modern air source heat pumps are more than twice as efficient as gas furnaces and can save families up to 9 percent on their utility bills in Climate Zone 6. This is one reason why the U.S. EPA just announced that standards for the most efficient appliances in 2022 certified under the ENERGY STAR program will be all-electric.

All-electric buildings are also healthier. Gas appliances release harmful pollutants like nitrogen dioxide (NO2) and carbon monoxide (CO) either indoors because of gas stoves or outdoors because of space-heating and water heating equipment. A recent study from the Harvard Chang School of Public Health and RMI shows that in 2017, air pollution from burning fuels in buildings led to an estimated 48,000 to 64,000 early deaths and $615 billion in health impact costs. These emissions can particularly affect children. In a meta-analysis analyzing the connections between gas stoves and childhood asthma, children in homes with gas stoves were 42% more likely to experience asthma symptoms, and 32% more likely to being diagnosed with asthma.

Therefore, constructing all-electric buildings is critical to reducing air pollution, protecting public health, reducing utility and construction costs, and meeting climate goals. NBI is submitting this amendment along with amendments that address on-site renewables, electric vehicles, and grid integration techniques. These proposed changes to the 2021 IECC, working together, will put the U.S. on the path to a decarbonized, resilient, and healthier future.

Cost Impact: The code change proposal will decrease the cost of construction
All-electric commercial buildings are less expensive to build than mixed fuel buildings because electric appliances and equipment are typically less expensive than combustion equipment and appliances. In additional developers avoid the cost of installing natural-gas lines and meters. Recent analysis by NBI and partners utilizing data from RS Means indicates that an all-electric 53,000 s.f. office building with a central heat pump water heater and minimum code compliant air source heat pump costs $0.09/s.f. less to build than a mixed-fuel office building of the same size. Additional analyses from a recent CASE study indicate that all-electric high-rise multifamily buildings are also less expensive to build and operate than mixed-fuel buildings. HVAC costs, for example, are on the order of $2,504 to $7,131 lower per dwelling unit depending on the HVAC system installed. Installing electric space heating and water heating equipment instead of natural gas equipment in the majority of California's climate zones also yielded a positive benefit to cost ratio over the 15- year analysis period despite California's high electricity rates.

Another study by ACEEE indicates that assuming energy-efficient construction, electrification incentives, and carbon pricing, space heating in 60% of the existing commercial building stock in the U.S. can be cost effectively retrofitted to electric space-heating with a simple payback of less than 10 years. The percentage of spaces where space-heating is cost effective across the country in new construction is likely higher because no retrofit costs are incurred in new construction and because new construction is already mandated to be energy efficient.

Finally, ensuring commercial buildings are all-electric now will guarantee that those buildings will not have to be retrofitted to be all-electric in the future to meet the nation's goal to be net-zero carbon emissions by 2050.

Resiliency Impact Statement: This proposal will increase Resiliency
As the grid becomes increasingly cleaner, all electric buildings will become less carbon intense as they age, unlike buildings with fossil fuel combustion, lessening their impact on climate change. Although these buildings will require more total electricity from the grid than their fossil fuel burning counterparts, they will be able to operate entirely on clean renewable energy.

All-electric buildings additionally support better indoor air quality. Better indoor air quality is directly linked to better health of occupants, including reduction of respiratory and chronic illnesses. The reductions of these types of illnesses increase overall resilience of individuals within our communities, making them less susceptible to the impacts of extreme heat and cold, reducing medical bills, and improving overall quality of life.

Finally, these buildings will also be less dependent on the geopolitics of the fossil fuel market, leveling out energy costs during periods of disruption.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: EC-C401.2-21

This proposal doesn't have any public comments.

Proposal # 1045

EC-C401.2-21 – Staff Summary

Proponent: Ben Rabe (New Buildings Institute)

Brief Description:

The proposal requires all new commercial buildings to be all-electric by eliminating combustion equipment that uses fossil fuels.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March, 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman (Sierra Club)
    - It will save residents money, it will reduce pollution, it's a critical measure for climate change, and will create a healthier house without the fumes from burning fossil fuels.
    - Believes it's in the state energy policy to get to zero net carbon emissions, not just for the electric utilities who are supposed to hit it by 2045. The reality is, to combat climate change, we've got to stop burning fossil fuels. Sea-level rise on the cost of Virginia is projected to rise 2ft by 2050 and that should scare all of us. Natural gas may be clean, but burning it leaks methane.

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Home Builders Association of Virginia)
    - Questioned if this conflicts with bills recently passed that included natural gas as an important component of reaching net zero? He thinks that one of those bills even said that natural gas could not be prohibited.
- Maggie Kelley Riggins (Southeast Energy Efficiency Alliance)
- Brian Clark (Habitat for Humanity)
- Steve Shapiro (AOBA/VAMA)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- K.C. Bleile: Viridiant
- Laura Baker (alternate for Eric Lacey): Responsible Energy Codes Alliance

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter. Note: partial attendance. Not in attendance during EC-C401.2-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy

- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. Note: partial attendance. Not in attendance during EC-C401.2-21 discussion and voting.
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Corey Caney: International Association of Electrical Inspectors, Virginia

Other stakeholders in attendance and opposing the proposal:

- Michael O'Connor (VPCGA and Virginia Propane Gas Association)
- John Ainslie

Other stakeholders in attendance and supporting the proposal:

- Ross Shearer

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman (Sierra Club – Virginia Chapter)

- William Penniman (Sierra Club – Virginia Chapter)
    - Supports the proposal, as it needs to happen as a matter of climate change mitigation and preparedness.

Opposition:

Names: Andrew Clark (Home Builders Association of Virginia); Steve Shapiro (AOBA/VAMA); and, Michael O'Connor (VPCGA and Virginia Propane Gas Association)

- Andrew Clark: This proposal is related to prohibiting natural gas in commercial buildings. We are opposed due to the comments already raised in the Sub-workgroup.
- Steve Shapiro: AOBA and VAMA also opposed, as noted in the Sub-workgroup.
- Michael O'Connor: Petroleum Marketers and Propane Gas Association
    - Opposed to this. Virginia small businesses provide oil heat and propane. There is no provision in this proposal to retrain workers in the petroleum and propane industries after they are forced out of business due to a proposal such as this. Also, the payback time on a heat pump is about 25 years. The only people who can afford to do this are the regulated utilities, who are using their rate-payer subsidized income to perform these conversions.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 38; Tab 11 - Page 21.

EC-C403.3-21

Proponents: Ben Rabe (ben@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org); Diana Burk (diana@newbuildings.org)

2021 International Energy Conservation Code

Revise as follows:

C403.3 ~~Heating and cooling equipment efficiencies~~ Equipment selection. Heating and cooling equipment installed in mechanical systems shall be sized in accordance with Section C403.3.1 and shall be not less efficient in the use of energy than as specified in Section C403.3.2.

Add new text as follows:

C403.3.5 Dedicated outdoor air systems (DOAS).
Outdoor air shall be provided to each occupied space by a dedicated outdoor air system (DOAS), as required by Table C403.3.5, which delivers 100 percent outdoor air without requiring operation of the heating and cooling system fans for ventilation air delivery, as required by Table C403.3.5. For DOAS having a total fan system motor nameplate hp less than 5 hp, total combined fan power shall not exceed 1 W/cfm of outdoor air. Total fan power limits of Section C403.8.1 shall apply to each outdoor air unit of the DOAS and shall not include the fan power associated with the zonal heating and cooling equipment.
Exceptions:

1. Use groups listed as exempted in Table C403.3.5
1. Occupied spaces that are solely ventilated by a natural ventilation system in accordance with Section 402 of the International Mechanical Code;
1. Buildings where the cooling and heating equipment exceeds the minimum efficiency requirements listed in the tables in Section C403.3.2 by 10 percent. Where multiple cooling performance requirements are provided, the equipment shall exceed the rating requirement, including IEER, SEER and IPLV as applicable. This exception shall not be used as a substitution for the more efficient HVAC equipment credit option per C406.2.

Table C403.3.5
Occupancy Classifications Requiring DOAS

OCCUPANCY CLASSIFICATIONs	COVERED USE GROUPS	EXEMPTED USE GROUPS
A-1	All occupancies	Television and radio studios
A-2	Casinos (gaming area)	All other use groups
A-3	Lecture halls, community halls, exhibition halls, gymnasiums, courtrooms, libraries, places of religious worship	All other use groups
A-4, A-5		All use groups
B	All use groups not specifically exempted	Food processing establishments including commercial kitchens, restaurants, cafeterias; laboratories for testing and research; data processing facilities and telephone exchanges; air traffic control towers; animal hospitals, kennels, pounds; ambulatory care facilities.
F, H, I, R, S, U		All use groups
E, M	All use groups	

C403.3.5.1 Heating/cooling system fan controls. Heating and cooling equipment fans, heating and cooling circulation pumps, and terminal unit fans shall cycle off and terminal unit primary cooling air shall be shut off when there is no call for heating or cooling in the zone.
Exception:
Fans used for heating and cooling using less than 0.12 watts per cfm may operate when space temperatures are within the set point dead band to provide destratification and air mixing in the space.
C403.3.5.2 Decoupled DOAS supply air. The DOAS supply air shall be delivered directly to the occupied space or downstream of the terminal heating and/or cooling units.
Exceptions:

1. Active chilled beam systems.
1. Sensible only cooling terminal units with pressure independent variable airflow regulating devices limiting the DOAS supply air to the greater of latent load or minimum ventilation requirements.
1. Terminal heating and/or cooling units that comply with the low fan power allowance requirements in the exception of Section C403.3.5.1.

Revise as follows:

C403.7.4 Energy recovery systems. Energy recovery ventilation systems shall be provided as specified in Section C403.7.4.3 and either Section

C403.7.4.1 or C403.7.4.2, as applicable.~~ in~~

Add new text as follows:

C403.7.4.3 Spaces with Dedicated Outdoor Air Systems (DOAS).
Dedicated outdoor air systems (DOAS) shall include energy recovery ventilation in call cases and shall be in accordance with either Section C403.7.4.1 or C403.7.4.2, as applicable.
Exception: Systems installed for the sole purpose of providing makeup air for systems exhausting toxic, flammable, paint, or corrosive fumes or dust, dryer exhaust, or commercial kitchen hoods used for collecting and removing grease vapors and smoke.

Revise as follows:

C406.1 Additional energy efficiency credit requirements. New buildings shall achieve a total of 10 credits from Tables C406.1(1) through C406.1(5) where the table is selected based on the use group of the building and from credit calculations as specified in relevant subsections of Section C406. Where a building contains multiple-use groups, credits from each use group shall be weighted by floor area of each group to determine the weighted average building credit. Credits from the tables or calculation shall be achieved where a building complies with one or more of the following:

1. More efficient HVAC performance in accordance with Section C406.2.
2. Reduced lighting power in accordance with Section C406.3.
3. Enhanced lighting controls in accordance with Section C406.4.
4. On-site supply of renewable energy in accordance with Section C406.5.
5. Where not required by Section 403.3.5, ~~Provision~~ provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.
6. High-efficiency service water heating in accordance with Section C406.7.
7. Enhanced envelope performance in accordance with Section C406.8.
8. Reduced air infiltration in accordance with Section C406.9
9. Where not required by Section C405.12, include an energy monitoring system in accordance with Section C406.10.
10. Where not required by Section C403.2.3, include a fault detection and diagnostics (FDD) system in accordance with Section C406.11.
11. Efficient kitchen equipment in accordance with Section C406.12.

Reason Statement: The majority of commercial HVAC systems are based around a central air handling delivery system. This system typically provides heating, cooling and ventilation air from a single source. Since cooling is typically the largest instantaneous load, the fans must be sized large enough to deliver enough air to meet the peak cooling requirements. When the ventilation is integrated, these large fans must operate during all occupied hours to deliver ventilation effectively to the space. This leads to very high fan energy use. With ventilation separated from the heating and cooling delivery, the large heating/cooling fans can be shut off unless there is a call for heating or cooling and the much smaller ventilation-only fans can operate to deliver fresh air to the space. Furthermore, when the ventilation air is delivered using either Energy Recovery Ventilation (ERV) the heating energy requirements associated with tempering the ventilation air are significantly reduced or eliminated. Compliance with this proposed code amendments requires the following in buildings where the cooling or heating system is not 10 percent more efficient than code requirements.
a. 100% ventilation air delivered directly to each zone separate from the heating/cooling system.

b. Ventilation air delivered using an ERV

c. Run heating and cooling equipment (fans and pumps) only when there is a call for conditioning in the zone.

Note that designs based around a DOAS is not new and it has long been established that this design direction leads to more energy efficient buildings. The General Services Administration required DOAS as the baseline design for all new GSA buildings unless otherwise directed by design programming in 1998. The specifications require perimeter and interior systems have 100 percent outside air ventilation systems which are completely independent of any other air distribution system. Enthalpy heat recovery must be included if the outside air required or equipment capacity exceeds a stated amount.

This proposed code change is similar to the requirements currently adopted in the Washington State Energy Code which requires buildings of only certain occupancy types to have a DOAS system. A DOAS would be required in buildings whose occupancy is intended for Mercantile (Group M), and Educational (Group E). A DOAS would also be required in most Business's (Group B) except those exempted, certain Assembly occupancies (Group A) for performing arts or motion pictures (except for television and radio studios), casinos, and lecture halls, community halls, exhibition halls, gymnasiums, courtrooms, libraries, and places of religious worship. A DOAS would not be required in buildings where the cooling or heating system is 10 percent more efficient than code requirements.

A DOAS would also not be required in the building for occupancies for Residential (Group R), Factory and Industrial (Group F), High Hazard (Group

H), Institutional (Group I), Storage (Group S), and Utility and Miscellaneous (Group U).

Cost Impact: The code change proposal will increase the cost of construction
On average the incremental cost of adding a DOAS for several building prototypes (small, medium and large office, retail, and schools) was found to be $880 per thousand square foot. The increased cost of requiring DOAS systems is more than offset by operating cost savings. When compared to a code-minimum system upgrade, very high efficiency DOAS can reduce commercial building energy use by an average of 9% to 17% depending on the type of DOAS system used in Climate Zone 4A. In California, installing a DOAS was found to save on average $4-$5 in operating costs for every additional dollar spent to install a DOAS in a building. Buildings with DOAS systems not only save energy but also exhibit improved indoor air quality which is especially important in businesses and schools.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. As we see increasing number of severe weather events, the electric grid's ability to withstand these events will become increasingly important. Dedicated Outdoor Air Systems will increase overall energy efficiency of space conditioning, therefore reducing strain on the electric grid would. As peak demand typically coincides with periods of high usage in the buildings sector, this would increase the resiliency of the grid.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: EC-C403.3-21

This proposal doesn't have any public comments.

Proposal # 1042

EC-C403.3-21 – Staff Summary

Proponent: Ben Rabe (New Buildings Institute)

Brief Description:

Requires dedicated outdoor air systems based on occupancy classifications. These systems would deliver 100% outdoor air without requiring operation of the heating and cooling system fans for ventilation air delivery.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was heard by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman (Sierra Club)
- Laura Baker (RECA)
- KC Bleile (Viridiant)
- Maggie Kelly Riggins (SEEA)
- Brian Clark (Habitat for Humanity)

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (HBAV)
- Steve Shapiro (AOBA/VAMA) *Note:* partial attendance only. Not in attendance at the time of voting but expressed opposition to the proposal in the Adobe Platform chat box prior to exiting the meeting room.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note:* partial attendance. Not in attendance during EC-C403.3-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during EC-C403.3-21 discussion and voting.
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Corey Caney: International Association of Electrical Inspectors, Virginia

Other stakeholders in attendance and supporting the proposal:

- Ross Shearer

  - Covid has taught us the importance of fresh air in commercial spaces when occupied. EC C403.3-21 would provide an important remedy for this feature. CO_2 sensors can provide the needed proxy, but good quality current designs do not normally monitor for CO_2 levels except when there is a call for heating or cooling. This proposal should be supported.

Other stakeholders in attendance and opposing the proposal:

- John Ainslie

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman (Sierra Club – Virginia Chapter)

Opposition:

Names: Steve Shapiro (AOBA/VAMA)

DHCD Staff Notes:

- The Energy Sub-Workgroup members did not provide any reasons for supporting or opposing the proposal.
- No specific reasons were offered by stakeholders for supporting or opposing the proposal during the General Stakeholders Workgroup meeting.

Meeting summaries and proposal related information: Tab 10 - Page 38; Tab 11 - Page 21.

EC-C403.4.1.6-21

Proponents: Ben Rabe (ben@newbuildings.org); Diana Burk (diana@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

DEMAND RESPONSE SIGNAL. A signal that indicates a price or a request to modify electricity consumption for a limited time period.

DEMAND RESPONSIVE CONTROL. A control capable of receiving and automatically responding to a demand response signal.

C403.4.1.6 Demand responsive controls. All thermostatic controls shall be provided with *demand responsive controls* capable of the following:

1. Automatically increasing the zone operating cooling set point by a minimum of 4°F (2.2°C)

2. Automatically decreasing the zone operating heating set point by a minimum of 4°F (2.2°C)

3. Automatically decreasing the zone operating cooling set point by a minimum of 2°F (1.1°C)

4. Automatically increasing the zone operation heating set point by a minimum of 2°F (1.1°C)

5. Both ramp-up and ramp-down logic to prevent the building peak demand from exceeding that expected without the DR implementation.

The thermostatic controls shall be capable of performing all other functions provided by the control when the *demand responsive controls* are not available. Systems with direct digital control of individual zones reporting to a central control panel shall be capable of remotely complying.

Exception: Health care and assisted living facilities.

Reason Statement: This proposal requires that thermostats in commercial buildings have demand control functionality that can be used to adjust thermostat set-points. Since this requirement is part of the construction code, it will not require buildings to participate in any demand response programs. But it will ensure that buildings are capable of participating, so that Virginia buildings will be able to help integrate building loads with available production.
Grid flexibility is one of the foundations of achieving meaningful decarbonization of building energy as it is an essential element of decarbonizing the electrical grid. Carbon free energy sources like solar and wind have varying production over the course of the day and the year. Demand responsive controls that can respond to demand response signals enable buildings to shape their loads to better align with available energy production. This could come in the form of curtailing energy use when demand is high or utilizing excess production for building tasks like pre-conditioning spaces or service hot water when demand is lower.

The ability to adjust by 4 degrees was chosen based on demand flexibility requirements in California's energy code Title 24 Part 6. This will align the requirements with the biggest American market – which is also a neighboring market – for demand responsive thermostats. The proposal includes an exemption for thermostats serving health care and assisted living facilities as these are occupancies where climate control can be related to health care.

Cost Impact: The code change proposal will increase the cost of construction
Demand responsive functionality will present a cost-saving opportunity for buildings in the future. More and more utilities are moving beyond voluntary programs and are expanding use of time-of-use rates for electricity as a tool for shaping demand. Installing demand-responsive thermostats now will allow building tenants and owners to better control their utility costs.

Demand responsive functionality has been required in Title24 since the 2013 edition and was found cost effective in CA. In the 8 years since, equipment prices have decreased (less than $60 for a basic DR thermostat7 compared to just under $30 for a basic 7-day programmable thermostat8) and WA peak prices have increased.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. As we see increasing number of severe weather events, the electric grid's ability to withstand these events will become increasingly important. Demand controlled thermostats will help integrate building loads with available production, lowering energy demand. Therefore, this proposal increase resiliency by reducing overall demand on the grid.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- ☐ Approved
- ☐ Approved with Modifications
- ☐ Carryover
- ☐ Disapproved
- ☐ None

Public Comments for: EC-C403.4.1.6-21

This proposal doesn't have any public comments.

Proposal # 1037

EC-C403.4.1.6– Staff Summary

Proponent: Ben Rabe, Diana Burk and Kimberly Newcomer (New Buildings Institute).

Brief Description:

The proposal requires that thermostats in commercial buildings have demand control functionality that can be used to adjust thermostat set-points. Since this requirement is part of the construction code, it will not require buildings to participate in any demand response programs. But it will ensure that buildings are capable of participating.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was heard by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March, 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman (Sierra Club – Virginia Chapter)
- KC Bleile (Viridiant)
- Laura Baker (RECA)

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (HBAV)
- Brian Clark (Habitat for Humanity)
- Maggie Kelley Riggins (SEEA)
- Steve Shapiro (AOBA/VAMA) Note: partial attendance only. Not in attendance at the time of voting but expressed opposition to the proposal in the Adobe Platform chat box prior to exiting the meeting room.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter*. Note:* partial attendance. Not in attendance during EC-C403.4.1.6-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during EC-C403.4.1.6-21 discussion and voting.
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Corey Caney: International Association of Electrical Inspectors, Virginia

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club – Virginia Chapter

- William Penniman (Sierra Club – Virginia Chapter), expressed support because this puts technology in place for a critical measure to manage electric grids while keeping people comfortable. The utility or third party would allow customers to opt in, giving control of the short term fluctuation in energy flows, thereby smoothing out peaks to reduce costs. The consumer is usually paid to opt in. It is growing in availability around the country and in Virginia.

Opposition:

Names: Steve Shapiro (AOBA/VAMA); Michael O'Connor (Petroleum and Propane Associations)

- Steve Shapiro (AOBA/VAMA), pointed out that the proposal based the 4 degrees criteria on the California energy code.
- Michael O'Connor (Petroleum and Propane Associations), asked who makes the decisions for large groups of buildings?
    - Proponent responded – The utility or third party provider would, but this provides the technology for the owner to opt in.

DHCD Staff Notes:

The Energy Sub-Workgroup members did not provide any reasons for supporting or opposing the proposal.

Meeting summaries and proposal related information: Tab 10 - Page 39; Tab 11 - Page 22.

EC-C403.15-21

Proponents: Ben Rabe (ben@newbuildings.org); Diana Burk (diana@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

DESSICANT DEHUMIDIFICATION SYSTEM. A mechanical dehumidification technology that uses a solid or liquid material to remove moisture from the air.

INTEGRATED HVAC SYSTEM. An HVAC system designed to handle both sensible and latent heat removal. Integrated HVAC systems may include, but are not limited to HVAC systems with a sensible heat ratio of 0.65 or less and the capability of providing cooling, dedicated outdoor air systems, single package air conditioners with at least one refrigerant circuit providing hot gas reheat, and dehumidifiers modified to allow external heat rejection.

DEHUMIDIFIER. A self-contained, electrically operated, and mechanically encased product with the sole purpose of dehumidifying the space consisting of 1) a refrigerated surface (evaporator) that condenses moisture from the atmosphere, 2) a refrigerating system, including an electric motor, 3) an air-circulating fan, and 4) a means for collecting or disposing of the condensate. A dehumidifier does not include a portable air conditioner, room air conditioner, or packaged terminal air conditioner.

C403.15 Dehumidification in spaces for plant growth and maintenance. Equipment that dehumidifies building spaces used for plant growth and maintenance shall comply with one of the following:

1. *Dehumidifiers* regulated under federal law in accordance with DOE 10 CFR 430 and tested in accordance with the test procedure listed in DOE 10 CFR 430 and DOE 10 CFR 430, Subpart B, Appendix X or X1 as applicable.

2. *Integrated HVAC system* with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat;

3. Chilled water system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat; or

4.Solid or liquid *desiccant dehumidification system* for system designs that require dewpoint of 50°F or less.

Revise as follows:

DOE

US Department of Energy
c/o Superintendent of Documents 1000 Independence Avenue SW
Washington, DC 20585

10 CFR, Part 430—2015 Energy Conservation Program for Consumer Products: Test Procedures and Certification and Enforcement Requirement for Plumbing Products; and Certification and Enforcement Requirements for Residential Appliances; Final Rule
Table C403.15

Reason Statement: Indoor agriculture energy usage is projected to grow significantly nationwide in this decade, driven in large part by state legalization of medical and recreational marijuana across the country. In 2017, a total of 20 million square feet of building space was dedicated to growing crops indoors. Since Virginia legalized recreational marijuana on July 1, 2021, this industry will also experience sharp growth in Virginia.

Energy use by HVAC systems in indoor horticulture facilities can account for 30 to 65% of energy use - primarily because these systems must maintain specific humidity and temperature levels to promote plant growth. Section 403 already requires HVAC systems meet a certain efficiency threshold but does not address the efficiency of dehumidification systems. The proposed language provides projects with a range of efficient dehumidification strategies. Indoor grow facilities can install dehumidifiers that meet federal minimum efficiency requirements. The proposal also provides options for solid or liquid desiccant dehumidification systems, for utilizing recovered energy in integrated HVAC systems, and for chilled water systems that can meet dehumidification reheat needs.
The incremental cost of installing more efficient dehumidification systems is around $8.11 per square foot of canopy. This measure results in significant energy savings of between 212 to 255 TDV kBtu/yr per square foot of canopy in Climate Zones 2-4. Every dollar spent to install more efficient equipment resulted in between $2.33 and $2.80 in operating and maintenance cost savings over the life of the system.

This proposal is based largely on the requirements listed in Section 120.6(h)1 of Title 24-2022 and is similar to requirements adopted in Denver, CO and being considered for adoption in Washington State, Michigan, and Illinois.

Cost Impact:
The incremental cost of installing more efficient dehumidification systems is around $8.11 per square foot of canopy. This measure results in significant energy savings of between 212 to 255 TDV kBtu/yr per square foot of canopy in Climate Zones 2-4. Every dollar spent to install more efficient equipment resulted in between $2.33 and $2.80 in operating and maintenance cost savings over the life of the system.

References:

Final CASE Report: Controlled Environment Horticulture, California Statewide Codes and Standards Enhancement (CASE) Program, Oct. 2020, https://title24stakeholders.com/wp-content/uploads/2020/10/2022-T24-NR-CEH-Final-CASE-Report.pdf.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. As we see increasing number of severe weather events, the electric grid's ability to withstand these events will become increasingly important. Indoor agricultural facilities place a huge demand on the local energy supply, rivaling that of data centers. The dehumidification proposal will significantly reduce energy demand of these facilities and therefore increase resiliency by reducing overall demand on the local grid where facilities are being added.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: EC-C403.15-21

This proposal doesn't have any public comments.

EC-C403.15– Staff Summary

Proponent: Ben Rabe (New Buildings Institute); Diana Burk (New Buildings Institute); Kimberly Newcomer (New Buildings Institute).

Brief Description:

The proposal sets efficiency requirements for dehumidification systems. Intended to address the growing indoor agriculture energy usage largely due to state legalization of medical and recreational marijuana.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman (Sierra Club – Virginia Chapter)
    - Marijuana growing operations are huge consumers of energy. He supports both proposals (EC-C403.15 and EC-C405.4-21) dealing with these operations.
- Brian Clark (Habitat for Humanity)
- Laura Baker (RECA, alternate for Eric Lacey)
- Maggie Kelley Riggins (SEEA)

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (HBAV)
- KC Bleile (Viridiant)
- Steve Shapiro (AOBA/VAMA) *Note:* partial attendance only. Not in attendance at the time of voting but expressed opposition to the proposal in the Adobe Platform chat box prior to exiting the meeting room.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note*: partial attendance. Not in attendance during EC-C403.15-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during EC-C403.15-21 discussion and voting.
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Corey Caney: International Association of Electrical Inspectors, Virginia

Other stakeholders in attendance and opposing the proposal:

- John Ainslie (HBAV Alternate)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club – Virginia Chapter

- William Penniman (Sierra Club – Virginia Chapter)
    - Stated this is a case where Virginia should learn from other states. Code changes should be done before the buildings are up and running.

Opposition:

Names: Andrew Clark (HBAV)

- Andrew Clark (HBAV)
    - Raised concerns about the lack of industry involvement and representation to discuss this proposal.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 39; Tab 11 - Page 23.

EC-C404.11-21

Proponents: Ben Rabe (ben@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

DEMAND RESPONSE SIGNAL. . A signal that indicates a price or a request to modify electricity consumption for a limited time period.

DEMAND RESPONSIVE CONTROL. A control capable of receiving and automatically responding to a demand response signal.

C404.11 Demand Responsive water heating. Electric storage water heaters with a rated water storage volume between 40 and 120 gallons and a nameplate input rating equal to or less than 12kW shall be provided with demand responsive controls that comply with Table C404.11
Exceptions:

1.Water heaters that provide a hot water delivery temperature of 180°F (82°C) or greater

2. Water heaters that comply with Section IV, Part HLW or Section X of theASME Boiler and Pressure Vessel Code

3. Water heaters that use 3-phase electric power

Table C404.11

Equipment Type	Rated Water Storage Volume	Controls	
		Before 7/1/2025	As of 7/1/2025
Electric Storage Water heaters	40-120 gallons	ANSI/CTA-2045-B Level 1 and also capable of initiating water heating to meet the temperature set point in response to a demand response signal.	ANSI/CTA-2045-B Level 2, except “Price Stream Communication” functionality as defined in the standard.

Revise as follows:

ASME

American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990

ANSI

American National Standards Institute
25 West 43rd Street, 4th Floor
New York, NY 10036

Reason Statement: Water heaters can provide significant load shifting and energy storage capacity in many building types. ANSI/CTA-2045 standardizes the socket, and communications protocol, for heat pump water heaters so they can communicate with the electricity grid other demand response signal providers. In addition, 2045 adds control and communications requirements for mixing valves in HPWH to enable them to provide

greater storage capacity to support increased load shifting. The addendum also creates a definition of demand responsive control to ensure its consistent use throughout the code. ANSI/CTA-2045 is the industry standard for demand responsive controls for water heaters, but the requirement allows for other protocols to be approved by the building official.
This proposal requires that water heaters with integrated storage tanks have this demand control functionality. The requirement is limited to electric water heaters with integrated storage tanks. It only applies to water heaters over 20 gallons in order to exclude small, point-of-use water heaters; these water heaters also only have very small capacity for demand response. Water heaters in health care facilities are also exempted since the hot water provided can be considered a part of health care. The requirement would also not apply to large water heating systems, as they generally have separate storage tanks. These water heaters subject to this requirement generally serve lavatories and kitchenettes in commercial buildings and some water heating approaches in mid-rise residential.   Grid flexibility is one of the foundations of achieving meaningful decarbonization of building energy as it is an essential element of decarbonizing the electrical grid. Carbon free energy sources like solar and wind have varying production over the course of the day and the year. Demand responsive controls that can respond to demand response signals enable buildings to shape their loads to better align with available energy production. This could come in the form of curtailing energy use when demand is high or utilizing excess production for building tasks like pre-conditioning spaces or service hot water when demand is lower. Demand control functionality will also present a cost-saving opportunity for buildings in the future.

More and more utilities are moving beyond voluntary programs and are expanding use of time-of-use rates for electricity as a tool for shaping demand. Installing demand-responsive lighting controls now will allow building tenants and owners to better control their utility costs. Since this requirement is part of the construction code, it will not require buildings to participate in any demand response programs. But it will ensure that buildings are capable of participating, so that VA buildings will be able to help integrate building loads with available production.

Cost Impact: The code change proposal will increase the cost of construction
Grid-integrated controls for water heaters which costs around $173 become cost effective when enrolled in a demand response program. Armada Power customers in Ohio who enrolled their water heaters in a demand response program saved $184 annually by enrolling in the program. If utilities nationwide instituted a similar program to shape demand, a customer could reap $12 in energy cost savings for every $1 spent on the additional controls

Resiliency Impact Statement: This proposal will increase Resiliency
Demand responsive controls allow for utilities to send and buildings to receive signals to ramp up or down set points based on a variety of conditions. This communication ability is a critical aspect of resilience for our communities.

Storage water heaters have a unique capability to act as thermal storage “batteries”. By allowing water heaters to receive a signal from the grid, water can be heated at a time when overall demand, price signals or carbon emissions are at their lowest. Pre-heating water in this way can help to lessen peak demands on the grid, creating grid resiliency, reduce costs for consumers, creating financial resiliency, and help absorb excess renewable generation, or at a minimum engage during the cleanest hours of generation, reducing carbon emissions and climate impact of water heating.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved

☐None

Public Comments for: EC-C404.11-21

This proposal doesn't have any public comments.

Proposal # 1038

EC-C404.11– Staff Summary

Proponent: Ben Rabe (New Buildings Institute); Diana Burk (New Buildings Institute); Kimberly Newcomer (New Buildings Institute).

Brief Description:

The proposal requires water heaters with integrated storage tanks to have demand control functionality.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman (Sierra Club – Virginia Chapter)

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (HBAV)
- KC Bleile (Viridiant)
- Brian Clark (Habitat for Humanity)
- Maggie Kelley Riggins (SEEA)
- Steve Shapiro (AOBA/VAMA) *Note:* partial attendance only. Not in attendance at the time of voting but expressed opposition to the proposal in the Adobe Platform chat box prior to exiting the meeting room.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- Laura Baker (RECA, alternate for Eric Lacey)

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note:* partial attendance. Not in attendance during EC-C404.11-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during EC-C404.11-21 discussion and voting.
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Corey Caney: International Association of Electrical Inspectors, Virginia

Other stakeholders in attendance and opposing the proposal:

- John Ainslie (HBAV Alternate)

- Michael O'Connor (Virginia Petroleum & Convenience Marketers Association and Virginia Propane Association)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club – Virginia Chapter

- William Penniman (Sierra Club – Virginia Chapter)
    - Supports as this would help the grid, and users are paid to participate.

Opposition:

Names: Andrew Clark (HBAV), no specific reasons provided.

DHCD Staff Notes:

The Energy Sub-Workgroup members did not provide any reasons for supporting or opposing the proposal.

Meeting summaries and proposal related information: Tab 10 - Page 39; Tab 11 - Page 23.

EC-C405.4-21

Proponents: Ben Rabe (ben@newbuildings.org); Diana Burk (diana@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org)

2021 International Energy Conservation Code

Revise as follows:

GREENHOUSE. A structure or a thermally isolated area of a building that maintains a specialized sunlit environment with a skylight roof ratio of 50% or more above the growing area exclusively used for, and essential to, the cultivation, protection or maintenance of plants.*Greenhouses* are those that are erected for a period of 180 days or more.

Add new text as follows:

HORTICULTURAL LIGHTING.
Electric lighting used for horticultural production, cultivation or maintenance.

PHOTOSYNTHETIC PHOTON EFFICACY (PPE). Photosynthetic photon flux emitted by a light source divided by its electrical input power in units of micromoles per second per watt, or micromoles per joule (µmol/J) between 400-700nm as defined by ANSI/ASABE S640.

Revise as follows:

C405.4 Lighting for plant growth and maintenance. ~~Not less than 95 percent of the permanently~~
Permanently installed luminaires used for plant growth and maintenance shall have a photosynthetic photon efficacy of not less than 1.7 µmol/J for horticultural lighting in greenhouses and not less than ~~1.6~~ 1.9 µmol/J for all other horticultural lighting. Luminaires for horticultural lighting in greenhouses shall be controlled by a device that automatically turns off the luminaire when sufficient daylight is available. Luminaires for horticultural lighting shall be controlled by a device that automatically turns off the luminaire at specific programmed times.

~~efficiency a as defined in accordance with ANSI/ASABE S640. efficiency a~~

Reason Statement: Indoor agriculture energy usage is projected to grow substantially nationwide over the next several years, driven in large part (but not entirely) by the legalization of medical and recreational marijuana across the country. This growth is going to occur rapidly in Virginia since Virginia legalized recreational marijuana on July 1, 2021. A total of 46 million square feet of grow area in the U.S. is lit by electric horticultural lighting, 58% of which was in supplemental greenhouses, 41% in non-stacked indoor farms, and 1% in vertical farms. Lighting in greenhouses operate on average 2,120 hours per year or 6 hours per day and lighting in non-stacked indoor operations were on 5,475 hours per year or 15 hours per day. Because of these long operating hours, lighting can account for 50 to 80% of a facilities energy use in indoor operations and 30% of energy use in greenhouses. Because sales of both recreational and medical marijuana are becoming legal across the country, it is critical to ensure these facilities are as efficient as possible. Because of the large opportunity for energy savings, the 2021 IECC has already adopted requirements for lighting in these applications using the efficiency metric of µmol/J (micromoles per Joule) which was developed in collaboration with the American Society of Agricultural and Biological Engineers to measure the efficacy of lighting used for plant growth. A double-ended High Pressure Sodium (HPS) luminaire can meet the existing 2021 IECC standard of 1.6 µmol/J. The proposed requirement increases the efficacy level required to 1.9 µmol/J. This new efficacy standard does not require a technology shift within indoor horticulture because slightly more efficient double-ended HPS lamps that meet the existing standard can also meet the proposed standard. Because a technology shift is not required, the additional energy savings from increasing the standard from 1.6 µmol/J to 1.9 µmol/J for indoor operations is very cost-effective. This proposed amendment also institutes a lower efficacy requirement of 1.7 µmol/J for greenhouses due to lower operating hours and thus longer payback periods in these applications. This amendment also introduces requirements for lighting controls that are able to turn off the luminaire at specific times during the day and a lighting control requirement for greenhouses to ensure lights are off when sufficient daylight is available. Finally, the amendment clarifies these requirements by introducing horticultural lighting and photosynthetic photon efficacy as new definitions and by amending the definition for greenhouse. These requirements are consistent with proposed Addendum ar-2019 recently released for public review to ASHRAE Standard 90.1 and with code requirements proposed for inclusion in Section 120.6(h)2 of California's Title 24-2022. The Technical Advisory Groups in Minnesota, Washington State, and Washington D.C. are also recommending these efficacy requirements as amendments to their local commercial energy codes. This proposal was also approved by the IECC Consensus Committee.
References:

Energy Savings Potential of SSL in Horticultural Applications. U.S. Department of Energy, Dec. 2017, https://www.energy.gov/sites/prod/files/2017/12/f46/ssl_horticulture_dec2017.pdf.

Schimelpfenig, Gretchen. Energy Efficiency for Massachusetts Marijuana Cultivators, Resource Innovation Institute, Sept. 2020, resourceinnovationinstitute.wildapricot.org/RII-REPORTS/.

Final CASE Report: Controlled Environment Horticulture, California Statewide Codes and Standards Enhancement (CASE) Program, Oct. 2020, https://title24stakeholders.com/wp-content/uploads/2020/10/2022-T24-NR-CEH-Final-CASE-Report.pdf.

15-Day Express Terms 2022 Energy Code - Residential and Nonresidential, California Energy Commission, 14 July 2021, https://efiling.energy.ca.gov/GetDocument.aspx?tn=238848.

Proposed Addendum ar to Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings, ASHRAE, Aug. 2021, http://osr.ashrae.org/Online-Comment-Database/ShowDoc2/Table/DocumentAttachments/FileName/3689-90.1(2019)ar%20PPR1%20Draft.pdf/download/false.

Cost Impact: The code change proposal will increase the cost of construction
This proposal will result in no additional cost for growers using greenhouses because there is little to no cost difference between luminaires meeting the current 2021 IECC requirement of 1.6 µmol/J and the proposed requirement of 1.7 µmol/J and because lighting control requirements are already common practice for these applications. For indoor grow operations, the cost of purchasing a luminaire that meets a 1.9 µmol/J requirement vs a 1.6 µmol/J would result in increased costs of approximately $13/square foot. Assuming an electricity rate of 11.09 cents/kWh, annual energy cost savings from this code proposal is approximately $4.55/square foot resulting in a three-year simple payback period.

References:

Morlino, Lauren, Emerging Technologies & Services Manager at Vermont Energy Investment Corporation . Re: Cost Information for VT Luminaires, 21 June 2021.

Final CASE Report: Controlled Environment Horticulture, California Statewide Codes and Standards Enhancement (CASE) Program, Oct. 2020, https://title24stakeholders.com/wp-content/uploads/2020/10/2022-T24-NR-CEH-Final-CASE-Report.pdf.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. As we see increasing number of severe weather events, the electric grid’s ability to withstand these events will become increasingly important. Indoor agricultural facilities place a huge demand on the local energy supply, rivaling that of data centers. The lighting proposal will significantly reduce energy demand of these facilities and therefore increase resiliency by reducing overall demand on the local grid where facilities are being added.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- ☐ Approved
- ☐ Approved with Modifications
- ☐ Carryover
- ☐ Disapproved
- ☐ None

Public Comments for: EC-C405.4-21

This proposal doesn't have any public comments.

EC-C405.4– Staff Summary

Proponent: Ben Rabe (New Buildings Institute)

Brief Description:

The proposal adds minimum energy efficiency requirements for permanently installed lighting used for interior plant growth.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

The following Energy Sub-Workgroup members in attendance were in support of this proposal:

- William Penniman (Sierra Club)
    - During discussions for EC-C403.15 stated that marijuana growing operations are huge consumers of energy. He supports both proposals (EC-C403.15 and EC-C405.4-21) dealing with these operations.
- Brian Clark (Habitat for Humanity)

The following Energy Sub-Workgroup members in attendance were in opposition of this proposal:

- Andrew Clark (HBAV)
- Steve Shapiro (AOBA/VAMA) *Note:* partial attendance only. Not in attendance at the time of voting but expressed opposition to the proposal in the Adobe Platform chat box prior to exiting the meeting room.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- KC Bleile (Viridiant)
- Laura Baker (RECA, alternate for Eric Lacey)
- Maggie Kelley Riggins (SEEA)

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note:* partial attendance. Not in attendance during EC-C405.4-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during EC-C405.4-21 discussion and voting.
- Energy Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Corey Caney: International Association of Electrical Inspectors, Virginia

Other stakeholders in attendance and opposing the proposal:

- John Ainslie (HBAV Alternate)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club – Virginia Chapter

- William Penniman (Sierra Club – Virginia Chapter)
    - When the marijuana industry develops, it will explode and put burden on the utilities. At minimum, there should be lighting requirements in place up front. He thinks it's a sensible proposal and he supports it.

Opposition:

Names: Andrew Clark (HBAV)

- Andrew Clark (HBAV)
    - Would want people from the industry involved to be able to provide input.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 40; Tab 11 - Page 24.

EC-C405.10-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Energy Conservation Code

Add new text as follows:

C202 General Definitions (Commercial). SECTION C202 GENERAL DEFINITIONS
ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, electric motorcycles and the like, which is primarily powered by an electric motor that draws current from a rechargeable storage battery. A “plug-in hybrid” is a type of electric vehicle which relies on a combination of a rechargeable storage battery and another source of motive power.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors, and the Electric Vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or charging apparatus installed specifically for the purpose of transferring energy between the premises wiring and the Electric Vehicle.

EVSE INSTALLED SPACE. A designated parking space which is provided with EVSE, including an energized branch circuit with at least 40-ampere, 208/240 volts capacity that connects electric panel capacity to charging apparatus located within three feet of the parking space.

EV CAPABLE SPACE. A designated parking space which is provided with electrical panel capacity and space to support a minimum 40-ampere, 208/240-volt branch circuit for EVSE, and with an adequately-sized raceway from the panel to a clearly identified location within three feet of the parking space, to support future EVSE.

EV READY SPACE. A designated parking space which is provided with one 40-ampere, 208/240-volt dedicated branch circuit and adequate electric panel capacity and space to electrify EVSE. The circuit shall terminate in a suitable termination point, such as a receptacle, junction box, or an EVSE, located within three feet of the parking space.

C405.10 Electric Vehicle (EV) charging for multifamily construction.. New multifamily construction shall provide and facilitate future installation and use of Electric Vehicle Supply Equipment (EVSE) in accordance with the National Electrical Code (NFPA 70) and C405.10.1.

Exception: EVSE Installed, EV Ready Spaces and EV Capable Spaces are not required where no parking spaces are provided to residents.

C405.10.1 Multifamily EV Readiness. Multifamily buildings not covered by R404.2 **(N1104.2)** shall provide EVSE Installed Spaces, EV Ready Spaces and EV Capable Spaces in proportion to the number of dwelling units in accordance with Table C405.10.1, such that the total number of such spaces equals the number of dwelling units for which parking spaces are made available to residents. Where the calculation of percentages of spaces to be served results in a fractional parking space, it shall round up to the next whole number. If a multifamily project is built in phases, the minimum number of EV Installed, EV Ready and EV Capable spaces shall be determined separately for each phase. Raceways to outdoor parking spaces shall be located underground and protected from water.

Table C405.10.1

Minimum EVSE Installed, EV Ready and EV Capable Spaces in Large Residential Buildings.

Type of space	Minimum number of spaces installed at completion of construction or phase of construction
EVSE Installed Spaces	Greater of 1 or 15% of total number of dwelling units
EV Ready Spaces	Greater of 1 or 15% of total number of dwelling units
EV Capable Spaces	Total number of dwelling units minus the sum of (EVSE Installed and EV Ready spaces)

C405.10.2 Identification. The service panel or subpanel circuit directory shall identify the spaces reserved to support EV charging as “EVSE Installed,” “EV Capable” or “EV Ready” and shall be updated as EVSE Installed Spaces are created. The raceway location shall be permanently and visibly marked as “EV Capable”. Construction documents shall indicate the raceway termination point and proposed location of future EV spaces and EV chargers. Construction documents shall also provide information on amperage of future EVSE, raceway methods, wiring schematics and electrical load calculations to verify that the electrical panel service capacity and electrical system, including any on-site distribution transformers, have sufficient capacity to simultaneously charge all EVs at all required EV spaces at the full rated amperage of the EVSE.

Reason Statement: This provision is designed to provide electric charging readiness for the growing use of electric vehicles (EVs) and to meet the essential need to offer at-home charging to residents of multifamily dwellings many of whom own EVs or would like to acquire EVs in the future. It is designed to minimize construction costs by phasing of EV charging development, with an emphasis on installing infrastructure during initial construction. To limit costs, the proposal is tied to the number of dwelling units for which parking is provided, not the total number of parking spaces. It also phases installation of chargers and branch circuits, with most of the emphasis being on the infrastructure of electric raceways and space for equipment needed to deliver the electricity. The rate at which the raceways are put to use will depend on the growth of demand.

In the case of multifamily construction, the proposal requires defined numbers of initial EV Installed, EV Ready spaces and EV Capable Spaces. The total of the three categories is tied to the number of dwelling units which are eligible for parking so that all residents have an opportunity to charge an EV when one is acquired. The intent is to provide a modest number of EV Installed and EV Ready Spaces from the outset, with EV Capable Spaces for the remainder up to the number of dwelling units for which parking is provided. Buildings that house individuals receiving medical or other care may not provide parking to serve residents of all dwelling units. The proposal will benefit residents and the public, saving money and cutting pollution.

EVs are growing in importance and will continue to grow in importance as climate risks compel shifting to vehicles that do not emit pollution and as more people recognize the potential value of owning or leasing EVs. EVs will save EV users up to $1900 per year in operating expenses compared to traditional vehicles (and more at today's high gas prices).[1] Those operating savings will further encourage EV sales growth and will greatly exceed the costs of pre-wiring garages and installing other necessary infrastructure during construction. Installing during construction is much cheaper than doing so by retrofit.

Vehicles are Virginia's largest source of carbon-dioxide emissions from fossil fuel combustion.[2] Even based on today's mix of generation in Virginia, DOE estimates that EVs would reduce CO2 emissions by roughly two-thirds compared to vehicles combusting gasoline.[3] Emissions from generation that supplies EVs will decline more as utilities' zero-carbon renewable energy replaces fossil-fuel generation. EVs' direct emissions are non-existent, which also has substantial health and pollution benefits compared to gasoline or diesel vehicles. Furthermore, in addition to the EV user's savings on annual operating costs (energy and maintenance), EV charging during off-peak periods can lead to a reduction of electric rates to all utility customers.[4]There is a national goal to have 50% of new vehicles to be EVs by 2030.[5] Major vehicle manufacturers have committed to shift production to EVs over the next 10 years with a number of manufactures committing to shift to 100% EV production in the next 5-10 years.[6].

At-home charging in conjunction with single and multifamily parking is important to meeting the needs of EV owners and to encourage charging during utilities' off-peak periods. According to research by JD Power, "80% of EV charging is done at home—almost always overnight—or while a car is parked during the workday" and EV users strongly prefer Level 2 (220/240V) charging. [7]

As a matter of equity, it is vital that residents of multifamily dwellings have access to the benefits of EVs, including the large reductions of operating costs and cleaner air. The absence of at-home EV charging is a major barrier for multifamily residents. The long periods required to fully charge an EV (7-10 hours with Level 2 charging depending on the size of the battery and level of charge) virtually requires at-home access to charging infrastructure. Off-peak charging can also save money on the electric rates. Going forward, utilities may get the added benefit of being able to draw on the batteries of parked electric vehicles in order meet peak demands and balance fluctuating loads. The public infrastructure for charging is still limited with relatively few "high speed" Level 3 chargers. Even when that public infrastructure is available, drivers have limited ability to take advantage of off-peak rates without home-charging.

Installing the wiring and basic infrastructure during construction when walls are open, parking is being constructed and workers are present is much cheaper than retrofitting. The presence of the wiring from the beginning (EV Ready) would permit low-cost installation of a different charging system to meet EV owners' needs. The presence of raceways from the beginning (EV Capable) will make it easy to expand service as demand grows. Failure to install the EV during infrastructure will create barriers to EV adoption and to the cost and pollution reductions that will come from EV utilization. Those barriers will be particularly great in the context of multifamily dwellings where retrofit costs are much higher and landlords' interests conflict with those of tenants.

[1] *See* Consumer Reports, "EVs Offer Big Savings Over Traditional Gas-Powered Cars" (October 2020); Union of Concerned Scientists, https://www.ucsusa.org/about/news/rural-communities-could-benefit-most-electric-vehicles (up to $1900/year savings for rural EV owners); https://augustafreepress.com/deq-launches-clean-air-communities-program-aimed-at-driving-investment-in-electric-vehicle The police department of Westport Connecticut achieved operating and maintenance savings of over $17,000 in its first year of using a Tesla Model 3 police car instead of a fossil fuel vehicle. Among the department's conclusions: after four years the Tesla will have saved enough money to buy another Tesla, and each EV avoids emission of over 23 tons of CO2 per year and saves $8763 in environmental and health costs. https://www.teslarati.com/tesla-model-3-westport-police-department-financial-analysis/

[2]https://www.epa.gov/sites/production/files/2019-11/documents/co2ffc_2017.pdf

[3] DOE estimates that an EV in Virginia emits (via electric generation) less than a third as much CO2 as a gasoline-driven vehicle. https://afdc.energy.gov/vehicles/electric_emissions.html ; https://evtool.ucsusa.org/

[4] See June 23, 2020 Comments of the Sierra Club to the State Corporation Commission in SCC Docket PUR-2020-00051, Electrification of Motor Vehicles. As the comments explain, with managed off-peak charging and efficient rate structures, rising EV loads can drive down rates to all customers. Regarding operating costs, an EV has very little maintenance costs and EV's electricity cost equivalent to a gallon of gasoline, in Virginia, was $1.16 versus roughly $4.00/gallon today. https://www.energy.gov/maps/egallon

[5] https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/fact-sheet-president-biden-announces-steps-to-drive-american-leadership-forward-on-clean-cars-and-trucks/

[6] EV sales are already increasing, and every major vehicle manufacturer has committed to expand EV production and even to go all-electric over the next decade or so. Electric pick-up trucks will soon be available and there are long waiting lists for pick-ups. *See*
https://www.reuters.com/business/autos-transportation/us-automakers-say-they-aspire-up-50-ev-sales-by-2030-sources-2021-08-04/
https://www.forbes.com/wheels/news/automaker-ev-plans/ ; https://www.cnbc.com/2022/01/05/chrysler-kicks-off-plans-to-go-all-electric-by-2028-with-airflow-concept.html
https://www.electrive.com/2021/08/05/us-carmakers-aim-for-40-50-ev-sales-by-2030/
[7] https://www.forbes.com/wheels/news/jd-power-study-electric-vehicle-owners-prefer-dedicated-home-charging-stations/ See also James Walkinshaw, Washington Post, Jan. 23, p.C4 (explaining the importance of home charging relative to public charging). Utilities' energy sales are lowest and cheapest in off-peak hours, particularly at night. A common utility strategy is to offer time-of-use rates with low night-time prices to encourage off-peak EV charging. For EV customers to make use of such incentives, they will need access to overnight charging at home where they spend the night.

Cost Impact: The code change proposal will increase the cost of construction
This code change proposal will somewhat increase the cost of constructing parking, but the increase will be small compared to the total cost of building construction and to the annual savings and other benefits to residents and the public. The availability of at-home charging charging will save residents money and avoid the higher costs of retrofitting in the future.The incremental cost of installing the electric equipment will be low when a residence is constructed. It is easy to install the wires, panel capacity and conduits for electric vehicle charging--along with the rest of a dwelling's wiring--when parking for multifamily dwelling or a nonresidential building is being constructed. It is much harder and much more expensive to do so as a retrofit. The branch circuit would cost a few dollars per foot, and raceways are also inexpensive.
The net benefits are clear. The costs per space of installing EV readiness during construction are less than the forecast savings of fuel and maintenance costs for residents with EVs. As DOE has explained: "Installing infrastructure during new construction avoids the retrofit costs of breaking and repairing walls, installing longer raceways, and using more expensive methods of upgrading service panels." See PNNL-31576, "Electric Vehicle Charging for Residential and Commercial Energy Codes: Technical Brief" (July 2021). While the potential costs can vary widely, they are reduced by addressing during initial construction, by taking advantage of upfront planning (e.g., as to locations of electrical systems and parking), and by economies of scale. The PNNL report (p.12) showed that 12 EV spaces in a 60-space parking structure would cost $860 per space with new construction or $2,370 per space with a retrofit, while 2 spaces in a 10 space lot would cost $930 per space with new construction or $3,710 per space in a retrofit. It states (p.7), "The availability and ease of access to Level 2 and DCFC EVSE is a critical barrier to EV adoption. A lack of pre-existing EV charging infrastructure, such as electrical panel capacity, raceways, and pre-wiring, can make the installation of a new charging station cost-prohibitive for a potential EV-owner. (fn omitted). Those costs would be a small fraction of new construction costs or rents, but a potential barrier to later installation.

In a large multifamily building, the cost would be greater than for a single-family dwelling due the larger garage or parking lot size and possibly the garage design. However, the costs of the infrastructure required by the proposal are still low compared to the overall construction cost, to potential retrofit costs, to residents' long-term savings from EVs, and to harm from impeding tenants' ability to reduce carbon and other pollutants which will reduce pollutants and benefit the public. The cost can be minimized by locating the EVSE (or future location for the EVSE) close to the electrical panels.

The proposal limits the costs both by limiting the requirements to one covered space per dwelling unit and to a limited number of spaces planned for employees and by deferring of much of the costs with respect to EV Ready and EV Capable spaces.
Staging, as spelled out in the Table, means that residents of every dwelling unit will have the opportunity to home-charge an EV, and the remaining electrical wiring and charger costs would only be incurred as occupant demand grows. (Sharing EV chargers would further slow the rate of build out; and, as demand evolves, lower capacity wire in the raceways might suffice for residents with plug-in hybrids.) The requirements for non-residential buildings are likely to be less than for multifamily. In submissions to the IECC as part of the 2021 IECC review process, data indicated that the cost of retrofitting commercial parking to EV ready status would be 3-8 times higher than doing to work at the time of building construction. See IECC Proposal CE217-19 Part 1(Cost Impact discussion). Such high retrofit costs will deter future retrofits and act as a barrier to EV access by residents of multifamily dwellings, potentially for decades.

Resiliency Impact Statement: This proposal will increase Resiliency
Expanding EV utilization will enhance resiliency in multiple ways.

It is anticipated that EV batteries can be connected to the grid to provide grid balancing and back up in the future.

Switching to EVs is also critical to resiliency because it will reduce CO_2, CO, SO_2, particulates, methane, and other harmful emissions from fossil-fuel combusting vehicles and from producing and delivering gasoline and diesel fuel for use in vehicles. Unlike traditional vehicles with internal combustion engines ("ICE"), electric vehicles emit no air pollution and are much more energy efficient than ICE vehicles. As Virginia's electric grid shifts to zero-carbon generation, the emission reduction benefits will grow.

According to Virginia's DEQ, "[t]he transportation sector is now the largest contributor of air pollutants and greenhouse gases in Virginia," and "[v]ehicle emissions are the largest single source of toxic and smog-forming air pollution in Northern Virginia and much of the rest of the country."

https://www.deq.virginia.gov/air/clean-vehicles . Transportation accounts for 48.6% of Virginia's CO_2 emissions. https://www.eia.gov/environment/emissions/state/

Polluting emissions from internal combustion vehicles compound the risks of climate change and adversely impact public health. CO_2 and other emissions from fossil fuel combustion and production are the primary drivers of climate change. The most recent IPCC report confirms that rapid reductions of greenhouse gas emissions is essential to avoid catastrophic climate impacts around the world. IPCC Sixth Assessment Report (February 2022), https://www.ipcc.ch/report/ar6/wg2/ Substantial harm has already occurred nationally and locally from global warming and much worse will follow without rapid reductions of greenhouse gases (particularly CO_2 and methane associated with fossil fuel production and combustion). Virginia's coastal areas are among the most vulnerable to sea level rise and destructive storms. They already experience "sunny day flooding," and sea level rise is accelerating. https://www.vims.edu/newsandevents/topstories/2020/slrc_2019.php Coastal areas are not the only part of Virginia threatened by worsening storms. https://www.wvtf.org/news/2022-04-28/study-shows-virginia-at-increased-risk-for-flash-floods-and-landslides

Climate change is already harming Virginia and the harms will get much worse if we do not sharply reduce GHG emissions (particularly CO_2 and methane associated with fossil fuel production and combustion). The most recent report from NOAA indicates that Virginia may face 2 feet of sea level rise by 2050 due to worsening climate change from human greenhouse gas emissions. https://www.noaa.gov/news-release/us-coastline-to-see-up-to-foot-of-sea-level-rise-by-2050 Virginia faces climate-driven sea level rise of 6.69 feet this century; the rate of sea level rise is accelerating; the danger of climate-driven severe storms, storm-surges and flooding are rising; and climate change will increasingly harm human health and lives, agriculture, businesses, military installations, private and public property, and Virginia's economy. http://www.vasem.org/reports/2021-the-impact-of-climate-change-on-virginias-coastal-areas/ Growing dangers also include rising atmospheric and water temperatures that worsen heat-related illnesses, disruptions of economic activity, and harms to agriculture, fisheries, and our natural heritage.

Because atmospheric CO_2 from emissions is cumulative, Virginia has less chance of mitigating and recovering from those harms the longer we delay maximizing energy savings and minimizing greenhouse gas pollution.

Shifting to EVs is a critical piece of the solution to global warming. Continuing to construct buildings that will not support use of clean EVs will make it harder to achieve climate goals, particularly since the buildings will likely remain in place for 70 years or more. Constructing buildings that cannot provide electric charging will also delay residents' ability to access large economic and energy savings from EV usage.

Building codes already recognize that fumes from traditional vehicles are dangerous. More broadly, small particle, SO_2 and other pollution from vehicles burning fossil fuels increases heart and lung disease, as well as cognitive and other disorders. https://blog.ucsusa.org/dave-reichmuth/air-pollution-from-cars-trucks-and-buses-in-the-u-s-everyone-is-exposed-but-the-burdens-are-not-equally-shared/ As Virginia's electric grid shifts to zero-carbon generation, the emission reduction benefits will grow particularly if we shift vehicles to clean electricity. Local air pollution harms caused by vehicle pollution will also be reduced which will particularly benefit high-traffic areas, including low-income urban areas.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved

☐ None

Public Comments for: EC-C405.10-21

This proposal doesn't have any public comments.

Proposal # 1044

EC-C405.10– Staff Summary

Proponent: William Penniman (Sierra Club – Virginia Chapter)

Brief Description:

Requires three types of electric vehicle (EV) charging parking spaces for multifamily buildings, EVSE installed, EV capable and EV ready.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at their May 12, 2022, meeting with the decision to carry over the proposal to the meeting on May 19, 2022 to allow for additional collaboration between stakeholders.

Energy Sub-Workgroup members in attendance at their May 12th meeting:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
  - Had concerns regarding load letters from the power providers and the impact these requirements may have.
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
- K.C. Bleile: Viridiant
  - Appreciated that the EV proposals were broken down into different proposals for single family dwellings, multifamily and commercial as the feedback related to commercial properties is not pertinent to single family dwellings.
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)
  - He discussed the proposal with the proponent and is in the process of getting feedback from his members. There might be a number of parking spaces they could agree with.
- William (Bill) Penniman: Sierra Club; Virginia chapter

Energy Sub-Workgroup members not in attendance at their May 12th meeting:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance

Additional feedback from other stakeholders in attendance:

- Ben Rabe (New Building Institute)
  - Supported this proposal in addition to his EV proposal.

- Sarah Thomas (The Vectre Corporation, representing The Virginia Association of Commercial Real Estate). Stated that she is also reaching out to members about this and other EV proposals and would like to carry this proposal over as well.

The proposal was also heard by the Sub-Workgroup at their May 19, 2022, meeting.

The discussion consisted of the proponent providing an update to the Sub-Workgroup indicating that he continued collaboration with several stakeholders and requested to carry over the proposal to the General Stakeholders Workgroup meeting in June with a hope that some agreement will be reached in the meantime. Proponent did revise the proposal based on feedback received to include EV ready and capable spaces in addition to EV installed spaces.

Energy Sub-Workgroup members in attendance at their May 19th meeting:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
- K.C. Bleile: Viridiant
- William (Bill) Penniman: Sierra Club – Virginia chapter

Energy Sub-Workgroup members not in attendance at their May 19th meeting:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

- Eric Lacey (Representing self)
    - Comments from similar proposal, EC-C405.13(2)-21. As a Virginia resident, doesn't think it's a good idea to wait 3 more years to implement EV readiness. Electric vehicles are not just the future, but are here now.
- Dan Willham (Fairfax County)
    - Comments from similar proposal, EC-C405.13(2)-21. Supports the concept in general. However, the 2021 ICC appeals board ruled this out of scope since it was not actually energy conservation. If this does go forward, they would have to determine where to put it, considering that it isn't an energy-conservation measure.
        - Eric Lacey responded that the appeal ruling was more of a technicality.

Opposition:

- Steve Shapiro (AOBA/VAMA)
  - AOBA and VAMA are in opposition to this proposal and all the other EV proposals. There has been a lot of discussion around these EV proposals with no agreement as of yet. Also, there are concerns around fire safety that still need to be addressed and integrated with the other EV proposals.
- Andrew Clark (HBAV)
  - Agrees with Steve Shapiro's comments. Even though EV may be the way to go in the future, more discussion is needed to ensure that the codes address all concerns. HBAV is opposed to this proposal.
- David Beahm (Warren County)
  - Agrees with comments from Steve Shapiro and Andrew Clark. Also has concerns regarding accessible parking.
- Sarah Thomas (Virginia Association for Commercial Real Estate)
  - Virginia Association for Commercial Real Estate is opposed to this proposal. She's also in agreement with the other comments in opposition.

DHCD Staff Notes:

Please note there is a similar staff proposal, EC-C405.13(2)-21, related to EV charging for multi-family buildings. Only one of these proposals should be approved if the board chooses to do so.

There is also a commercial version of this proposal, EC-C405.11.1. These proposals can be considered independently.

Meeting summaries and proposal related information: Tab 10 - Page 77; Tab 11 - Page 35; Tab 11 - Page 41.

EC-C405.11.1-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Construction Code

Add new text as follows:

C202 GENERAL DEFINITIONS. Add:
ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, electric motorcycles and the like, which is primarily powered by an electric motor that draws current from a rechargeable storage battery. A "plug-in hybrid" is a type of electric vehicle which relies on a combination of a rechargeable storage battery and another source of motive power.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors, and the Electric Vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or charging apparatus installed specifically for the purpose of transferring energy between the premises wiring and the Electric Vehicle.

EVSE INSTALLED SPACE. A designated parking space which is provided with EVSE, including an energized branch circuit with at least 40-ampere, 208/240 volts capacity that connects electric panel capacity to charging apparatus located within three feet of the parking space.

EV CAPABLE SPACE. A designated parking space which is provided with electrical panel capacity and space to support a minimum 40-ampere, 208/240-volt branch circuit for EVSE, and with an adequately-sized raceway from the panel to a clearly identified location within three feet of the parking space, to support future EVSE.

EV READY SPACE. A designated parking space which is provided with one 40-ampere, 208/240-volt dedicated branch circuit and adequate electric panel capacity and space to electrify EVSE. The circuit shall terminate in a suitable termination point, such as a receptacle, junction box, or an EVSE, located within three feet of the parking space.

C405.11.1 EV Readiness for Certain Commercial Buildings Other Than Multifamily. Commercial construction other than multifamily that includes parking spaces for use by employees or students shall, at a minimum, provide EVSE Installed, EV Ready and EV Capable Parking Spaces shown in Table C405.11.1. Where the calculation of percentages of spaces to be served results in a fractional parking space, it shall round up to the next whole number. If a covered project is built in phases, the minimum number of required spaces shall be determined separately for each phase. Raceways to outdoor parking spaces shall be located underground and protected from water.
EXCEPTIONS: EVSE Installed, EV Ready and EV Capable Parking Spaces are not required for parking intended for vehicle inventory, vehicle storage, construction equipment, commercial customer use or farms.

TABLE C405.11.1
Number of EV Ready Spaces for Certain Non-Multifamily Construction.

Type of building/space	EVSE Installed	EV Ready	EV Capable
Office, manufacturing or processing plants with more than 10 parking spaces for employees	Greater of 1 or 5% of employee spaces	Greater of 1 or 10% of employee spaces	Greater of 1 or 20% of such spaces of employee spaces
Hotel, motel, extended stay, other temporary lodging	Greater of 1 or 5% of sleeping units if more than 10 such units	Greater of 1 or 10% of sleeping units if more than 10 such units	30% of sleeping units if more than 10 such units
Educational institutions if more than 10 spaces to be provided for faculty and other employees or students	Greater of 1 or 5% of spaces provided to faculty and other employees and 1 or 5% spaces provided to students	Greater of 1 or 10% of spaces provided to faculty and other employees and 1 or 5% of spaces provided to students	Greater of 1 or 20% of spaces provided to faculty and other employees and 1 or 10% of spaces provided to students

Reason Statement: This provision is designed to provide electric charging readiness for the growing use of electric vehicles (EVs) and to meet the need for some EV charging capabilities for certain workplaces, temporary lodgings, and educational venues. It recognizes that employees, travelers and students may travel considerable round-trip distances from home or may not have access to at-home charging. Substantially or fully charging an EV can take many hours, which fits with a typical workday or overnight at home, but not along the roadway as an addition to a typical commute. The proposal will benefit businesses and their employees and students. It will also benefit the public and enhance the economy by cutting air, water and climate pollution from internal combustion engines; by saving money for vehicle users; by saving time by charging vehicles when they are going to be parked anyway, and by reducing noise pollution. Reductions of air and climate pollution will have huge health, safety and infrastructure benefits.
The proposal is designed to minimize costs through phasing of EV development, with an emphasis on installing infrastructure during initial construction. Installing the wiring and basic infrastructure during construction is much cheaper than retrofitting. The proposal requires a relatively small upfront investment in infrastructure, with easy installation of additional chargers (EVSE) as needs grow. It assumes that there is a lesser need for workplace and customer EV charging than at-home charging (assuming at-home charging develops), but recognizes that some EV charging capabilities are needed at workplaces and commercial venues. Not everyone will have access to at-home EV charging, and many employees will

need some workplace charging to support expanded EV usage. Residents of older buildings and ones who rely on street parking are unlikely to get at-home charging for many years, if ever.

The proposal focuses on employees, travelers and students because of their unique needs and the likelihood that they will be able to use EV charging for a period of hours. Employees typically must work regular daily schedule; must commute farther to work than customers do for shopping; are likely to be at their workplace for extended periods; and have less time for roadside-charging. Travelers who drive will generally need overnight charging at places of lodging.

The intent is to provide a modest number of EV Installed and EV Ready Spaces from the outset, with EV Capable Spaces available for easy charging expansion as demand rises.

Providing access to at-work charging is also important as a matter of equity since residents of older, multifamily dwellings and townhouses are least likely to have access to at-home charging. Although the purchase cost of EVs is currently higher than the low end of vehicles with combustion engines, the purchase price is falling as competition grows and, more importantly, the EV savings in fuel and maintenance costs more than pay for the initial price difference. Also, air pollution from traditional vehicles is particularly harmful to low-income residents of Virginia.

EVs are growing in importance and will continue to grow in importance as climate risks compel shifting to vehicles that do not emit pollution and as more people recognize the potential value of owning or leasing EVs. EVs will save EV users up to $1900 per year in operating expenses compared to traditional vehicles (based on prices when those reviews were done, which were considerably lower than the $4.00/gallon or so seen today).[1] Those operating savings will encourage EV sales growth and will greatly exceed the costs of pre-wiring parking lots and installing other necessary infrastructure during construction. Installing during construction is much cheaper than doing so by retrofit.

Vehicles are Virginia's largest source of carbon-dioxide emissions from fossil fuel combustion.[2] Even based on today's mix of generation in Virginia, DOE estimates that EVs would reduce CO_2 emissions by roughly two-thirds compared to vehicles combusting gasoline.[3] Emissions from generation that supplies EVs will decline more as utilities' zero-carbon renewable energy replaces fossil-fuel generation. EVs' direct emissions are non-existent, which also has substantial health and pollution benefits compared to gasoline or diesel vehicles.

Unfortunately, charging EVs is a time-consuming process. Even "Level 2" (40 amp, 208-240Volt) charging will only add 20-30 miles of range per hour of charging; while Level 1 provides approximately 5 miles per hour of charging. That creates a significant problem for individuals who cannot charge at work or home.

There is a national goal to have 50% of new vehicles to be EVs by 2030.[4] Major vehicle manufacturers have committed to shift production to EVs over the next 10 years with a number of manufactures committing to shift to 100% EV production in the next 5-10 years.[5]. According to research by JD Power, "80% of EV charging is done at home—almost always overnight—or while a car is parked during the workday" and EV users strongly prefer Level 2 (220/240V) charging. [6] The opportunity to charge at work is critical for long-distance commuter and for drivers who cannot install at-home charging due to their reliance on street parking or living in older buildings that lack parking or charging. The availability of at-work and at-home charging will substantially reduce barriers to EV adoption that arise from the inconveniences that EV charging is slower than pumping gasoline.. Going forward, utilities may get the added benefit of being able to draw on the batteries of parked electric vehicles in order meet peak demands and balance fluctuating loads..

[1] See Consumer Reports, "EVs Offer Big Savings Over Traditional Gas-Powered Cars" (October 2020); Union of Concerned Scientists, https://www.ucsusa.org/about/news/rural-communities-could-benefit-most-electric-vehicles (up to $1900/year savings for rural EV owners); https://augustafreepress.com/deq-launches-clean-air-communities-program-aimed-at-driving-investment-in-electric-vehicle The police department of Westport Connecticut achieved operating and maintenance savings of over $17,000 in its first year of using a Tesla Model 3 police car instead of a fossil fuel vehicle. Among the department's conclusions: after four years the Tesla will have saved enough money to buy another Tesla, and each EV avoids emission of over 23 tons of CO_2 per year and saves $8763 in environmental and health costs. https://www.teslarati.com/tesla-model-3-westport-police-department-financial-analysis/ Those studies were based on much lower gas prices than exist today, which means that today's savings would be much larger. Regarding operating costs, an EV has very little maintenance costs and EV's electricity cost equivalent to a gallon of gasoline, in Virginia, was $1.16 versus roughly $4.00/gallon today. https://www.energy.gov/maps/egallon

[2]https://www.epa.gov/sites/production/files/2019-11/documents/co2ffc_2017.pdf

[3] DOE estimates that an EV in Virginia emits (via electric generation) less than a third as much CO_2 as a gasoline-driven vehicle. https://afdc.energy.gov/vehicles/electric_emissions.html ; https://evtool.ucsusa.org/

[4] https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/fact-sheet-president-biden-announces-steps-to-drive-americanleadership-forward-on-clean-cars-and-trucks/

[5] EV sales are already increasing, and every major vehicle manufacturer has committed to expand EV production and even to go all-electric over the next decade or so. Electric pick-up trucks will soon be available and there are long waiting lists for pick-ups. See https://www.reuters.com/business/autos-transportation/us-automakers-say-they-aspire-up-50-ev-sales-by-2030-sources-2021-08-04/ https://www.forbes.com/wheels/news/automaker-ev-plans/ ; https://www.cnbc.com/2022/01/05/chrysler-kicks-off-plans-to-go-all-electric-by-2028-with-airflow-concept.html https://www.electrive.com/2021/08/05/us-carmakers-aim-for-40-50-ev-sales-by-2030/

[6] https://www.forbes.com/wheels/news/jd-power-study-electric-vehicle-owners-prefer-dedicated-home-charging-stations/ See also James Walkinshaw, Washington Post, Jan. 23, p.C4 (explaining the importance of home charging relative to public charging). Utilities' energy sales are lowest and cheapest in off-peak hours, particularly at night. A common utility strategy is to offer time-of-use rates with low night-time prices to encourage off-peak EV charging. For EV customers to make use of such incentives, they will need access to overnight charging at home where they spend the night.

Cost Impact: The code change proposal will increase the cost of construction

The code change proposal will somewhat increase the cost of constructing parking, but the increase will be small compared to the total cost of construction and the benefits to employees, travelers, students and the public. Installing EV charging or at least readiness for EV charging at the covered locations will save users money on fuel and avoid the much higher costs of retrofitting parking in the future.The incremental cost of installing the electric equipment is much lower during initial construction. See PNNL-31576, "Electric Vehicle Charging for Residential and Commercial Energy Codes: Technical Brief" (July 2021). While the potential costs can vary widely, they are substantially reduced by addressing during initial construction, by taking advantage of upfront planning (e.g., as to locations of electrical systems and parking), and by economies of scale. The PNNL report (p.12) showed that 12 EV spaces in a 60-space parking structure would cost $860 per space with new construction or $2,370 per space with a retrofit, while 2 spaces in a 10 space lot would cost $930 per space with new construction or $3,710 per space in a retrofit. It states (p.7), "The availability and ease of access to Level 2 and DCFC EVSE is a critical barrier to EV adoption. A lack of pre-existing EV charging infrastructure, such as electrical panel capacity, raceways, and pre-wiring, can make the installation of a new charging station cost-prohibitive for a potential EV-owner. (fn omitted). Those costs would be a small fraction of new construction costs or rents, but a potential barrier to later installation.

In submissions to the IECC as part of the 2021 IECC review process, data indicated that the cost of retrofitting commercial parking to EV ready status would be 3-8 times higher than doing to work at the time of building construction. Such high retrofit costs will deter future retrofits and act as a barrier to EV expansion in Virginia.

It is easy to install the wires, panel capacity and conduits for electric vehicle charging--along with the rest of a dwelling's wiring--when a single or multifamily dwelling is built. It is much harder and much more expensive to do so as a retrofit, which may require tearing up walls or parking surfaces. The branch circuit for an EVSE Installed or EVSE Ready space would cost a few dollars per foot, and would not be required during construction for a EV Capable Space.

The cost can be minimized by locating the EVSE or future location for the EVSE close to the electrical infrastructure. The proposal limits the costs both by limiting the total requirement to many fewer than the total parking spaces to be constructed and by allowing deferral of some costs for EV Ready and EV Capable spaces. Also, while 40-Amp circuits are required for the initial EVSE Installed and EV Ready Spaces and the capacity is needed to handle future branch circuits in EV Capable raceways, the door is left open to the possibility that, with experience and new technology, lower-capacity wiring might eventually be installed in at least some EV Capable spaces.

Resiliency Impact Statement: This proposal will increase Resiliency

Expanding EV utilization will enhance resiliency in multiple ways.

Many potential EV users lack at-home EV charging capabilities, which means that some workplace coverage is essential. Travelers also need access to overnight charging during stays at hotels and motels. Even if an employee or student has access to EV charging at home, the ability to charge at work can offset power outages at home. EVSE can be designed to deliver electricity back to a building or to the utility grid. https://www.ford.com/trucks/f150/f150-lightning/2022/

Switching to EVs is also critical to resiliency because it will reduce CO_2, CO, SO_2, particulates, methane, and other harmful emissions from fossil fuel combusting vehicles and from producing and delivering gasoline and diesel fuel for use in vehicles. Unlike traditional vehicles with internal combustion engines ("ICE"), electric vehicles emit no air pollution and are much more energy efficient than ICE vehicles. As Virginia's electric grid shifts to zero-carbon generation, the emission reduction benefits will grow.

According to Virginia's DEQ, "[t]he transportation sector is now the largest contributor of air pollutants and greenhouse gases in Virginia," and "[v]ehicle emissions are the largest single source of toxic and smog-forming air pollution in Northern Virginia and much of the rest of the country." https://www.deq.virginia.gov/air/clean-vehicles . Transportation accounts for 48.6% of Virginia's CO_2 emissions. https://www.eia.gov/environment/emissions/state/

Polluting emissions from internal combustion vehicles compound the risks of climate change and adversely impact public health. CO_2 and other emissions from fossil fuel combustion and production are the primary drivers of climate change. The most recent IPCC report confirms that rapid reductions of greenhouse gas emissions is essential to avoid catastrophic climate impacts around the world. IPCC Sixth Assessment Report (February 2022), https://www.ipcc.ch/report/ar6/wg2/ Substantial harm has already occurred nationally and locally from global warming and much worse will follow without rapid reductions of greenhouse gases (particularly CO_2 and methane associated with fossil fuel production and combustion). Virginia's coastal areas are among the most vulnerable to sea level rise and destructive storms. They already experience "sunny day flooding," and sea level rise is accelerating. https://www.vims.edu/newsandevents/topstories/2020/slrc_2019.php Climate change is already harming Virginia and the harms will get much worse if we do not sharply reduce GHG emissions (particularly CO_2 and methane associated with fossil fuel production and combustion). The most recent report from NOAA indicates that Virginia may face 2 feet of sea level rise by 2050 due to worsening climate change from human greenhouse gas emissions. https://www.noaa.gov/news-release/us-coastline-to-see-up-to-foot-of-sealevel-rise-by-2050 Virginia faces climate-driven sea level rise of 6.69 feet this century; the rate of sea level rise is accelerating; the danger of climate-driven severe storms, storm-surges and flooding are rising; and climate change will increasingly harm human health and lives, agriculture, businesses, military installations, private and public property, and Virginia's economy. http://www.vasem.org/reports/2021-the-impact-of-climatechange-on-virginias-coastal-areas/ Growing dangers also include rising atmospheric and water temperatures that worsen heat-related illnesses, disruptions of economic activity, and harms to agriculture, fisheries, and our natural heritage.

Because atmospheric CO_2 from emissions is cumulative, Virginia has less chance of mitigating and recovering from those harms the longer we delay maximizing energy savings and minimizing greenhouse gas pollution. Shifting to EVs is a critical piece of the solution to global warming. Continuing to construct buildings that will not support use of clean EVs will make it harder to achieve climate goals, particularly since the buildings will likely remain in place for 70 years or more. Constructing buildings that cannot provide electric charging will also delay residents' ability to access large economic and energy savings from EV usage.

Building codes already recognize that fumes from traditional vehicles are dangerous. More broadly, small particle, SO2 and other pollution from vehicles burning fossil fuels increases heart and lung disease, as well as cognitive and other disorders. https://blog.ucsusa.org/dave-reichmuth/airpollution-from-cars-trucks-and-buses-in-the-u-s-everyone-is-exposed-but-the-burdens-are-not-equally-shared/ As Virginia's electric grid shifts to zero-carbon generation, the emission reduction benefits will grow particularly if we shift vehicles to clean electricity. Local air pollution harms caused by vehicle pollution will also be reduced which will particularly benefit high-traffic areas, including low-income urban areas.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: EC-C405.11.1-21

This proposal doesn't have any public comments.

Proposal # 1185

EC-C405.11.1 – Staff Summary

Proponent: William Penniman (Sierra Club – Virginia Chapter)

Brief Description:

Requires three types of electric vehicle (EV) charging parking spaces for commercial buildings, EVSE installed, EV capable and EV ready.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal is very similar in nature with proposal EC-C405.10 and it was heard by the Sub-Workgroup at their May 12th and May 19th, 2022, meetings. Given their similarities and the fact that this proposal was heard immediately after EC-C405.10, stakeholders rested on the statements made during EC-C405.10 discussions. The information has been reproduced here for convenience.

Energy Sub-Workgroup members in attendance at their May 12th meeting:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
    - Had concerns regarding load letters from the power providers and the impact these requirements may have.
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
- K.C. Bleile: Viridiant
    - Appreciated that the EV proposals were broken down into different proposals for single family dwellings, multifamily and commercial as the feedback related to commercial properties is not pertinent to single family dwellings.
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)
    - He discussed the proposal with the proponent and is in the process of getting feedback from his members. There might be a number of parking spaces they could agree with.
- William (Bill) Penniman: Sierra Club; Virginia chapter

Energy Sub-Workgroup members not in attendance at their May 12th meeting:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance

Additional feedback from other stakeholders in attendance:

- Ben Rabe (New Building Institute)
    - Supported this proposal in addition to his EV proposal.
- Sarah Thomas (The Vectre Corporation, representing The Virginia Association of Commercial Real Estate). Stated that she is also reaching out to members about this and other EV proposals and would like to carry this proposal over as well.

The proposal was also heard by the Sub-Workgroup at their May 19, 2022, meeting.

The discussion consisted of the proponent providing an update to the Sub-Workgroup indicating that he continued collaboration with several stakeholders and requested to carry over the proposal to the General Stakeholders Workgroup meeting in June with a hope that some agreement will be reached in the meantime. Proponent did revise the proposal based on feedback received to include EV ready and capable spaces in addition to EV installed spaces.

Energy Sub-Workgroup members in attendance at their May 19th meeting:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
- K.C. Bleile: Viridiant
- William (Bill) Penniman: Sierra Club – Virginia chapter

Energy Sub-Workgroup members not in attendance at their May 19th meeting:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

The proposal is similar in nature with proposals EC-C405.10 and EC-C405.13(2)-21. Given their similarities and the fact that this proposal was heard immediately after EC-C405.10, stakeholders rested on the statements made during EC-C405.10 and EC-C405.13(2)-21 discussions. The information has been reproduced here for convenience.

Support:

- Eric Lacey (Representing self)

    - Comments from similar proposal, EC-C405.13(2)-21. As a Virginia resident, doesn't think it's a good idea to wait 3 more years to implement EV readiness. Electric vehicles are not just the future, but are here now.
- Dan Willham (Fairfax County)
    - Comments from similar proposal, EC-C405.13(2)-21. Supports the concept in general. However, the 2021 ICC appeals board ruled this out of scope since it was not actually energy conservation. If this does go forward, they would have to determine where to put it, considering that it isn't an energy-conservation measure.
        - Eric Lacey responded that the appeal ruling was more of a technicality.

Opposition:

- Steve Shapiro (AOBA/VAMA)
    - AOBA and VAMA are in opposition to this proposal and all the other EV proposals. There has been a lot of discussion around these EV proposals with no agreement as of yet. Also, there are concerns around fire safety that still need to be addressed and integrated with the other EV proposals.
- Andrew Clark (HBAV)
    - Agrees with Steve Shapiro's comments. Even though EV may be the way to go in the future, more discussion is needed to ensure that the codes address all concerns. HBAV is opposed to this proposal.
- David Beahm (Warren County)
    - Agrees with comments from Steve Shapiro and Andrew Clark. Also has concerns regarding accessible parking.
- Sarah Thomas (Virginia Association for Commercial Real Estate)

Virginia Association for Commercial Real Estate is opposed to this proposal. She's also in agreement with the other comments in opposition.

DHCD Staff Notes:

There is a multifamily version of this proposal submitted by the proponent, EC-C405.10. These proposals can be considered independently.

Meeting summaries and proposal related information: Tab 10 - Page 77; Tab 11 - Page 35; Tab 11 - Page 41.

EC-C405.13-21

Proponents: Ben Rabe (ben@newbuildings.org); Diana Burk (diana@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

RENEWABLE ENERGY CERTIFICATE (REC). An instrument that represents the environmental attributes of one megawatt-hour of renewable electricity; also known as an energy attribute certificate (EAC).

C405.13 Renewable energy systems..
Each building site shall have equipment for on-site renewable energy with a rated capacity of not less than 0.25 W/ft² (2.7 W/m²) multiplied by the sum of the gross conditioned floor area of the three largest floors.

Exceptions:

1. Any building located where an unshaded flat plate collector oriented towards the equator and tilted at an angle from horizontal equal to the latitude receives an annual daily average incident solar radiation less than 3.5 kWh/m²·day (1.1 kBtu/ft²·day).

2. Any building where more than 80 percent of the roof area is covered by any combination of equipment other than for on-site renewable energy systems, planters, vegetated space, skylights, or occupied roof deck.

3. Any building where more than 50 percent of roof area is shaded from direct-beam sunlight by natural objects or by structures that are not part of the building for more than 2,500 annual hours between 8:00 AM and 4:00 PM.

C405.13.1 Renewable energy certificate documentation. Documentation shall be provided to the code official that indicates that renewable energy certificates (RECs) associated with the on-site renewable energy will be retained and retired by or on behalf of the owner or tenant.

C405.13.1 Additional efficiency package options. . The PV capacity required in this section shall not be used for compliance with the on-site renewable energy option of Section C406.5.

Revise as follows:

C406.5 On-site renewable energy. ~~Buildings shall comply with Section C406.5.1 or C406.5.2.~~ The total minimum ratings of on-site renewable energy systems, not including onsite renewable energy system capacity used for compliance with Section C405.13, shall be one of the following

TABLE C407.4.1(1) SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

BUILDING COMPONENT CHARACTERISTICS	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Space use classification	Same as proposed	The space use classification shall be chosen in accordance with Table C405.3.2(1) or C405.3.2(2) for all areas of the building covered by this permit. Where the space use classification for a building is not known, the building shall be categorized as an office building.
Roofs	Type: insulation entirely above deck	As proposed
	Gross area: same as proposed	As proposed
	U-factor: as specified in Table C402.1.4	As proposed
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, above-grade	Type: same as proposed	As proposed
	Gross area: same as proposed	As proposed
	U-factor: as specified in Table C402.1.4	As proposed
	Solar absorptance: 0.75	As proposed
	Emittance: 0.90	As proposed
Walls, below-grade	Type: mass wall	As proposed
	Gross area: same as proposed	As proposed
	U-Factor: as specified in Table C402.1.4 with insulation layer on interior side of walls	As proposed
Floors, above-grade	Type: joist/framed floor	As proposed
	Gross area: same as proposed	As proposed
	U-factor: as specified in Table C402.1.4	As proposed
Floors, slab-on-grade	Type: unheated	As proposed
	F-factor: as specified in Table C402.1.4	As proposed
Opaque doors	Type: swinging	As proposed
	Area: Same as proposed	As proposed
	U-factor: as specified in Table C402.1.4	As proposed
Vertical fenestration other than opaque doors	Area 1. The proposed vertical fenestration area; where the proposed vertical fenestration area is less than 40 percent of above-grade wall area. 2. 40 percent of above-grade wall area; where the proposed vertical fenestration area is 40 percent or more of the above-grade wall area.	As proposed
	U-factor: as specified in Table C402.4	As proposed
	SHGC: as specified in Table C402.4 except that for climates with no requirement (NR) SHGC = 0.40 shall be used	As proposed
	External shading and PF: none	As proposed
Skylights	Area 1. The proposed skylight area; where the proposed skylight area is less than that permitted by Section C402.1. 2. The area permitted by Section C402.1; where the proposed skylight area exceeds that permitted by Section C402.1.	As proposed

	U-factor: as specified in Table C402.4	As proposed
	SHGC: as specified in Table C402.4 except that for climates with no requirement (NR) SHGC = 0.40 shall be used.	As proposed
Lighting, interior	The interior lighting power shall be determined in accordance with Section C405.3.2. Where the occupancy of the building is not known, the lighting power density shall be 1.0 watt per square foot based on the categorization of buildings with unknown space classification as offices.	As proposed
Lighting, exterior	The lighting power shall be determined in accordance with Tables C405.5.2(1), C405.5.2(2) and C405.5.2(3). Areas and dimensions of surfaces shall be the same as proposed.	As proposed
Internal gains	Same as proposed	Receptacle, motor and process loads shall be modeled and estimated based on the space use classification. End-use load components within and associated with the building shall be modeled to include, but not be limited to, the following: exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators, escalators, refrigeration equipment and cooking equipment.
Schedules	Same as proposed **Exception:** Thermostat settings and schedules for HVAC systems that utilize radiant heating, radiant cooling and elevated air speed, provided that equivalent levels of occupant thermal comfort are demonstrated by means of equal Standard Effective Temperature as calculated in Normative Appendix B of ASHRAE Standard 55.	Operating schedules shall include hourly profiles for daily operation and shall account for variations between weekdays, weekends, holidays and any seasonal operation. Schedules shall model the time-dependent variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads. The schedules shall be typical of the proposed building type as determined by the designer and approved by the jurisdiction.
Mechanical ventilation	Same as proposed	As proposed, in accordance with Section C403.2.2.
Heating systems	Fuel type: same as proposed design	As proposed
	Equipment type[a]: as specified in Tables C407.4.1(2) and C407.4.1(3)	As proposed
	Efficiency: as specified in the tables in Section C403.3.2.	As proposed
	Capacity[b]: sized proportionally to the capacities in the proposed design based on sizing runs, and shall be established such that no smaller number of unmet heating load hours and no larger heating capacity safety factors are provided than in the proposed design.	As proposed
Cooling systems	Fuel type: same as proposed design	As proposed
	Equipment type[c]: as specified in Tables C407.4.1(2) and C407.4.1(3)	As proposed
	Efficiency: as specified in Tables C403.3.2(1), C403.3.2(2) and C403.3.2(3)	As proposed
	Capacity[b]: sized proportionally to the capacities in the proposed design based on sizing runs, and shall be established such that no smaller number of unmet cooling load hours and no larger cooling capacity safety factors are provided than in the proposed design.	As proposed
	Economizer[d]: same as proposed, in	

	Economizer : same as proposed, in accordance with Section C403.5.	As proposed
Service water heating[e]	Fuel type: same as proposed	As proposed
	Efficiency: as specified in Table C404.2	For Group R, as proposed multiplied by SWHF. For other than Group R, as proposed multiplied by efficiency as provided by the manufacturer of the DWHR unit.
	Capacity: same as proposed	As proposed
	Where no service water hot water system exists or is specified in the proposed design, no service hot water heating shall be modeled.	
On-site Renewable Energy	Where a *system* providing *on-site renewable energy* has been modeled in the *proposed design* the same *system* shall be modeled identically in the *standard reference design* except the rated capacity shall meet the requirements of Section C405.13	As proposed
	Where no system is designed or included in the proposed design, model an unshaded photovoltaic system with the following characteristics:	
	Size: Rated capacity per Section C405.13	
	Module Type: Crystalline Silicon Panel with a glass cover, 19.1% nominal efficiency and temperature coefficient of -0.35%/°C, Performance shall be based on a reference temperature of 77°F (25°C), airmass of 1.5 atmosphere and irradiance of 317 Btu/h·ft^2 (1000 W/m^2).	
	Array Type: Rack mounted array with installed nominal operating cell temperature (INOCT) of 103°F (45°C).	
	Total System Losses (DC output to AC output): 11.3%.	
	Tilt: 0-degrees (mounted horizontally).	
	Azimuth: 180 degrees.	

For SI: 1 watt per square foot = 10.7 w/m^2.

SWHF = Service Water Heat Recovery Factor, DWHR = Drain Water Heat Recovery.

a. Where no heating system exists or has been specified, the heating system shall be modeled as fossil fuel. The system characteristics shall be identical in both the standard reference design and proposed design.

b. The ratio between the capacities used in the annual simulations and the capacities determined by sizing runs shall be the same for both the standard reference design and proposed design.

c. Where no cooling system exists or no cooling system has been specified, the cooling system shall be modeled as an air-cooled single-zone system, one unit per thermal zone. The system characteristics shall be identical in both the standard reference design and proposed design.

d. If an economizer is required in accordance with Table C403.5(1) and where no economizer exists or is specified in the proposed design, then a supply-air economizer shall be provided in the standard reference design in accordance with Section C403.5.

e. The SWHF shall be applied as follows:

1. Where potable water from the DWHR unit supplies not less than one shower and not greater than two showers, of which the drain water from the same showers flows through the DWHR unit then SWHF = [1 – (DWHR unit efficiency × 0.36)].
2. Where potable water from the DWHR unit supplies not less than three showers and not greater than four showers, of which the drain water from the same showers flows through the DWHR unit then SWHF = [1 – (DWHR unit efficiency × 0.33)].
3. Where potable water from the DWHR unit supplies not less than five showers and not greater than six showers, of which the drain water from the same showers flows through the DWHR unit, then SWHF = [1 – (DWHR unit efficiency × 0.26)].
4. Where Items 1 through 3 are not met, SWHF = 1.0.

Reason Statement: In order to meet the state's 2045 carbon neutrality goal, Virginia must not only reduce energy use through energy efficiency but also move to utility scale and on-site renewable energy. In 2020, renewable energy sources were responsible for 21% of U.S. electricity generation. In order to cost-effectively achieve Virginia's goal to achieve carbon neutrality by 2045, it is paramount to begin installing a nominal capacity of renewable energy on-site in all new buildings now. According to a recent study entitled "A New Roadmap for the Lowest Cost Grid", the least expensive grid involves a large amount of centralized renewables and a large amount of distributed renewables located on the building site. More renewables placed onsite can enable the efficient deployment of rapidly expanding utility-scale renewables. It is therefore crucial for new commercial buildings to install renewable energy on-site during new construction so that the U.S. can reach its 100% carbon-free power sector goal in the most cost-effective manner. Installing renewables on site will also allow building owners to economically benefit from the transition towards a low-carbon economy, to prepare their building for expansion of renewable capacity, and to benefit from additional resiliency during disruptions in centrally supplied power. In addition, this proposal will expand good paying jobs in one of the nation's fastest growing employment sectors. According to the Bureau of Labor Statistics, the two fastest growing occupations in the US in 2019 were solar PV installers and wind turbine service technician. The Interstate Renewable Energy Council estimates that to reach Biden's target of 100% renewable energy by 2035, the industry will need to employ three times the number of workers employed in 2020.
This code proposal change is based on approved ASHRAE addenda by, ck, and cp to Standard 90.1-2019 which will be published in ASHRAE Standard 90.1-2022 and a recent technical brief developed by PNNL in support of further revisions to 90.1. Proposed definitions clarify renewable energy requirements for community renewable energy facility, financial renewable power purchase agreement, physical power purchase agreement and renewable energy credits. The proposal more closelyaligns these definitions with language under consideration both in ASHRAE Standard 228P, The Standard Method of Evaluating Zero Energy Building Performance, and in ASHRAE Standard 189.1, which will be the basis of the 2024 IgCC.

The addenda establishes a prescriptive requirement for onsite renewable energy of 1.5W/s.f. of the three largest floors of all commercial buildings. The size of the required on-site renewable energy will supply on average 30% of building energy use. The recent technical brief from PNNL indicates there is enough roof space to meet this requirement for the vast majority of commercial buildings. If there is insufficient roof space or substantial shading, building owners are allowed to be exempted from on-site renewable energy requirements if they procure an equivalent amount of renewable energy off-site from a community renewable energy facility, a physical power purchase agreement or a financial power purchase agreement.

The proposal also requires building owners to retain any renewable energy credits (RECS) so that no other individual or organization can claim or take credit for the production from the system (thus preventing double-counting). REC documentation requirements are based on those currently in R406.7.3 of the 2021 IECC and 701.4.1.1.1 of the 2021 IgCC, and revisions pending for ASHRAE Standard 189.1-2023.

Finally, this proposal includes requirements to illustrate raceways used for the renewable energy system in construction documents and revises section C406.5 to prevent double-counting of the minimum renewable energy requirements in section C405.

References:

Renewables Became the Second-Most Prevalent U.S. Electricity Source in 2020 , U.S. Energy Information Administration, https://www.eia.gov/todayinenergy/detail.php?id=48896.

Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies, The White House, 22 Apr. 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/.

Why Local Solar For All Costs Less: A New Roadmap for the Lowest Cost Grid, Vibrant Clean Energy, Dec. 2020, www.vibrantcleanenergy.com/wp-content/uploads/2020/12/ https://irecusa.org/wp-content/uploads/2021/07/National-Solar-Jobs-Census-2020-FINAL.pdf. WhyDERs_ES_Final.pdf.

The National Solar Job Census 2020, Interstate Renewable Energy Council, May 2021, Richardson, Jake. Solar and Wind Tech Are the Fastest Growing Jobs in US, Red, Green, and Blue, 28 Jan. 2019, http://redgreenandblue.org/2019/01/27/solar-wind-tech-fastest-growing-jobs-us/.

ANSI/ASHRAE/IES Addendum by, ck, and cp to ANSI/ASHRAE/IES Standards 90.1-2019, ASHRAE Standards Committee, 31 July 2020, https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/90_1_2019_by_ck_cp_202007

Cost Impact: The code change proposal will increase the cost of construction
This proposed code change will increase cost of construction modestly for commercial buildings following the prescriptive pathway of the 2021 IECC. The following table lists the required size of the photovoltaic array and cost effectiveness of that array under this proposed code amendment for a set of prototype commercial buildings following the prescriptive pathway. Analysis of the approximate total installed costs for these photovoltaic system is estimated at $2.20/W based on analysis by NBI and partners. The annual energy cost savings in the first year of production are based on generation estimated by NREL's PVWatts in Minneapolis (which has below average solar radiation compared with the majority of the U.S.) and average U.S. electricity rates according to the U.S. EIA. The analysis indicates that this requirement would result in a payback time that is far less than the system lifetime.

	PV System Size (kW)	PV Cost/s.f.	Annual Energy Cost Savings	Simple Payback Period (yrs)
Small Business (3-story, 10,000 s.f.)	2.5	$5,070	$ 410	12.4
Multifamily High Rise (10-story, 80,000 s.f.)	6.0	$12,168	$1,383	8.8
Office (4-story, 50,000 s.f.)	9.4	$19,013	$ 1,536	12.4

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. As we see increasing number of severe weather events, the electric grid's ability to withstand these events will become increasingly important. Community resilience will be increasingly dependent on distributed generation, and more localized production can help buildings and communities keep power when other areas of the grid may be offline. This local production of power can support critical building functions – varying by building type and use during a resilience event – providing life supporting functions of small/at home medical devices that require on power, allowing for needed cell phone charging to stay in touch during an emergency, and literally keeping the lights on for safety and security.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved

☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: EC-C405.13-21

This proposal doesn't have any public comments.

Proposal # 1043

EC-C405.13– Staff Summary

Proponent: Ben Rabe (New Buildings Institute); Diana Burk (New Buildings Institute); Kimberly Newcomer (New Buildings Institute).

Brief Description:

The proposal adds requirements for minimum onsite renewable energy and requires building owners to retain any renewable energy credits (RECS).

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- Brian Clark (Habitat for Humanity)
- William Penniman (Sierra Club) *Note:* partial attendance only. Not in attendance at the time of voting but expressed support for the proposal in the Adobe Platform chat box prior to exiting the meeting room.

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Home Builders Association of Virginia)
- Steve Shapiro (AOBA/VAMA) *Note:* partial attendance only. Not in attendance at the time of voting but expressed opposition to the proposal in the Adobe Platform chat box prior to exiting the meeting room.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- KC Bleile (Viridiant)
- Laura Baker (RECA, alternate for Eric Lacey)

Energy Sub-Workgroup members not in attendance:

- Maggie Kelley Riggins (SEEA). *Note:* partial attendance. Stepped away during EC-C405.13-21 discussion and voting.
- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note:* partial attendance. Not in attendance during EC-C405.13-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during EC-C405.13-21 discussion and voting.
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Corey Caney: International Association of Electrical Inspectors, Virginia

Other stakeholders in attendance and supporting the proposal:

- Ross Shearer stated that the proposal should be supported. It is more useful of geographic space to place solar on roofs than in former farmland or other cleared areas.

Other stakeholders in attendance and opposing the proposal:

- John Ainslie (HBAV Alternate)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman (Sierra Club – Virginia Chapter)

Opposition:

Names: Steve Shapiro (AOBA/VAMA)

DHCD Staff Notes:

- The Energy Sub-Workgroup members did not provide any reasons for supporting or opposing the proposal.
- No specific reasons were offered by stakeholders for supporting or opposing the proposal during the General Stakeholders Workgroup meeting.

Meeting summaries and proposal related information: Tab 10 - Page 40; Tab 11 - Page 24.

EC-C405.13(2)-21

Proponents: DHCD Staff (sbco@dhcd.virginia.gov)

2021 International Energy Conservation Code

Add new text as follows:

AUTOMOBILE PARKING SPACE. A space within a building or private or public parking lot, exclusive of driveways, ramps, columns, office and work areas, for the parking of an automobile.

ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, and electric motorcycles, primarily powered by an electric motor that draws current from a building electrical service, EVSE, a rechargeable storage battery, a fuel cell, a photovoltaic array, or another source of electric current.

ELECTRIC VEHICLE SUPPLY EQUIPMENT INSTALLED SPACE (EVSE space). An *automobile parking space* that is provided with a dedicated *EVSE* connection.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). Equipment for plug-in power transfer including the ungrounded, grounded and equipment grounding conductors, and the *electric vehicle* connectors, attachment plugs, personal protection system and all other fittings, devices, power outlets or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the *electric vehicle* .

C405.13 Electric Vehicle Power Transfer Infrastructure. New parking facilities for R-2 occupancies with 50 units or more shall be provided with *electric vehicle* power transfer infrastructure in compliance with Sections C405.13.1 through C405.13.6.

C405.13.1 Quantity. The number of required *EV spaces* shall be determined in accordance with Table C405.13.1, the Table requirements shall be based on the total number of dwelling units or the total number of automobile parking spaces, whichever is less.

Table C405.13.1 REQUIRED EV POWER TRANSFER INFRASTRUCTURE.

OCCUPANCY	EVSE SPACES
GROUP R-2	10%

C405.13.2 EVSE Spaces. An installed *EVSE* with multiple output connections shall be permitted to serve multiple *EVSE spaces*. Each *EVSE* installed to meet the requirements of Section C405.13.1, serving either a single *EVSE space* or multiple *EVSE spaces*, shall comply with all of the following:

1. Have a minimum circuit capacity in accordance with C405.13.3.
2. Be located within 3 feet (914 mm) of each *EVSE space* it serves.
3. Be installed in accordance with Section C405.13.3.

C405.13.2.1 EVSE Minimum Charging Rate.

Each installed EVSE shall comply with one of the following:

1. Be capable of charging at a minimum rate of 6.2 kVA (or 30A at 208/240V).
2. When serving multiple *EVSE spaces* and controlled by an energy management system providing load management, be capable of simultaneously charing each *EVSE space* at a minimum rate of no less than 3.3 kVA.
3. When serving *EVSE spaces* allowed to have a minimum circuit capacity of 2.7 kVA in accordance with C405.13.3.1 and controlled by an energy management system providing load management, be capable of simultaneously charging each *ESVE space* at a minimum rate of no less than 2.1 kVA.

C405.13.3 Circuit Capacity. The capacity of electrical infrastructure serving each *EV space* shall have a branch circuit with a rated capacity not less than 8.3 kVA (or 40A at 208/240V) for each *EVSE space* it serves.

C405.13.3.1 Circuit Capacity Management. The capacity of each branch circuit serving multiple EVSE spaces designed to be controlled by an energy management system providing load management in accordance with NFPA 70, shall comply with one of the following:

1. Have a minimum capacity of 4.1 kVA per space.
2. Have a minimum capacity of 2.7 kVA per space when serving *EVSE spaces* for R-2 occupancies when all (100%) of the automobile parking spaces designated for R-2 occupancies are designed to be *EVSE spaces*.

3. Have a minimum capacity of 2.7 kVA per space when serving *EVSE spaces* for a building site when all (100%) of the automobile parking spaces are designed to be *EVSE spaces*.

C405.13.4 EVSE Installation. *EVSE* shall be installed in accordance with NFPA 70 and shall be listed and labeled in accordance with UL 2202 or UL 2594. *EVSE* shall be accessible in accordance with International Building Code Section 1107.

AUTOMOBILE PARKING SPACE. A space within a building or private or public parking lot, exclusive of driveways, ramps, columns, office and work areas, for the parking of an automobile.

Revise as follows:

ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, and electric motorcycles, primarily powered by an electric motor that draws current from a building electrical service, EVSE, a rechargeable storage battery, a fuel cell, a photovoltaic array, or another source of electric current.

Add new text as follows:

ELECTRIC VEHICLE SUPPLY EQUIPMENT INSTALLED SPACE (EVSE space). An *automobile parking space* that is provided with a dedicated *EVSE* connection.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). Equipment for plug-in power transfer including the ungrounded, grounded and equipment grounding conductors, and the *electric vehicle* connectors, attachment plugs, personal protection system and all other fittings, devices, power outlets or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the *electric vehicle* .

R404.4 Electric Vehicle Power Transfer Infrastructure. New parking facilities for R-2 occupancies with 50 units or more shall be provided with *electric vehicle* power transfer infrastructure in compliance with Sections R404.4.1 through R404.4.4.

R404.4.1 Quantity. The number of required *EV spaces* shall be determined in accordance with Table R404.4.1, the Table requirements shall be based on the total number of dwelling units or the total number of automobile parking spaces, whichever is less.

Table R404.4.1 REQUIRED EV POWER TRANSFER INFRASTRUCTURE.

OCCUPANCY	EVSE SPACES
GROUP R-2	10%

R404.4.2 EVSE Spaces. An installed *EVSE* with multiple output connections shall be permitted to serve multiple *EVSE spaces*. Each *EVSE* installed to meet the requirements of Section R404.4.1, serving either a single *EVSE space* or multiple *EVSE spaces*, shall comply with all of the following:

1. Have a minimum circuit capacity in accordance with R404.4.3.
2. Be located within 3 feet (914 mm) of each *EVSE space* it serves.
4. Be installed in accordance with Section R404.4.4.

R404.4.2.1 EVSE Minimum Charging Rate. Each installed EVSE shall comply with one of the following:

1. Be capable of charging at a minimum rate of 6.2 kVA (or 30A at 208/240V).
2. When serving multiple *EVSE spaces* and controlled by an energy management system providing load management, be capable of simultaneously charing each *EVSE space* at a minimum rate of no less than 3.3 kVA.
3. When serving *EVSE spaces* allowed to have a minimum circuit capacity of 2.7 kVA in accordance with R404.4.3.1 and controlled by an energy management system providing load management, be capable of simultaneously charging each *ESVE space* at a minimum rate of no less than 2.1 kVA.

R404.4.3 Circuit Capacity. The capacity of electrical infrastructure serving each *EV space* shall have a branch circuit with a rated capacity not less than 8.3 kVA (or 40A at 208/240V) for each *EVSE space* it serves.

R404.4.3.1 Circuit Capacity Management. The capacity of each branch circuit serving multiple EVSE spaces designed to be controlled by an energy management system providing load management in accordance with NFPA 70, shall comply with one of the following:

1. Have a minimum capacity of 4.1 kVA per space.
2. Have a minimum capacity of 2.7 kVA per space when serving *EVSE spaces* for R-2 occupancies when all (100%) of the automobile parking spaces designated for R-2 occupancies are designed to be *EVSE spaces*.
3. Have a minimum capacity of 2.7 kVA per space when serving *EVSE spaces* for a building site when all (100%) of the automobile parking spaces are designed to be *EVSE spaces*.

R404.4.4 **EVSE Installation.** *EVSE* shall be installed in accordance with NFPA 70 and shall be listed and labeled in accordance with UL 2202 or UL 2594. *EVSE* shall be accessible in accordance with International Building Code Section 1107.

Reason Statement: This proposal was created by staff in response to a request from Delegates Reid and Bulova (letter attached) to "...make EV purchases a viable option for residents of multi-family dwelling units...". The proposal is partly based on CEPI-1-21, submitted for the 2024 IECC, but has been revised in several ways, including only addressing multi-family dwellings.

Cost Impact: The code change proposal will increase the cost of construction
This proposal will increase the cost of construction.

Resiliency Impact Statement: This proposal will increase Resiliency

Attached Files

- **LETTER-EV_Charging_Readiness_(1) (1).pdf**
  https://va.cdpaccess.com/proposal/1143/1573/files/download/670/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: EC-C405.13(2)-21

This proposal doesn't have any public comments.

Proposal # 1143

EC-C405.13(2)-21 – Staff Summary

Proponent: DHCD Staff

Brief Description:

The proposal requires at least 10% of the parking spaces in Group R-2 occupancies to be Electric Vehicle Supply Equipment Installed Spaces.

STUDY GROUP OR SUB-WORKGROUP INFORMATION.

The proposal was intended to be discussed at the May 12th, 2022 Energy Sub-Workgroup meeting but was carried over to the May 19th, 2022 Energy Sub-Workgroup Meeting.

At the May 19th meeting, to be consistent with positions on similar proposals (EC-C405.10 and EC-C405.11.1), the Sub-Workgroup members requested for the proposal to be carried over so that stakeholders can continue collaborating up until the Workgroup meeting.

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Ben Rabe, NBI; William Penniman, Sierra Club - Virginia Chapter; Dan Willham, Fairfax County; Eric Lacey, representing self.

- Ben Rabe (NBI) stated that he supports this proposal and all EV proposals being considered.
- William Penniman (Sierra Club) stated that, as a proponent of other EV proposals, he supports this proposal as well because he believes something should go forward that deals with EV spaces.
- Dan Willham, Fairfax County, supported the concept in general. However, the 2021 ICC appeals board ruled this out of scope since it was not actually energy conservation. If this does go forward, it would have to be determined where exactly to put it in the code, considering that it isn’t an energy-conservation measure.
- Eric Lacey, representing self, indicated that as a Virginia resident, he doesn’t think it is a good idea to wait three more years to implement EV readiness. The ICC appeal was more of a technicality. Electric Vehicles are not just the future, they are here now. It will be harder to address as more time goes by.

Opposition:

Names: Steve Shapiro, AOBA and VAMA; David Beahm, Warren County; Sarah Thomas, Virginia Association for Commercial Real Estate

- Steve Shapiro stated that AOBA and VAMA are in opposition to this EV proposal as well as all other EV proposals and raised concerns regarding the fire safety of these spaces, which, he argues, need to be considered and integrated into the other EV proposals.

- Andrew Clark, HBAV, expressed opposition to the proposal, agreed with Steve Shapiro's comments and noted that even though EV may be the way to go in the future, more discussion is needed to ensure that the codes address all concerns.
- David Beahm, Warren County, agreed with the previous commenters and also raised concerns about accessible parking.

DHCD Staff Notes:

- Please note there is a similar proposal, EC-C405.10-21, related to EV charging for multi-family buildings. Only one of these proposals should be approved if the board chooses to do so. There is also a commercial version of this proposal, EC-C405.11.1. These proposals can be considered independently.
- The proposal was created by staff in response to a request from Delegates Reid and Bulova (letter attached) to "...make EV purchases a viable option for residents of multi-family dwelling units..."

Meeting summaries and proposal related information: Tab 10 - Page 76; Tab 11 - Page 36; Tab 11 - Page 42.

Commonwealth of Virginia

General Assembly
RICHMOND

March 25th, 2021

Director Erik Johnston
Department of Housing and Community Development
Virginia Uniform Statewide Building Code
600 East Main Street #300
Richmond, VA, 23219

SUBJ: Virginia Uniform Statewide Building Code Updates - Electric Vehicle Charging Readiness

Dear Director Johnston:

As the Commonwealth continues the transition from fossil fuels to electric vehicles (EV), all aspects of the charging infrastructure need to be addressed. Several companies are making investments in roadside and destination charging; convenience stores and malls are using EV charging as a way to draw in customers for longer stays; and at-home, single-family charging installations are now more easily available for homeowners. However, for residents in either townhome communities, condominiums, or apartments, gaining access to EV charging is not readily available. The lack of charging infrastructure in these communities limits EV adoption and also limits the choices these individuals can make when purchasing a new or used vehicle.

In order to better accommodate the rising number of EV owners in Virginia and to make EV purchases a viable option for residents of multi-family dwelling units, we recommend and encourage DHCD to update the Virginia Uniform Statewide Building Code (USBC) to:

- Require that new multi-family dwelling units with 50 units or more set-aside at least 10% of their parking spaces for EV charging
- Make these spaces ready for EV charging during the design and construction process
- Provide electrical room/breaker box areas designed to accommodate the electrical equipment and distribution wiring to provide a minimum of a Level 2 chargers as defined by DoE (https://www.energy.gov/eere/electricvehicles/vehicle-charging) at each of the set-aside parking spaces

Apartment owners, condo associations, or homeowner associations may then negotiate with EV charging providers for installation, maintenance, and revenue sharing. We believe these measures will support the strategic goals outlined in the Virginia Energy Plan and Virginia Clean Economy Act; help to reduce carbon emissions in the transportation sector; facilitate EV purchases in Virginia; and allow residents of multi-family dwelling units to make purchase decisions on par with residents of single-family homes.
Sincerely,

David A. Reid
Delegate (VA-32)

David Bulova
Delegate (VA-37)

EC-C405.13(3)-21

Proponents: Ben Rabe (ben@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

AUTOMOBILE PARKING SPACE. A space within a building or private or public parking lot, exclusive of driveways, ramps, columns, office and work areas, for the parking of an automobile.

ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, and electric motorcycles, primarily powered by an electric motor that draws current from a building electrical service, EVSE, a rechargeable storage battery, a fuel cell, a photovoltaic array, or another source of electric current.

Revise as follows:

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). Equipment for plug-in power transfer including the ungrounded, grounded and equipment grounding conductors, and the *electric vehicle* connectors, attachment plugs, personal protection system and all other fittings, devices, power outlets or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the *electric vehicle* .

Add new text as follows:

ELECTRIC VEHICLE SUPPLY EQUIPMENT INSTALLED SPACE (EVSE space). An *automobile parking space* that is provided with a dedicated *EVSE* connection.

ELECTRIC VEHICLE CAPABLE SPACE (EV CAPABLE SPACE). A designated *automobile parking space* that is provided with electrica l i nfrastructure, such as, but not limited to, raceways, cables, electrical capacity, and panelboard or other electrical distribution equipment space, necessary for the future installation of an *EVSE* .

ELECTRIC VEHICLE READY SPACE (EV READY SPACE). An *automobile parking space* that is provided with a branch circuit and either an outlet, junction box or receptacle, that will support an installed *EVSE* .

C405.13 Electric Vehicle Power Transfer Infrastructure. New parking facilities shall be provided with *electric vehicle* power transfer infrastructure i n compliance with Sections C405.13.1 through C405.13.6.C405.13.1 Quantity . The number of required *EV spaces* , *EV capable spaces* and *EV ready spaces* shall be determined in accordance with this Section and Table C405.13.1 based on the total number of *automobile parking spaces* and shall be rounded up to the nearest whole number. For R- 2 buildings, the Table requirements shall be based on the total number of dwelling units or the total number of automobile parking spaces, whichever is less.

1. Where more than one parking facility is provided on a building site, the number of required *automobile parking spaces* required to have *EV* power transfer infrastructure shall be calculated separately for each parking facility.

2. Where one shared parking facility serves multiple building occupancies, the required number of spaces shall be determined proportionally based on the floor area of each building occupancy.

3. Installed *EVSE* spaces that exceed the minimum requirements of this section may be used to meet minimum requirements for *EV readyspaces* and *EV capable spaces* .

4. Installed *EV ready spaces* that exceed the minimum requirements of this section may be used to meet minimum requirements for *EV capablespaces* .**5.** Where the Where all (100%) parking serving R-2 occupancies are *EV ready spaces* , requirements for *EVSE spaces* for R-2 occupancies shall not apply.

5. Where the number of EV ready spaces allocated for R-2 occupancies is equal to the number of dwelling units or to the number of automobile parking spaces allocated to R-2 occupancies, whichever is less, requirements for EVSE spaces for R-2 occupancies shall not apply .

6. Requirements for a Group S-2 parking garage shall be determined by the occupancies served by that parking garage. Where new automobile spaces do not serve specific occupancies, the values for Group S-2 parking garage in Table C405.13.1 shall be used

Exception: Parking facilities, serving occupancies other than R2 with fewer than 10 automobile parking spaces.

Table C405.13.1 REQUIRED EV POWER TRANSFER INFRASTRUCTURE

OCCUPANCY	EVSE SPACES	EV READY SPACES	EV CAPABLE SPACES
GROUP A	10%	0%	10%
GROUP B	15%	0%	30%
GROUP E	2%	0%	5%
GROUP F	2%	0%	5%
GROUP H	1%	0%	0%
GROUP I	2%	0%	5%
GROUP M	10%	0%	10%
GROUP R-1	20%	5%	75%
GROUP R-2	20%	5%	75%
GROUP R-3 AND R-4	2%	0%	5%
GROUP S exclusive of parking garages	1%	0%	0%
GROUP S-2 parking garages	1%	0%	0%

C405.13.2 EV Capable Spaces . Each *EV capable space* used to meet the requirements of Section C405.13.1 shall comply with all of the following:

1. A continuous raceway or cable assembly shall be installed between an enclosure or outlet located within 3 feet (914 mm) of the *EV capablespace* and a suitable panelboard or other onsite electrical distribution equipment.

2. Installed raceway or cable assembly shall be sized and rated to supply an minimum circuit capacity in accordance with C405.13.5

3 The electrical distribution equipment to which the raceway or cable assembly connects shall have sufficient dedicated space and spare electrical capacity for a 2-pole circuit breaker or set of fuses.

4. The electrical enclosure or outlet and the electrical distribution equipment directory shall be marked: "For future *electric vehicle supplyequipment* (EVSE)."

5. Reserved capacity shall be no less than 4.1 kVA (20A 208/240V) for each *EV capable space* .

C405.13.3 EV Ready Spaces . Each branch circuit serving EV ready spaces used to meet the requirements of Section C405.13.1 shall comply with all of the following:

1. Terminate at an outlet or enclosure, located within 3 feet (914 mm) of each *EV ready space* it serves.

2. Have a minimum circuit capacity in accordance with C405.13.5.

3. The panelboard or other electrical distribution equipment directory shall designate the branch circuit as "For electric vehicle supply equipment (EVSE)" and the outlet or enclosure shall be marked "For electric vehicle supply equipment (EVSE)."

C405.13.4 EVSE Spaces . An installed *EVSE* with multiple output connections shall be permitted to serve multiple *EVSE spaces* . Each *EVSE* installed to meet the requirements of Section C405.13.1, serving either a single *EVSE space* or multiple *EVSE spaces* , shall comply with all of the following:

1. Have a minimum circuit capacity in accordance with C405.13.5.

2. Have a minimum charging rate in accordance with C405.13.4.1.

3. Be located within 3 feet (914 mm) of each *EVSE space* it serves.

4. Be installed in accordance with Section C405.13.6.

C405.13.4.1 EVSE Minimum Charging Rate . Each installed EVSE shall comply with one of the following:

1. Be capable of charging at a minimum rate of 6.2 kVA (or 30A at 208/240V).

2. When serving multiple *EVSE spaces* and controlled by an energy management system providing load management, be capable of simultaneously charging each *EVSE space* at a minimum rate of no less than 3.3 kVA.

3. When serving *EVSE spaces* allowed to have a minimum circuit capacity of 2.7 kVA in accordance with C405.13.5.1 and controlled by an energy management system providing load management, be capable of simultaneously charging each *ESVE space* at a minimum rate of no l ess than 2.1 kVA.

C405.13.5 Circuit Capacity . The capacity of electrical infrastructure serving each *EV capable space* , *EV ready space* , and *EVSE space* shal l comply with one of the following:

1. A branch circuit shall have a rated capacity not less than 8.3 kVA (or 40A at 208/240V) for each *EV ready space* or *EVSE space* it serves.

2. The requirements of C405.13.5.1.

C405.13.5.1 Circuit Capacity Management . The capacity of each branch circuit serving multiple EVSE spaces, EV ready spaces or EV capable spaces designed to be controlled by an energy management system providing load management in accordance with NFPA 70, shall comply with one of the following:

1. Have a minimum capacity of 4.1 kVA per space.

2. Have a minimum capacity of 2.7 kVA per space when serving *EV ready spaces* or *EVSE spaces* for a building site when all (100%) of the automobile parking spaces are designed to be *EV ready* or *EVSE spaces* .

C405.13.6 EVSE Installation . *EVSE* shall be installed in accordance with NFPA 70 and shall be listed and labeled in accordance with UL 2202 or UL 2594. *EVSE* shall be accessible in accordance with International Building Code Section 1107.

Revise as follows:

UL

UL LLC
333 Pfingsten Road
Northbrook, IL 60062-2096

2202-2009 *Electric Vehicle (EV) Charging System- with revisions through February*

Add new text as follows:

UL

UL LLC
333 Pfingsten Road
Northbrook, IL 60062

2594-2016 *Standard for Electric Vehicle Supply Equipment*

Reason Statement: Preparing our buildings for safe and convenient EV charging infrastructure is critical to deployment of electric vehicles. The transportation sector is the single largest source of GHG emissions in the nation. Near complete electrification of the transportation sector is necessary to achieve the GHG emission reductions needed to avoid the worst effects of climate change.
Electric vehicle sales increased by 80 percent from 2017 to 2018, and is expected to grow from 1 million vehicles at the end of 2018 to 18.7 million by 2030. As newer EVs with longer drive ranges enter the market, the older, shorter drive range EVs will move to the used vehicle market, and become readily accessible to a secondary market for which the accessibility of EV charging infrastructure at home and at work will be critical.

Inclusion in the IECC of EV Infrastructure requirements is critical in the prevention of the use of extension cords to inappropriate outlets for the purpose of vehicle charging. We must be building structures that will address the vehicles that the major automakers have already shown us they are producing, especially as they close out the production of ICE vehicles and switch to total EV manufacturing.

Buildings built in 2022 should last 50 years. By 2045 Ernst & Young predicts internal combustion engine (ICE) vehicles will make up less than 1% of new car sales globally. Bloomberg reports that the automakers' capital expenditures on capital equipment for electric vehicle manufacturing is important because it is the culmination of a manufacturer's multi-year exploration of the future; "Capex is Destiny." *

Shouldn't we be building structures to accommodate the vehicles that the automakers are telling us they are switching to? Shouldn't we be installing the infrastructure when it is least expensive to install? Shouldn't we be addressing the single largest source of GHG emissions?

Cost Impact: The code change proposal will increase the cost of construction
Recent analysis by NBI and partners using cost data from RSMeans and the PNNL medium office prototype found that the average total cost of an EVSE space in a commercial parking lot was $4702: $1558 in materials and $3145 in labor. These costs include a dual-head commercial Clipper Creek EVSE mounted on a commercial pedestal, raceways, and all electrical conductors. If the electrical panel and onsite transformer have to be upsized – something that will only happen on some projects – there would be an additional cost of $1200 per space.

Using the same prototype and data sources, each EV capable space required an additional cost of $123 per space for conduit (assuming an average 100' run) and junction boxes if no capacity upgrade is required. If the panel and onsite transformer have to upsized to accommodate design loads, then that cost could increase by $1200 per space.

However, with the future demand for EVs and EV charging discussed in the reason statement, commercial parking facilities that do not include EV spaces during new construction will face substantially higher costs to retrofit those spaces in the future. For example, a cost-effectiveness study for the City and County of San Francisco conducted by Pacific Gas & Electric (PG&E) showed that the cost of an EV Ready space (full circuit for level 2 charging) installed during new construction was $860-$920, while a retrofit would cost $2370-$3710,[1] 3-4 times the cost. An analysis conducted by the California Air Resource Board found much higher cost savings of $7000 from avoided retrofit costs when EV spaces are installed during construction rather than retrofit, with the majority of the cost delta due to the cost of retrenching parking lots and doing costly panel and transformer upgrades.[2] The EV Capable spaces required by this proposal avoid nearly all of these incremental retrofit costs by including the most difficult elements to retrofit (trenching and panels) during new construction.

These EV chargers will also yield substantial economic benefits for both the individual that owns the EV and the building owner. For individuals, EVs cost much less to fuel and maintain than gas-powered vehicles. According to AAA, an electric vehicle (EV) will save roughly $1,039 per year in total fuel and maintenance costs compared to a comparable gasoline vehicle. Although Electric Vehicles are often more expensive than gasoline powered vehicles, Bloomberg New Energy Finance on battery costs suggests EVs could reach upfront cost parity with gasoline vehicles by the early-to-mid 2020s. For building owners, installing EV chargers will increase property values, attract new customers or tenants and improve staff and tenant retention.

With the growing market demand for EVs and the growing demand for charging they create, it not a question of if EV spaces will be needed, but when. Building owners and tenants will be paying for this cost now or in the future.   Failing to install a minimal number of EVSE spaces and EV capable spaces now will saddle building owners and tenants with substantially higher costs due to costly future retrofits.

Resiliency Impact Statement: This proposal will increase Resiliency
As electric vehicles (EVs) become more prevalent (as noted in reason statement) they will provide a valuable resource to the electric grid. EVs will essentially become mobile batteries available to the grid to help absorb load at renewable peak generation, or supply buildings to help smooth load peak demand or during emergency events. Beyond their contribution to the buildings they plug into and the grid they interact with, EVs will remove another direct combustion source from climate equation, helping prevent the worst impacts of climate change. Providing charging infrastructure to new commercial and multifamily building will help speed the EV transition.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: EC-C405.13(3)-21

This proposal doesn't have any public comments.

EC-C405.13(3)-21 – Staff Summary

Proponent: Ben Rabe (New Buildings Institute); Diana Burk (New Buildings Institute); Kimberly Newcomer (New Buildings Institute).

Brief Description:

The proposal requires new parking facilities to be provided with electric vehicle power transfer infrastructure (electric vehicle charging), with specific percentages of spaces dedicated to Electric Vehicle Supply Equipment Spaces, Electric Vehicle Ready Spaces, and Electric Vehicle Capable Spaces, with each occupancy requiring different percentages.

STUDY GROUP OR SUB-WORKGROUP INFORMATION.

The proposal was intended to be discussed at the May 12th, 2022 Energy Sub-Workgroup meeting but was carried over to the May 19th, 2022 Energy Sub-Workgroup Meeting and the proponent subsequently decided to continue discussions with stakeholders offline. No sub-workgroup determination was made with respect to this proposal.

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Ben Rabe, NBI

Opposition:

Names: Steve Shapiro, AOBA and VAMA; Andrew Clark, HBAV; David Beahm, Warren County

DHCD Staff Notes:

The proposal is very similar in nature with proposal EC-C405.13(2)-21. The feedback from stakeholders consisted of expressing support or opposition and rested on previous statements.

Comments from EC-C405.13(2)-21 discussions have been reproduced here for convenience:

Support:

Names: Ben Rabe, NBI; William Penniman, Sierra Club - Virginia Chapter; Dan Willham, Fairfax County; Eric Lacey, representing self.

- Ben Rabe (NBI) stated that he supports this proposal and all EV proposals being considered.
- William Penniman (Sierra Club) stated that, as a proponent of other EV proposals, he supports this proposal as well because he believes something should go forward that deals with EV spaces.
- Dan Willham, Fairfax County, supported the concept in general. However, the 2021 ICC appeals board ruled this out of scope since it was not actually energy conservation. If this does go

forward, it would have to be determined where exactly to put it in the code, considering that it isn't an energy-conservation measure.

- Eric Lacey, representing self, indicated that as a Virginia resident, he doesn't think it is a good idea to wait three more years to implement EV readiness. The ICC appeal was more of a technicality. Electric Vehicles are not just the future, they are here now. It will be harder to address as more time goes by.

Opposition:

Names: Steve Shapiro, AOBA and VAMA; David Beahm, Warren County; Sarah Thomas, Virginia Association for Commercial Real Estate

- Steve Shapiro stated that AOBA and VAMA are in opposition to this EV proposal as well as all other EV proposals and raised concerns regarding the fire safety of these spaces, which, he argues, need to be considered and integrated into the other EV proposals.
- Andrew Clark, HBAV, expressed opposition to the proposal, agreed with Steve Shapiro's comments and noted that even though EV may be the way to go in the future, more discussion is needed to ensure that the codes address all concerns.
- David Beahm, Warren County, agreed with the previous commenters and also raised concerns about accessible parking.

Meeting summaries and proposal related information: Tab 10 - Page 77; Tab 11 - Page 36; Tab 11 - Page 42.

EC-C405.16-21

Proponents: Ben Rabe (ben@newbuildings.org); Diana Burk (diana@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

C103.2.2 Electrification system. The construction documents shall provide details for additional electric infrastructure, including branch circuits, conduit, or pre-wiring, and panel capacity in compliance with the provisions of this code.

Revise as follows:

C105.2.5 Electrical system. Inspections shall verify lighting system controls, ~~components and~~ components meters , and additional electric infrastructure as required by the code, *approved* plans and specifications.

Add new text as follows:

ALL-ELECTRIC BUILDING. A *building* that contains no *combustion equipment* , or plumbing for *combustion equipment,* installed within the *building* or *building site.*

APPLIANCE. A device or apparatus that is manufactured and designed to utilize energy and for which this code provides specific requirements.

COMBUSTION EQUIPMENT. Any *equipment* or *appliance* used for space heating, *service water heating* , cooking, clothes drying and/or lighting that uses *fuel gas* or *fuel oil* .

COMMERCIAL COOKING APPLIANCES. Appliances used in a commercial food service establishment for heating or cooking food and which produce grease vapors, steam, fumes, smoke or odors that are required to be removed through a local exhaust ventilation system. Such appliances include deep fat fryers, upright broilers, griddles, broilers, steam-jacketed kettles, hot-top ranges, under-fired broilers (charbroilers), ovens, barbecues, rotisseries, and similar appliances. For the purpose of this definition, a food service establishment shall include any building or a portion thereof used for the preparation and serving of food.

EQUIPMENT. Piping, ducts, vents, control devices and other components of systems other than appliances that are permanently installed and integrated to provide control of environmental conditions for buildings. This definition shall also include other systems specifically regulated in this code.

FUEL GAS. A natural gas, manufactured gas, liquified petroleum gas or a mixture of these.

FUEL OIL. Kerosene or any hydrocarbon oil having a flash point not less than 100°F (38°C).

MIXED-FUEL BUILDING. A *building* that contains *combustion equipment* or includes piping for such *equipment* .

C405.16 Additional electric infrastructure. C405.16 Additional electric infrastructure. Buildings that contain *combustion equipment* and end-uses shall be required to install electric infrastructure in accordance with this section.

C405.16.1 Electric infrastructure for dwelling and sleeping units. *Combustion equipment* and end-uses serving individual *dwelling units* or *sleeping units* shall comply with Section R404.6.

C405.16.2 Combustion space heating. Space heating *equipment* that uses *fossil fuels* shall comply with either C405.16.2.1 or C405.16.2.2

C405.16.2.1Unitized heating. Warm-air furnaceswith a capacitylessthan 225,000 Btu/handgas- and oil-fired boilerswith a capacitylessthan 400,000 Btu/hshall be provided with a designated exterior location(s) in accordance with the following:

a. Natural drainage for condensate from cooling equipment operationor a condensate drain located within 3 feet (914 mm)of the location of the space heating equipment, and

b. A dedicated branch circuit in compliance withNFPA70 Section 424.4based on heat pump space heating equipment sized in accordance withthe requirements of ANSI/ASHRAE/IES Standard 90.1,Section 6.4.2 and terminating within 3 feet (914 mm) of the locationof the space heating equipmentwith no obstructions. Both ends of the branch circuit shall be labeled “For Future Heat Pump Space Heater.”

Exception to C405.16.2.1(b): Where an electrical circuit in compliance withNFPA70 Sections 440.4(B) and 440.35exists for space cooling equipment.

C405.16.2.2Central heating. All other space heating*equipment* shall be provided with conduit that is continuous between a junction box located within 3 feet (914 mm) of the*equipment* and an electrical panel. The junction box, conduit and bus bar in the electrical panel shall be rated and sized to accommodate a branch circuit with sufficient capacity for an equivalent electric*equipment* with an equivalent equipmentcapacity. The electrical junction box and electrical panel shall have labels stating, “ForFutureElectricSpace HeatingEquipment”.

C405.16.3 Combustion water heating .Water heating *equipment* that uses*fossil fuels* shall comply with either C405.16.3.1 or C405.16.3.2

C405.16.3.1Unitizedwater heating .Water heaters with a capacity less than 300,000 Btu/h (88 kW) shall be installed in accordance with the following:

1. A dedicated 208/240-volt branch circuit with a minimum capacity of 30 amps shall terminate within 3 feet (914 mm) from the water heater and be accessible to the water heater with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Heat Pump Water Heater" and be electrically isolated,

2. A condensate drain that is no more than 2 inches (51 mm) higher than the base of the installed water heater and allows natural draining without pump assistance shall be installed within 3 feet (914 mm) of the water heater,

3. The water heater shall be installed in a space with minimum dimensions of 3 feet (914 mm) by 3 feet (914 mm) by 7 feet (2134 mm) high, and

4. The water heater shall be installed in a space with a minimum volume of 700 cubic feet (20,000 L) or the equivalent of one 16-inch (406 mm) by 24-inch (610 mm) grill to a heated space and one 8-inch (203 mm) duct of no more than 10 feet (3048 mm) in length for cool exhaust air.

C405.16.3.2Central water heating. Water heaters with a capacitygreaterthanor equal to300,000 Btu/h (88 kW) shall beprovided withthe following:

1. Conduit that is continuous between a junction box located within 3 feet (914 mm) of the*equipment* and an electrical panel. The junction box, conduit and bus bar in the electrical panel shall be rated and sized to accommodate a branch circuit with sufficient capacity for an equivalent electric*equipment* with an equivalent equipment capacity. The electrical junction box and electrical panel shall have labels stating, “For Future ElectricWater HeatingEquipment”, and

2. A condensate drain that is no more than 2 inches (51 mm) higher than the base of the installed water heater and allows natural draining without pump assistance shall be installed within 3 feet (914 mm) of the water heater,

C405.16.4 Combustion cooking. Cooking *equipment* thatuse*fossil fuel* shall comply with either C405.16.4.1 orC405.16.4.2

C405.16.4.1 Commercial cooking.*Commercial cooking appliances* shall be provided with a dedicated branch circuit with a minimum capacity of 12 kVA per 1kBtuof appliance input capacity. The branch circuit shall terminate within 3 feet (914 mm) of the appliance with no obstructions. Both ends of the branch circuit shall be labeled with the words “For Future Electric Cooking Equipment” and be electrically isolated.

C405.16.4.2Light and medium dutycooking. Light-and mediumduty cooking *equipment* not designated as*commercial cooking appliances* shall be provided with a dedicated branch circuitin compliance with NFPA 70 Section422.10. The branch circuitshall terminate within 6 feet (1829 mm) of*fossil fuel* ranges, cooktops and ovens and be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words “For Future ElectricCookingEquipment” and be electrically isolated.

C405.16.5 Combustion clothes drying .Clothes drying *equipment* that use*fossil fuels* shall comply with either C405.16.5.1 or C405.16.5.2

C405.16.5.1 Commercial drying. Clothes drying*equipment*, and end-usesfor commercial laundry applicationsshall be provided with conduit that is continuous between a junction box located within 3 feet (914 mm) of the*equipment* and an electrical panel. The junction box, conduit and bus bar in the electrical panel shall be rated and sized to accommodate a branch circuit with sufficient capacity for an equivalent electric*equipment* with an equivalent equipment capacity. The electrical junction box and electrical panel shall have labels stating, “For Future ElectricClothes DryingEquipment”, and

C405.16.5.2 Residential drying. Clothes drying*equipment*, *appliances*, and end-uses serving multiple*dwelling units* or sleeping areaswith a capacity less thanor equal to9.2 cubicfeetshall be provided withadedicated 240-volt branch circuit with a minimum capacity of 30 amps shall terminate within 6 feet (1829 mm) of*fossil fuel* clothes dryers and shall be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words “For Future Electric Clothes DryingEquipment” and be electrically isolated.

Revise as follows:

C406.1 Additional energy efficiency credit requirements. New *all-electric buildings* shall achieve a total of 10 ~~credits~~ credits and new *mixed-fuel buildings* shall achieve a total of 15 credits from Tables C406.1(1) through C406.1(5) where the table is selected based on the use group of the building and from credit calculations as specified in relevant subsections of Section C406. Where a building contains multiple-use groups, credits from each use group shall be weighted by floor area of each group to determine the weighted average building credit. Credits from the tables or calculation shall be achieved where a building complies with one or more of the following:

1. More efficient HVAC performance in accordance with Section C406.2.
2. Reduced lighting power in accordance with Section C406.3.
3. Enhanced lighting controls in accordance with Section C406.4.
4. On-site supply of renewable energy in accordance with Section C406.5.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.
6. High-efficiency service water heating in accordance with Section C406.7.
7. Enhanced envelope performance in accordance with Section C406.8.
8. Reduced air infiltration in accordance with Section C406.9
9. Where not required by Section C405.12, include an energy monitoring system in accordance with Section C406.10.
10. Where not required by Section C403.2.3, include a fault detection and diagnostics (FDD) system in accordance with Section C406.11.
11. Efficient kitchen equipment in accordance with Section C406.12.

Reason Statement: In order to meet the state's 2045 carbon neutrality goal, Virginia must not only reduce energy use through energy efficiency and move to utility scale and on-site renewable energy, but also begin to transition away from using combustion equipment in buildings that runs on fossil fuels to electric equipment. Therefore it is crucial that new buildings today can be cost-effectively retrofitted in the future with electric equipment so that emissions are not "locked-in" by gas-dependent building infrastructure. Fortunately, heat pump technology has dramatically improved over the last few decades, giving contractors and building owners access to highly efficient electric heating and cooling, and water heating technologies.

One of the biggest expenses of electrification retrofits – and therefore barriers to electrification in existing buildings - is running electrical infrastructure through a completed and enclosed building that has combustion equipment. This significant future cost can be greatly reduced through making simple, low-cost modifications to buildings during construction that enable easier electrification in the future. The requirements in this proposed amendment ensure that the electrical infrastructure is in place so that building owners can convert to an all-electric building in the future and ensures that unitized gas water heaters can be replaced with high-performance heat pump water heaters (HPWHs).

Cost Impact: The code change proposal will increase the cost of construction
Virginia buildings that are all-electric would have no change in construction costs. Mixed fuel buildings would be slightly more expensive to build because they would both have to be electric-ready and meet additional efficiency requirements. Electric-ready requirements are anticipated to be nominal. Recent analysis by NBI and partners using cost data from RSMeans indicates that additional electrical infrastructure costs for water-heating and space-heating would cost a typical office building an additional $8,380. However if a building owner were to have to retrofit their building from using combustion equipment to natural gas equipment costs without these requirements in place, costs could be exorbitant.

Resiliency Impact Statement: This proposal will increase Resiliency
Electric ready infrastructure allows buildings the ability to take advantage of the greening grid while spreading out the costs. As noted in the reason statement, they will likely transition from fossil fuel to electric appliances over their lifespan. Although these buildings will require more electricity from the grid than their fossil fuel burning counterparts as they transition, they will be able to operate entirely on clean renewable energy.

By constructing electric-ready, building owners will additionally be given the tools they need to make decisions on the timing to switch fuel sources. As the costs of fuels change over time, owners will be ready to remove themselves from the volatility and geopolitics of the fossil fuel market.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: EC-C405.16-21

This proposal doesn't have any public comments.

Proposal # 1047

EC-C405.16-21 – Staff Summary

Proponent: Ben Rabe (New Buildings Institute); Diana Burk (New Buildings Institute).

Brief Description:

The proposal requires the installation of additional electric infrastructure in buildings that contain combustion equipment to allow future users to install electric versions of that equipment, in the future, without the need for retrofitting the space(s).

STUDY GROUP OR SUB-WORKGROUP INFORMATION.

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- KC Bleile, Viridiant
- William Penniman (Sierra Club) *Note:* partial attendance only. Not in attendance at the time of voting but expressed support for the proposal in the Adobe Platform chat box prior to exiting the meeting room.

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark, Homebuilders Association of Virginia
- Brian Clark, Habitat for Humanity
- Steve Shapiro (AOBA/VAMA) *Note:* partial attendance only. Not in attendance at the time of voting but expressed opposition to the proposal in the Adobe Platform chat box prior to exiting the meeting room.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- Laura Baker (RECA, alternate for Eric Lacey)

Energy Sub-Workgroup members not in attendance:

- Maggie Kelley Riggins (SEEA). *Note:* partial attendance. Stepped away during EC-C405.13-21 discussion and voting.
- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note:* partial attendance. Not in attendance during EC-C405.16-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during EC-C405.16-21 discussion and voting.
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Corey Caney: International Association of Electrical Inspectors, Virginia

Other stakeholders in attendance and opposing the proposal:

- Michael O'Connor, Virginia Petroleum and Convenience Marketers Association (VPCMA) and VA Propane Gas

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club

William Penniman stated that in order to combat climate change, electricity to the maximum extent possible needs to be implemented. Further, he stated that getting ready for it with relatively low costs up front will make the transition better and cheaper. He felt that this proposal will benefit everyone.

Opposition:

Names: Steve Shapiro, AOBA and VAMA; Andrew Clark, HBAV

- Steve Shapiro, AOBA and VAMA, recorded his opposition to the proposal.
- Andrew Clark, HBAV, opposed the proposal and rested on the statements made during Energy Sub-Workgroup discussions on similar proposals (see REC-R401.2-21), reproduced here for convenience: *"He indicated that HBAV is unequivocally opposed to the proposal and shared concerns that this proposal is in potential conflict with other state laws, the Virginia Energy Plan and the net-zero path that Virginia is currently on."*

DHCD Staff Notes:

The Energy Sub-Workgroup members did not provide any specific reasons for supporting or opposing the proposal but rested on comments made during previous proposals with a similar scope (see REC-R401.2-21), reproduced here for convenience:

Support:

- William Penniman: Sierra Club - Virginia Chapter
    - He opined that the proposal will save money for residents, it will reduce pollution, it's a critical measure for climate change, and will create a healthier house without the fumes from burning fossil fuels. *Note:* in response to some of the opposing statements noted below, he indicated that he does not think that the proposal conflicts with the net-zero path Virginia is currently on.

Opposition:

- Andrew Clark: Home Builders Association of Virginia
    - He indicated that HBAV is unequivocally opposed to the proposal and shared concerns that this proposal is in potential conflict with other state laws, the Virginia Energy Plan and the net-zero path that Virginia is currently on.

Meeting summaries and proposal related information: Tab 10 - Page 40; Tab 11 - Page 25.

EC-C407.6-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Energy Conservation Code

Add new text as follows:

C407.6 Zero Energy Commercial Construction. Any commercial building constructed and marketed or otherwise held out to be a “zero energy” building or “net zero energy building” or made subject to an equivalent claim must satisfy the standards set forth in Appendix CC Zero Energy Commercial Building Provisions, in addition to any other energy efficiency and renewable energy standards that are applicable to such building. Written notice must be given to the permitting authority of the intent to market a building as a "zero energy" or "net zero energy." A building inspection and independent confirmation of compliance with Appendix CC must be conducted and supporting documentation must be submitted to demonstrate full compliance with Appendix CC. The building code official may require additional information, as appropriate, to demonstrate compliance. A written report certifying compliance or non-compliance with Appendix CC shall be delivered to the buyer or owner prior to building occupancy.

R406.8 Zero Energy Residential Construction. Any residential building constructed and marketed or otherwise held out to be a “zero energy” building or “net zero energy” or made subject to an equivalent claim must satisfy the standards set forth in Appendix RC Zero Energy Residential Building Provisions in addition to any other energy efficiency and renewable energy standards applicable to such construction or rehabilitation. Inspection and independent confirmation of compliance with Appendix RC must be conducted and documentation provided to confirm compliance with Appendix RC Zero Energy Residential Building Provisions. The building code official may require additional information, as appropriate, to demonstrate compliance. A written certification of compliance or non-compliance with the standards in Appendix RC shall be delivered to buyer prior to occupancy and shall be added to the permanent certificate required by R401.3.

N1106.8 Zero Energy Residential Construction.
Any residential building constructed and marketed or otherwise held out to be a “zero energy” building or “net zero energy” or made subject to an equivalent claim must satisfy the standards set forth in Appendix RC Zero Energy Residential Building Provisions in addition to any other energy efficiency and renewable energy standards applicable to such construction or rehabilitation. Inspection and independent confirmation of compliance with Appendix RC must be conducted and documentation provided to confirm compliance with Appendix RC Zero Energy Residential Building Provisions. The building code official may require additional information, as appropriate, to demonstrate compliance. A written certification of compliance or non-compliance with the standards in Appendix RC shall be delivered to buyer prior to occupancy and shall be added to the permanent certificate required by N1101.3.

Reason Statement: The 2021 IECC adds two appendices specifying the requirements for "zero energy" construction: "Appendix CC Zero Energy Commercial Building Provisions" and "Appendix RC Zero Energy Residential Building Provisions".

The purpose of this proposal is to activate the standards set forth in these two appendices by making them applicable and mandatory for any buildings constructed and sold, leased, or otherwise marketed or held out as being "zero energy" or "net zero energy" or equivalent labels. It does not require builders to go beyond the generally applicable terms of the 2021 IECC, but it protects buyers, residents and competing "zero energy" builders by assuring that buildings claimed to be "zero energy" actually meet recognized "zero energy" energy conservation standards set forth in the Code. The appendices are new and will be incorporated into Virginia's 2021 building code update.

There are many instances in which building code provisions are tied to the intended purpose or specific use of a building, which is also part of the marketing of that building. Achieving specific levels of performance (efficiency or otherwise) is also commonly required of new buildings whether separately advertised or simply assumed as part of building code compliance. Thus, there is nothing unreasonable about requiring a builder (a) to notify building officials in a permit application of an intent to market a building as "zero energy" or "net zero energy," (b) to subject the building to inspections and testing that confirm compliance with the code provisions, and (c) to provide written notification to the buyer or owner of the outcome of compliance tests. The phrase "or made subject to a similar claim" is to prevent a builder from trying to evade the standard by saying things like "it won't use any net energy" or "it will produce all the energy it needs".

Zero energy buildings are hugely valuable for residents and landlords because they eliminate energy costs of occupancy, over time, through a combination of enhanced energy efficiency and renewable energy. Such buildings are becoming increasingly popular, particularly since they cut both occupancy costs and pollution driving climate change. In reality, a shift to zero energy (net zero energy) housing will be critical to keeping global temperatures at levels that will prevent catastrophic climate harms. Given that new housing will operate for 70 or more years, it is vital that quality zero carbon construction begin sooner rather than later. Even though it does not mandate zero carbon construction, this proposal will at least establish minimum standards for such construction.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This proposal does not require construction of zero energy buildings. It merely assures that buildings meet basic standards of construction and truth in advertising if they are built and sold or leased as "zero energy" or "net zero energy" buildings.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal will increase resiliency in several ways. Individual zero energy buildings and their occupants will be more resilient because they will (a) consume less energy, (b) produce zero-carbon renewable energy equal to or in excess of their energy needs, (c) retain heat or cooling during periods of utility outages, (d) be more capable of self-supplying electricity and possibly other energy during periods of utility outages, and (e) less exposed to economic harm from fluctuating energy prices. These are large resiliency benefits for residents in zero energy dwellings and their lenders or landlords.

This proposal will also increase resiliency for the public by reducing greenhouse gas emissions, reducing demands on utilities during critical supply and price periods and reducing risks of loan and lease defaults attributable to fluctuating energy prices.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: EC-C407.6-21

Discussion by William Penniman
Apr 1, 2022 18:58 UTC

Questions were raised about the proposal's references to selling or marketing a building as "zero energy." Tying this to marketing seems reasonable to me because the standard is meaningless if builders can sell non-complying buildings as "zero energy". This is equivalent to designing a building for a particular purpose, which is addressed in other places in the code.

A linkage was also made during the discussion to statements in the permanent certificate. With that in mind, I propose to modify the language of the proposal by adding language along the following lines, which we can discuss at the ESWG and WG meetings.

Add to proposed C407.6 (or a new C407.6.1):
In addition to other required submissions, the builder or other approved party shall submit a signed statement to the Building Inspector stating (a) whether the building is being sold or marketed as “zero energy” or “net zero energy” or using equivalent terms and (b) whether the building qualifies as Zero Energy pursuant to Appendix CC, accompanied by test results demonstrating compliance. A copy of the statements and report shall be delivered to the buyer or owner prior to closing.

Add to proposed R406.8/N1106.8 (or to a new R406.8.1/N1106.8.1):
The builder or other approved party shall submit a signed statement to the Building Inspector, following completion of air leakage testing, stating (a) whether the building is being sold or marketed as “zero energy” or “net zero energy” or using equivalent terms and (b) whether the building qualifies as Zero Energy pursuant to Appendix RC, accompanied by test results demonstrating compliance. A copy of the statements and report shall be delivered to the buyer prior to closing.

Add to the permanent certificate requirement of R401.3/N1101.3 (whether existing Virginia or 2021 IECC) language stating that "the permanent certificate shall state whether the building does or does not qualify as “Zero Energy” in compliance with Appendix RC. An exact copy of the Permanent Certificate shall be delivered to buyer prior to closing."

Proposal # 996

EC-C407.6– Staff Summary

Proponent: William Penniman (Sierra Club)

Brief Description:

The proposal requires any commercial or residential building constructed and marketed as a "zero energy" or "net zero energy" building or an equivalent claim to comply with a respective Zero Energy Buildings Provisions Appendix (new to the 2021 IECC).

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was heard at several meetings and carried over multiple times to continue discussion (March 24, 2022; April 11, 2022; May 12, 2022 and May 19, 2022). The comments captured in this summary may span over multiple meetings.

The following Energy Sub-Workgroup members in attendance during the May 19 meeting were in support of this proposal:

- Eric Lacey (RECA)
    - He liked this proposal because it provides some truth in advertising. If you're going to call a home or building "Net Zero" you should meet these standards. Provided background that these appendices are new to the 2021 IECC. On the commercial side, this appendix came out of AIA's 2030 challenge and based on your occupancy type you're required to install a certain amount of renewable energy to bridge the gap between the efficiency of the building and getting it to net zero. On the residential side, this is kind of an extension of the Energy Rating Index (ERI) and the home must demonstrate a net zero ERI score. A reason these go into appendices is that a lot of states create net-zero paths and standardizing these paths have value.
- KC Bleile (Viridiant)
- William Penniman (Sierra Club – Virginia Chapter)

The following Energy Sub-Workgroup members in attendance during the May 19 meeting were in opposition of this proposal:

- Andrew Clark (HBAV)
    - He can't identify any other provisions in the code dealing with advertising. Only one section came close and it was regarding universal design features.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council

Energy Sub-Workgroup members not in attendance during the May 19, 2022 meeting:

- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

    - Expressed opposition during the May 12, 2022 meeting.
        - He appreciated the wording change, but he still doesn't think this belongs in the building code because it's marketing. It still says that the inspection must comply with the appendix. He doesn't support this.
- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Eric Lacey (RECA); Ben Rabe (New Buildings Institute)

- Eric Lacey (RECA)
    - Has seen stretch energy and net zero codes adopted across the country. Some are better than others. There was an improvement in the 2021 IECC with more standardized appendices. There would be real value to getting these programs similarly situated. He supports William's effort. It points to a standard that shows the consumer what a net zero energy building is. This language pre-approves appendix RC and appendix CC for compliance when making buildings zero energy.
- Ben Rabe (New Buildings Institute)
    - NBI was highly involved in developing this proposal. It's a great opportunity for Virginia.

Opposition:

Names: Steve Shapiro (AOBA/VAMA); David Beahm (Warren County); Andrew Clark (HBAV)

- Steve Shapiro (AOBA/VAMA) wanted to get on the record as opposing the proposal.
- David Beahm (Warren County)
    - Is opposed to this proposal. He doesn't think a code official could enforce this. How the builder advertises the dwelling would be considered a buyer beware situation.
- Andrew Clark (HBAV)
    - HBAV is opposed to this and considers it to be a truth in advertising issue.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 40; Tab 10 - Page 77; Tab 11 - Page 5; Tab 11 - Page 25; Tab 11 - Page 29; Tab 11 - Page 32; Tab 11 - Page 40.

EC-C502.3-21

Proponents: Ben Rabe (ben@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org); Diana Burk (diana@newbuildings.org)

2018 Virginia Existing Building Code

Add new text as follows:

601.4.8 Additional energy efficiency credits.. Alterations shall achieve a total of 5 credits in accordance with Section 601.4.9.

Exceptions:

1. Alterations that include replacement of no more than one of the following:
   - 1.1. HVAC unitary systems or HVAC central heating or cooling equipment serving the alteration area.
   - 1.2. 50% or more of the lighting fixtures in the alteration area.
   - 1.3. 50% or more of the area of interior surfaces in the alteration area.
   - 1.4 50% or more of the area of the building's exterior wall envelope.
2. 50% or more of the area of the building's exterior wall envelope.
3. Alterations that comply with Section C407.

601.4.9
ADDITIONAL EFFICIENCY CREDITS

601.4.9.1 General. Where required in Section 601.4.8, credits shall be achieved from Tables C406.1 (1) through C406.1 (5) where the table is selected based on the use group of the building and from credit calculations as specified in relevant subsections of Section C406. Where a building contains multiple use groups, credits from each use group shall be weighted by floor area of each group to determine the weighted average building credit. Credits from the tables of calculation shall be achieved where a building complies with one or more of the following:

1. More efficient HVAC performance in accordance with Section C406.2.
2. Reduced lighting power in accordance with Section C406.3.
3. Enhanced lighting controls in accordance with Section C406.4.
4. On-site supply of renewable energy in accordance with Section C406.5.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.
6. High-efficiency service water heating in accordance with Section C406.7.
7. Enhanced envelope performance in accordance with Section C406.8.
8. Reduced air infiltration in accordance with Section C406.9.
9. Where not required by Section C405.12, include an energy monitoring system in accordance with Section C406.10.
10. Where not required by Section C403.2.3, include a fault detection and diagnostics (FDD) system in accordance with Section C406.11.
11. Efficient kitchen equipment in accordance with Section C406.12.

805.4 Additional energy efficiency credits . Additions shall achieve a total of 10 credits in accordance with Section 805.5. Alterations to the existing building that are not part of an addition, but permitted with an addition, may be used to achieve the required credits.

Exceptions:

1. Buildings in Utility and Miscellaneous Group U, Storage Group S, Factory Group F, High-Hazard Group H.
2. Additions less than 1,000 ft^2 and less than 50% of existing floor area.
3. Additions that do not include the addition or replacement of equipment covered in Section C403.3 or C404.2 of the VECC that achieve a total of 5 credits.
4. Additions that do not contain conditioned space that achieve a total of 5 credits.

5. Buildings in Residential Group R and Institutional Groups I in climate zones 3C, 4B, 4C, 5C that achieve a total of 5 credits.

6. Where the addition alone or the existing building and addition together comply with Section C407 of the VECC.

805.5
ADDITIONAL EFFICIENCY CREDITS

805.5.1 General. Where required in Section 805.4, credits shall be achieved from Tables C406.1 (1) through C406.1 (5) of the VECC where the table is selected based on the use group of the building and from credit calculations as specified in relevant subsections of Section C406 of the VECC. Where a building contains multiple use groups, credits from each use group shall be weighted by floor area of each group to determine the weighted average building credit. Credits from the tables of calculation shall be achieved where a building complies with one or more of the following:

1. More efficient HVAC performance in accordance with Section C406.2 of the VECC.
2. Reduced lighting power in accordance with Section C406.3 of the VECC.
3. Enhanced lighting controls in accordance with Section C406.4 of the VECC.
4. On-site supply of renewable energy in accordance with Section C406.5 of the VECC.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6 of the VECC.
6. High-efficiency service water heating in accordance with Section C406.7 of the VECC.
7. Enhanced envelope performance in accordance with Section C406.8 of the VECC.
8. Reduced air infiltration in accordance with Section C406.9 of the VECC.
9. Where not required by Section C405.12 of the VECC, include an energy monitoring system in accordance with Section C406.10 of the VECC.
10. Where not required by Section C403.2.3 of the VECC, include a fault detection and diagnostics (FDD) system in accordance with Section C406.11 of the VECC.
11. Efficient kitchen equipment in accordance with Section C406.12 of the VECC.

Reason Statement: Since 2012, the IECC has leveraged Section C406 to achieve additional efficiency in the prescriptive path. This section has received steady improvements over the subsequent code cycles with an expansion in the number of options and the adoption of a more flexible credit approach to the additional efficiency option. However, there is one significant gap in C406, it does not apply to additions or alterations. C502 and C503 do not reference C406 in the sections with which additions and alterations must comply. The exclusion from C406 is a significant loophole. Additions and large alterations are prime opportunities for achieving greater energy efficiency utilizing C406.
This missed opportunity is particularly significant given the advent of Building Performance Standards (BPS). These policies set performance requirements that subject existing buildings need to meet. States and local jurisdiction around the country including the states of WA and CO and cities like New York, Boston, Washington DC, and St Louis have already adopted Building Performance Standards (BPS). Many more cities are considering this policy tool as they come to realize that meeting their climate goals will require achieving significant energy and/or carbon improvements in existing buildings. This creates a need for the IECC to be much more proactive in tailoring requirements specifically for existing buildings. Building energy retrofits that are implemented as part of alterations, additions and changes in occupancy are far more cost-effective than stand-alone retrofit projects implemented only to meet a BPS. By incorporating reasonable and cost-effective retrofits into typical existing building projects, the IECC will both provide additional energy, carbon and cost savings to building owners and tenants and help ensure that more building retrofits are undertaken at opportune and cost-effective times.

This proposal creates a framework to apply C406 to additions and large alterations. It creates a new Section C506 that provides guidance for how to utilize C406 for existing buildings. C506.1 essentially replaces and mirrors C406.1, providing charging language for how to calculate credit totals and utilize the sections (C406.2-12) that establish the requirements for each credit option. This section C506 is utilized by new sections in C502 and C503 to set credit requirements for additions and alterations, respectively.

The new Section C502.2.7.1 sets requirements for additions. As additions generally have to meet the requirements for new construction, the credit requirement has been set at 10 credits, the same as C406 for new construction. The section specifically allows additions and alterations to comply together under this section, eliminating the possibility that a building with both an addition and alteration would have to achieve credits for each individually. The section includes a number of important exceptions for situations where achieving the full 10 credits would be less feasible due to lower energy building types, more limited credit options and more limited project scope:

1. Occupancies such as storage, utility, factory and high hazard that generally have low energy usage.

2. Small additions

3. Additions that do not include new HVAC or hot water systems that achieve 5 credits

4. Additions that do not include conditioned space that achieve 5 credits

5. Group R and I occupancies in more temperate climate zones that achieve 5 credits

6. Additions that comply with C407.

The new section C503.7 requires that large alterations achieve 5 credits. The section includes important exceptions:

1. The first exception ensures that the requirements only apply to large additions with significant scope. The exemption is worded to address small alterations that only impact one of the main buildings systems: envelope (C402), HVAC (C403), water heating (C404) and lighting (C405). Alterations that impact two or more of these systems – and must therefore comply with two or more of these sections – will have a larger scope with more opportunities to choose from among the available credit options.

2. An exception that reflects the allowance for alterations and additions to comply together under C502.

3. An exception for buildings that model using C407.

By limiting requirement to large alterations and keeping the credit requirement low, the proposal ensures that projects will likely have sufficient credit options within the existing scope of the project. The project team will be able to pick credit options that apply to building elements that are already within the project scope.

The savings for this proposal would be at least 2.5% for additions and 1.25% for alterations based on the modeling for the C406 credit options done by PNNL for the 2021 edition of the IECC. However, the savings should be higher for alterations in particular since the baselines for alterations include many below-code existing building features. Depending on how inefficient the rest of the building is, the impact of this proposal could be substantially higher without any greater cost than new construction C406 measures.

Cost Impact: The code change proposal will increase the cost of construction
This proposal is crafted so that it will only impact major renovations / large-scope alterations that are already impacting the major systems that serve as the basis for credits under C406. This means that these projects are already undertaking the cost of bringing two or more of these major systems up to current code requirements, and the incremental cost is therefore only the cost from code rather than the cost of a standalone retrofit. Therefore, the costs for this proposal are the same as the costs for C406 requirements for new construction. However, savings for each package will generally be much higher since the rest of the building will nearly always have specifications that fall short of the latest energy code and each package will deliver greater savings. As a result, any package that is cost effective for new construction will be even more cost effective for major alterations.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. Encouraging energy efficient retrofits helps to reduce building energy use. This reduces the buildings overall reliance on energy, reducing carbon emissions directly and indirectly, lessening the impact on climate change and climate related events. For the building's own resilience, the proposed efficiency credits focus on more efficient systems overall – even in an event like a black out, these more efficient systems require less energy to run, making any back up generation energy source last longer – providing extended comfort and safety to building users. For energy infrastructure resilience, the electric grid's ability to deliver capacity to an increasing number of buildings will become increasingly important. By reducing overall energy use, this measure may contribute to a reduction in peak demand increasing the resiliency of the grid during high usage events.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: EC-C502.3-21

Discussion by Florin Moldovan
Jun 13, 2022 19:04 UTC

See attached floor modification discussed at the GSWG meeting on 06/09/2022.
Attachments: https://va.cdpaccess.com/proposal/1052/discuss/174/file/download/781/EC-C502.3+Floor+Modification.pdf

Proposal # 1052

EC-C502.3– Staff Summary

Proponent: Ben Rabe (New Buildings Institute), Kimberly Newcomer (New Buildings Institute), Diana Burk (New Buildings Institute).

Brief Description:

The proposal requires additional efficiency measures for additions and alterations in commercial buildings. These additional efficiency measures are already required for new buildings (See Section C406 of the IECC); however, alterations would only require half of the credits (5) to comply.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed and supported by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on May 19, 2022. It was also discussed during the May 12th, 2022 meeting before being carried over.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- Eric Lacey (RECA)
  - For a minimal amount of energy efficiency upgrade, in a substantial enough addition, it makes sense to go beyond what is required for the code.
- Chelsea Harnish (VAEEC)
- KC Bleile (Viridiant)
- William Penniman (Sierra Club – Virginia Chapter)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Andrew Clark (HBAV) abstained
  - *Note:* although he abstained during the sub-workgroup meeting, he did notify the group that he had to further review the proposal which may result in his opposition during the general workgroup meeting.

Energy Sub-Workgroup members not in attendance during the May 19, 2022 meeting:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Eric Lacey (RECA); William Penniman (Sierra Club – Virginia Chapter)

- Eric Lacey (RECA)
    - RECA supports this proposal. He's disappointed with the lack of support. When they make proposals to the new building code they get told that the existing buildings are more in need of energy updates. This proposal doesn't make significant changes, it only asks for some changes with many options available when making additions or alterations.

Opposition:

Names: Steve Shapiro (AOBA/VAMA); Andrew Clark (HBAV)

- Steve Shapiro (AOBA/VAMA)
    - Doesn't think that this proposal is in line with the purpose of the existing building code. Additions and alterations should not have to comply with anything additional than what is already there. If the owner wants to do more, that should be their choice.
- Andrew Clark (HBAV)
    - Agrees with Steve Shapiro, the proposal seems to go against incentivizing existing building rehabilitation.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 78; Tab 11 - Page 36; Tab 11 - Page 42.

EC-C502.3
Revised to VEBC

805.4 Additional energy efficiency credits.

Additions shall achieve a total of 10 credits in accordance with Section 805.5. *Alterations* to the existing building that are not part of an *addition*, but permitted with an *addition*, may be used to achieve the required credits.

Exceptions:

1. *Buildings* in Utility and Miscellaneous Group U, Storage Group S, Factory Group F, High-Hazard Group H

2. *Additions* less than 1,000 ft^2 and less than 50% of existing floor area.

3. *Additions* that do not include the addition or replacement of equipment covered in Section C403.3 or C404.2 of the VECC that achieve a total of 5 credits.

4. *Additions* that do not contain *conditioned space* that achieve a total of 5 credits.

5. *Buildings* in Residential Group R and Institutional Groups I in climate zones 3C, 4B, 4C, 5C that achieve a total of 5 credits

6. Where the *addition* alone or the existing building and *addition* together comply with Section C407 of the VECC

805.5

ADDITIONAL EFFICIENCY CREDITS
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805.5.1 General. Where required in Section 805.4, credits shall be achieved from Tables C406.1 (1) through C406.1 (5) of the VECC where the table is selected based on the use group of the building and from credit calculations as specified in relevant subsections of Section C406 of the VECC. Where a building contains multiple use groups, credits from each use group shall be weighted by floor area of each group to determine the weighted average building credit. Credits from the tables of calculation shall be achieved where a building complies with one or more of the following:

1. More efficient HVAC performance in accordance with Section C406.2 of the VECC.

2. Reduced lighting power in accordance with Section C406.3 of the VECC.

3. Enhanced lighting controls in accordance with Section C406.4 of the VECC.

4. On-site supply of renewable energy in accordance with Section C406.5 of the VECC.

5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6 of the VECC.

6. High-efficiency service water heating in accordance with Section C406.7 of the VECC.

7. Enhanced envelope performance in accordance with Section C406.8 of the VECC.

8. Reduced air infiltration in accordance with Section C406.9 of the VECC

9. Where not required by Section C405.12 of the VECC, include an energy monitoring system in accordance with Section C406.10 of the VECC.

10. Where not required by Section C403.2.3 of the VECC, include a fault detection and diagnostics (FDD) system in accordance with Section C406.11 of the VECC.

11. Efficient kitchen equipment in accordance with Section C406.12 of the VECC.

601.4.8 Additional energy efficiency credits..

Alterations shall achieve a total of 5 credits in accordance with Section 601.4.9.

Exception:

1. *Alterations* that include replacement of no more than one of the following:

1.1. HVAC unitary systems or HVAC central heating or cooling equipment serving the *alteration* area.

1.2. 50% or more of the lighting fixtures in the *alteration* area.

1.3. 50% or more of the area of interior surfaces in the alteration area

1.4. 50% or more of the area of the *building's exterior wall envelope*

2. *Alterations* that are part of an *addition* complying with section 805.

3. *Alterations* that comply with Section C407.

601.4.9
ADDITIONAL EFFICIENCY CREDITS
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601.4.9.1 General. Where required in Section 601.4.8, credits shall be achieved from Tables C406.1 (1) through C406.1 (5) where the table is selected based on the use group of the building and from credit calculations as specified in relevant subsections of Section C406. Where a building contains multiple use groups, credits from each use group shall be weighted by floor area of each group to determine the weighted average building credit. Credits from the tables of calculation shall be achieved where a building complies with one or more of the following:

1. More efficient HVAC performance in accordance with Section C406.2.

2. Reduced lighting power in accordance with Section C406.3.

3. Enhanced lighting controls in accordance with Section C406.4.

4. On-site supply of renewable energy in accordance with Section C406.5.

5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.

6. High-efficiency service water heating in accordance with Section C406.7.

7. Enhanced envelope performance in accordance with Section C406.8.

8. Reduced air infiltration in accordance with Section C406.9

9. Where not required by Section C405.12, include an energy monitoring system in accordance with Section C406.10.

10. Where not required by Section C403.2.3, include a fault detection and diagnostics (FDD) system in accordance with Section C406.11.

11. Efficient kitchen equipment in accordance with Section C406.12.

REC-R401.2-21

Proponents: Ben Rabe (ben@newbuildings.org); Diana Burk (diana@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

ALL-ELECTRIC BUILDING. A *building* that contains no *combustion equipment* , or plumbing for *combustion equipment*, installed within the *building*, or *building site.*

Revise as follows:

APPLIANCE. A device or apparatus that is manufactured and designed to utilize energy and for which this code provides specific requirements.

Add new text as follows:

COMBUSTION EQUIPMENT. Any *equipment* or *appliance* used for space heating, *service water heating* , cooking, clothes drying, or lighting that uses *fuel gas* or *fuel oil*

EQUIPMENT. Piping, ducts, vents, control devices and other components of systems other than appliances that are permanently installed and integrated to provide control of environmental conditions for buildings. This definition shall also include other systems specifically regulated in this code.

CHAPTER 4 [RE]
RESIDENTIAL ENERGY EFFICIENCY

Revise as follows:

R401.2 Application . Residential ~~buildings shall~~ buildings shall be *all-electric buildings* and shall comply with Section ~~R401.2.5~~ R401.2.4 and either Sections R401.2.1, R401.2.2 ~~, R401.2.3 or R401.2.4.~~ or R401.2.3.

Exception: Additions, *alterations*, repairs and changes of occupancy to existing buildings complying with Chapter 5.

R401.3 Certificate. A permanent certificate shall be completed by the builder or other *approved* party and posted on a wall in the space where the furnace is located, a utility room or an *approved* location inside the *building*. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory *label*, service disconnect *label* or other required labels. The certificate shall indicate the following:

1. The predominant *R*-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, *basement walls*, *crawl space walls* and floors and ducts outside *conditioned spaces.*
2. *U*-factors of fenestration and the *solar heat gain coefficient* (SHGC) of fenestration. Where there is more than one value for any component of the building envelope, the certificate shall indicate both the value covering the largest area and the area weighted average value if available.
3. The results from any required duct system and building envelope air leakage testing performed on the building.
4. The types, sizes and efficiencies of heating, cooling and service water-heating equipment. Where ~~a gas-fired unvented room heater,~~ an electric furnace or baseboard electric heater is installed in the residence, the certificate shall indicate ~~“gas-fired unvented room heater,”~~ “electric furnace” or “baseboard electric heater,” as appropriate. An efficiency shall not be indicated for ~~gas-fired unvented room heaters,~~ electric furnaces and electric baseboard heaters.
5. Where on-site *photovoltaic panel* systems have been installed, the array capacity, inverter efficiency, panel tilt and orientation shall be noted on the certificate.
6. For buildings where an Energy Rating Index score is determined in accordance with Section R406, the Energy Rating Index score, both with and without any on-site generation, shall be listed on the certificate.
7. The code edition under which the structure was permitted and the compliance path used.

Delete without substitution:

~~**R402.4.4 Rooms containing fuel-burning appliances.** In Climate Zones 3 through 8, where open combustion air ducts provide combustion air to open combustion fuel-burning appliances, the appliances and combustion air opening shall be located outside the *building thermal envelope* or enclosed in a room that is isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table R402.1.3, where the walls, floors and ceilings shall meet a minimum of the *basement wall R*-value requirement. The door into the room shall be fully gasketed and any water lines and ducts in the room insulated in accordance with Section R403. The combustion air duct shall be insulated where it passes through *conditioned space* to an *R*-value of not less than R-8.~~

~~**Exceptions:**~~

1. ~~Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.~~
2. ~~Fireplaces and stoves complying with Section R402.4.2 and Section R1006 of the International Residential Code.~~

Revise as follows:

R404.1.2 Fuel gas lighting equipment. Fuel gas lighting systems shall not be installed.~~ have continuously burning pilot lights.~~

R408.2.2 More efficient HVAC equipment performance option. Heating and cooling *equipment* shall meet one of the following efficiencies:

~~1. Greater than or equal to 95 AFUE natural gas furnace and 16 SEER air conditioner.~~

~~2.~~ 1. Greater than or equal to 10 HSPF/16 SEER air source heat pump.

~~3.~~ 2. Greater than or equal to 3.5 COP ground source heat pump.

For multiple cooling systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the cooling design load. For multiple heating systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the heating design load.

R408.2.3 Reduced energy use in service water-heating option. The hot water system shall meet one of the following efficiencies:

~~1. Greater than or equal to 82 EF fossil fuel service water-heating system.~~

~~2.~~ 1. Greater than or equal to 2.0 EF electric service water-heating system.

~~3.~~ 2. Greater than or equal to 0.4 solar fraction solar water-heating system.

Reason Statement: In order to meet the state's 2045 carbon neutrality goal, Virginia must not only reduce energy use through energy efficiency and move to utility scale and on-site renewable energy, but also begin to transition away from using combustion equipment in buildings that runs on fossil fuels to electric equipment.

In 2020, combustion equipment in commercial and residential buildings accounted for 36% of the United States energy-related greenhouse gas emissions. . To meet Virginia's goal, it is crucial that new homes built today are all-electric so that emissions from these buildings are not “locked-in” by gas-dependent building infrastructure.

Fortunately, heat pump technology has dramatically improved over the last few decades, giving contractors and building owners access to highly efficient electric heating and cooling, and water heating technologies. An Ecotope study of the 2017 Oregon Residential code found that homes heated by electric heat pumps use 40 percent less energy than homes heated with gas (including water heating). Even accounting for reduced efficiency in extreme cold weather, according to a study by RMI, modern air source heat pumps are more than twice as efficient as gas furnaces and can save families up to 14 percent on their utility bills in Climate Zone 5. This is one reason why the U.S. EPA just announced that standards for the most efficient appliances in 2022 certified under the ENERGY STAR program will be all-electric.

All-electric homes are also healthier homes. Gas appliances release harmful pollutants like nitrogen dioxide (NO2) and carbon monoxide (CO) either indoors because of gas stoves or outdoors because of space-heating and water heating equipment. A recent study from the Harvard Chang School of Public Health and RMI shows that in 2017, air pollution from burning fuels in buildings led to an estimated 48,000 to 64,000 early deaths and $615 billion in health impact costs. These emissions can particularly affect children. In a meta-analysis analyzing the connections between gas stoves and childhood asthma, children in homes with gas stoves were 42% more likely to experience asthma symptoms, and 32% more likely to being diagnosed with asthma.

All-electric new construction is also less expensive to build than a home with gas appliances and in the long term will result in fewer retrofit costs for homeowners to meet future policy goals to eliminate all carbon emissions in the U.S. by 2050.

Therefore, building all-electric buildings is critical to reducing air pollution, protecting public health, reducing utility and construction costs, and meeting climate goals. NBI is submitting this amendment along with amendments that address on-site renewables, electric vehicles, and grid integration techniques. These proposed changes to the 2021 IECC, working together, will put the U.S. on the path to a decarbonized, resilient, and healthier future.

Cost Impact: The code change proposal will decrease the cost of construction

Electric appliances and equipment cost less than gas appliances. Installing all-electric appliances also reduces natural gas infrastructure costs such as gas mains, services and meters. Using data from RSMeans, Grainger, Home Depot, NBI estimates that an all-electric home costs $8,735 less than a home built with natural gas appliances and equipment. A recent analysis by RMI which examined the cost effectiveness of all-electric homes in seven cities across the country from Climate Zone 2A to 6A, found that installing efficient heat pumps in water heating and space-heating compared to standard equipment installed in a mixed-fuel home resulted in life cycle cost savings in every city. Including the cost of more efficient electric equipment, the all-electric home cost on average $2,700 less than a code compliant mixed-fuel home. All-electric homes with efficient heat pumps exhibited on average $107 in lower annual utility costs. The analysis concluded that a homeowner with an all-electric home would save $3,700 over a 15-year analysis period. In addition, all electric homes with efficient heat pumps resulted in carbon emissions savings of between fifty to ninety-three percent in all climate zones. Accounting for the societal benefit carbon emissions would result in increased life cycle cost savings across all climate zones.

Finally, neither analysis cited includes the cost of electrical retrofits that will be required of homes that are not all-electric to meet future policy goals of achieving net zero carbon emissions by 2050. Simply upgrading the electrical panel itself to add electrical capacity for new electric appliances can cost a homeowner between $2,650 to $4,500. Adding electrical outlets that can service major appliances so that homeowners can replace a natural gas appliance with an all-electric appliance will also add significant additional costs especially if those appliances are in areas where dry wall must be removed and repaired.

Resiliency Impact Statement: This proposal will increase Resiliency
As the grid becomes increasingly cleaner, all electric buildings will become less carbon intense as they age, unlike buildings with fossil fuel combustion, lessening their impact on climate change. Although these buildings will require more total electricity from the grid than their fossil fuel burning counterparts, they will be able to operate entirely on clean renewable energy.

All-electric single-family and low-rise multifamily homes additionally support better indoor air quality. Better indoor air quality is directly linked to better health of residents, including reduction of respiratory and chronic illnesses. This is especially importance in homes. The reductions of these types of illnesses increase overall resilience of individuals within our communities, making them less susceptible to the impacts of extreme heat and cold, reducing medical bills, and improving overall quality of life.

Finally, these buildings will also be less dependent on the geopolitics of the fossil fuel market, leveling out energy costs during periods of disruption.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: REC-R401.2-21

Discussion by Richard Potts
Jun 3, 2022 23:44 UTC

Attached are two public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.
Attachments:
https://va.cdpaccess.com/proposal/1055/discuss/144/file/download/732/HBAV_Clarifying%20ACEEE%20Report%20on%20Virginia%27s%20Residenti
https://va.cdpaccess.com/proposal/1055/discuss/144/file/download/731/HBAV_DoE%20Data%20on%20New%20Construction%20EE%20Improvemer

REC-R401.2-21 – Staff Summary

Proponent: Ben Rabe (New Buildings Institute); Diana Burk (New Buildings Institute)

Brief Description:

The proposal prohibits the use of combustion equipment and appliances for space heating, water heating, cooking, etc., within residential buildings.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman: Sierra Club - Virginia Chapter
    - He opined that the proposal will save money for residents, it will reduce pollution, it's a critical measure for climate change, and will create a healthier house without the fumes from burning fossil fuels. *Note:* in response to some of the opposing statements noted below, he indicated that he does not think that the proposal conflicts with the net-zero path Virginia is currently on.
- Laura Baker (alternate for Eric Lacey): Responsible Energy Codes Alliance

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)
    - He indicated that HBAV is unequivocally opposed to the proposal and shared concerns that this proposal is in potential conflict with other state laws, the Virginia Energy Plan and the net-zero path that Virginia is currently on.
- Brian Clark: Habitat for Humanity
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- K.C. Bleile: Viridiant

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note:* partial attendance. Not in attendance during REC-R401.2-21 discussion and voting.
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during REC-R401.2-21 discussion and voting.

- Jim Canter: Virginia Building & Code Officials Association (VBCOA)
- Bettina Bergoo: Virginia Department of Energy
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter

Statements from other stakeholders in support of the proposal:

- Ross Shearer, representing self, noted that there are countless environmental, health and safety issues associated with natural gas. Earlier this week the Washington Post reported a story of family experiencing illnesses including nausea. It turned out to be carbon monoxide leaking from a loose connection to the exhaust line of the gas furnace. Natural gas should not be used for any new construction.

Statements from other stakeholders in opposition to the proposal:

- John Ainslie (HBAV alternate), in response to statements by proponents suggesting that it is cleaner to use electricity than fuel gas, he argued that he has read that homes burning gas leave a smaller carbon footprint than those using electric.
- Michael O'Connor, Virginia Petroleum and Convenience Marketers Association (VPCMA) and Virginia Propane Gas Association (VAPGA) recorded their opposition to the proposal and expressed concerns related to the more than 60,000 generators in operation in Virginia fueled by natural gas and propane serving hospitals, first responders nursing homes and other buildings; and how would those essential sectors be served in times of emergency when the electricity is not available.
- Morgan Whayland, Virginia Natural Gas, noted their opposition and stated that natural gas, which is affordable for the consumer, is a critical part in the effort to achieve net-zero. When we think about energy efficiency, we have to think about the entire supply chain. Natural gas is a more efficient energy source than electricity.

Note:
Chelsea Harnish, Virginia Energy Efficiency Council, commented in the Adobe Platform chat box that the VCEA (Virginia Clean Economy Act of 2020?) regulates electric utilities and sets carbon goals for that sector. The VCEA does not set carbon goals for the built environment*.*

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club

- William Penniman, Sierra Club, expressed support for the proposal and opined that electrification is essential to meet climate goals and is healthier for people.

Opposition:

Names: Andrew Clark, HBAV; Mike O'Connor, VPCMA and VAPGA.

- Andrew Clark, HBAV, opposed the proposal and stood on the reasons offered during the Energy Sub-Workgroup meeting on March 24, 2022.
- Mike O'Connor, Virginia Petroleum Marketers and Convenience Stores; Virginia Propane Gas Association, opposed the proposal and stood on the reasons offered during the Energy Sub-Workgroup meeting on March 24, 2022.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 41; Tab 11 - Page 16.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

Clarifying the *American Council for an Energy-Efficient Economy's* Report on Virginia's Energy Policy and Building Codes

The American Council for an Energy-Efficient Economy (ACEEE) periodically releases a report ranking each state's energy efficiency policies and programs. This report is *widely* cited by energy efficiency stakeholders as justification for additional advancements in Virginia's energy codes – particularly, the report's ranking of Virginia as 25th in the country for energy efficiency[1].

Although the Home Builders Association of Virginia has partnered with these stakeholders during the 2015 and 2018 code cycles (which resulted in several significant advancements) and has continued to do so during the 2021 cycle, we felt it important to clarify the ACEEE's findings on Virginia's energy codes.

While the ACEEE report is a helpful resource for policymakers and regulatory boards, a state's ***overall ranking*** in the report is not particularly informative when evaluating the "strength" or "weakness" of a state's residential and commercial energy codes or specific energy code proposals. A deeper analysis of the ACEEE report shows that Virginia's ***overall ranking*** distorts the fact that Virginia receives extremely high scores for residential and commercial energy codes.

Virginia loses nearly half (24.5 points) of its points in categories *unrelated* to building codes

The ACEEE report ranks states based on five categories: (i) utility and public benefits programs and policies; (ii) transportation policies; (iii) building energy efficiency policies; (iv) state government initiatives; (v) appliance efficiency standards.

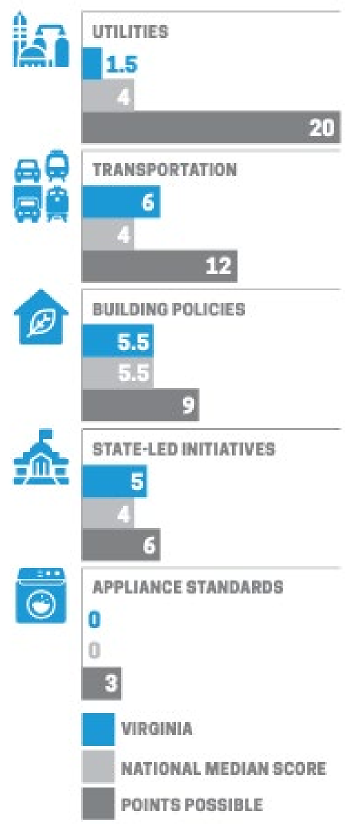
A state can only earn a certain number of points in each category:

- Utility and public benefits programs and policies (20 pts)
- Transportation policies (12 pts)
- Building energy efficiency policies (9 pts)
- State government initiatives (6 pts)
- Appliance efficiency standards (3 pts)

In the ACEEE's most recent report (2020), Virginia earned 18 out of 50 points – which is 25th in the nation.

However, a deeper analysis of the ACEEE's findings shows that Virginia lost nearly 50% of its points (24.5) in categories that are *unrelated* to energy efficiency building codes. Specifically, Virginia only earned 1.5 out of 20 pts for "Utility and Public Benefits Programs and Policies" and only received 6 out of 12 points for "Transportation Policies". *(See figure to the right)*

Due to the report's scoring system, it is inaccurate to claim that Virginia's 25th-in-the-Nation ranking in this report is the result of the Commonwealth's "weak energy code".



[1] American Council for an Energy-Efficient Economy – 2020 State Energy Efficiency Scorecard

Virginia receives a near-perfect score for residential code stringency and perfect score for commercial code stringency.

In the “Building Energy Efficiency Policy” category, Virginia receives 5.5 out of 9 points – by comparison, Virginia is only .5 points behind Maryland and 2 points behind California, which are the two states most frequently described by energy efficiency stakeholders as “leaders” in energy efficiency.

The “Building Energy Efficiency Policy” category consists of 8 sub-categories, including “residential code stringency” and “commercial code stringency”. Contrary to statements made during several sub-workgroup and workgroup meetings, Virginia receives a near perfect score for “residential energy efficiency” (1.5 points out of 2) and a perfect score for “commercial energy efficiency” (2 points out of 2).

It is HBAV’s understanding that these rankings were determined while Virginia was in the middle of the last code development cycle. While Virginia received exemplary scores for residential and commercial energy code stringency in ACEEE’s report, the rankings only reflect a *portion* of the progress which was made in Virginia’s energy codes during the last code cycle. During the last code cycle, the Home Builders Association of Virginia and other organizations reached consensus with energy efficiency stakeholders on several proposals, including:

1. Removed visual option for verifying building envelope air tightness and required blower door testing for all new residential buildings. Also added requirement that all new homes pass the blower door test with 5 air changes per hour;
2. Require an “energy certificate” in all new residential buildings to inform current and future homeowners about the key energy characteristics of their home;
3. Increase minimum ceiling insulation requirements (R-38 to R-49) for all new residential buildings;
4. ResCheck compliance updated to 2018 IECC, without Virginia amendments. Previously, a work around had been created for VA amendments that weakened the current IECC;
5. Increased fenestration requirements.

While the ACEEE has yet to release an updated report, it is highly likely that Virginia will receive further recognition for the full scope of energy efficiency code proposals that were adopted during the last code cycle – and possibly for the energy efficiency code proposals which are likely to be forwarded to the Board as “consensus” during the current code development cycle.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

U.S. Department of Energy Data Shows Significant Advancements in Residential Energy Efficiency and Reduction in Energy Cost Burdens in New Construction

"The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs."

Building code regulations were first established – and are continually revised – to ensure a *baseline standard* of quality, safety, and efficiency in new residential structures. For example, they provide assurance for consumers that they are residing in safe structures, guidelines for builders/design professionals as to what constitutes a safe and durable structure, and certainty for lenders of the value and quality of structure.

Similarly, energy efficiency standards were first adopted by the U.S. Housing and Home Finance Agency in the 1950's to address a concerning *public health and welfare* issue at the time: the rising number of mortgage defaults on federally insured loans on homes with high utility bills.

While increasing the efficiency of new residential structures is a laudable objective, it is critically important for policymakers to balance that objective with the growing concerns over the cost of housing in Virginia and the dramatic undersupply of housing that is attainable for households across the income spectrum. Furthermore, it is important for policymakers to distinguish between building code requirements that are essential to providing that baseline standard of quality, safety, and efficiency, and code requirements that are "aspirational".

Consumers can make a personal financial decision to purchase or build a home that is constructed to a higher energy efficiency standard, if that is an amenity that they are willing and able to afford. While energy efficiency requirements can reduce negative environmental externalities, promote high-quality housing stock, and protect consumers from soaring energy costs over time, the ability to afford the **upfront costs** of additional energy efficiency code requirements will vary widely by income.

The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs.

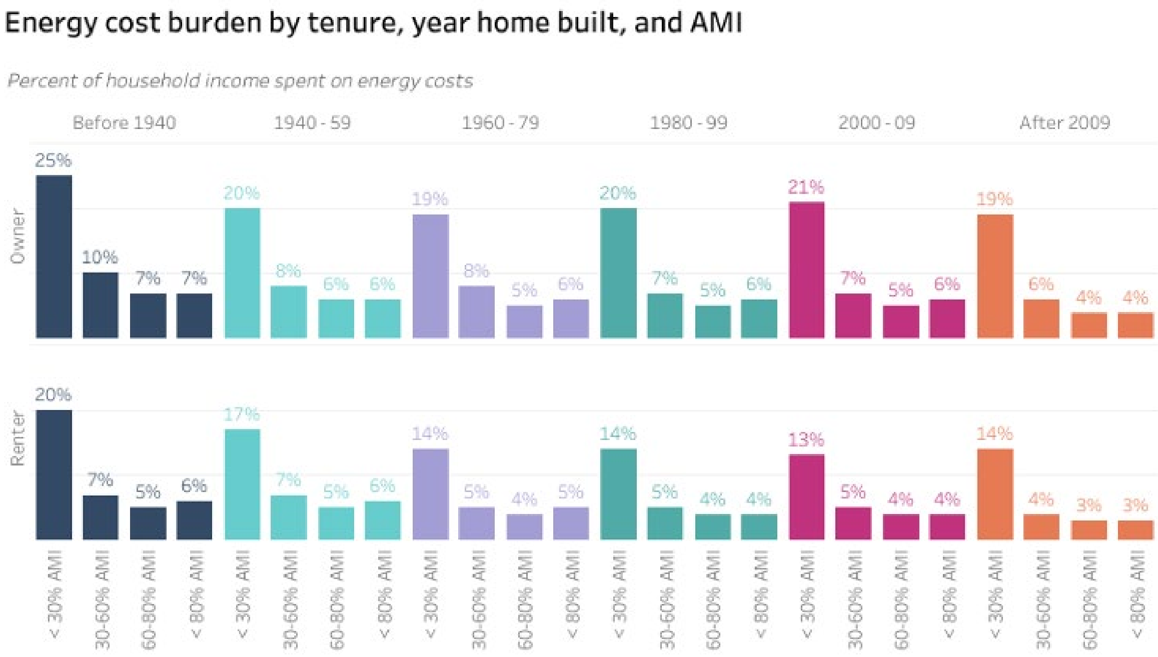
U.S. Department of Energy Data

Data from the U.S. Department of Energy's *Low-Income Energy Affordability Data (LEAD) Tool* validates the claim that Virginia *has* made vast improvements in residential energy efficiency over the last 80 years and has significantly reduced household energy costs to a level considered sustainable for individuals and families across the income spectrum.

A household is considered "energy cost burdened" when over 6% of the household income is dedicated to covering energy bills – this calculation includes all costs associated with energy used by the house (e.g., electricity and natural gas). When a household is "energy cost burdened", it impacts their ability to use electricity and heat or cool their home – and forces households to choose between paying utility bills, paying a mortgage or rent, or other essential expenses. In short, high energy cost burdens results in higher levels of housing instability, including evictions and foreclosures.

The chart below was compiled using data from the U.S. Department of Energy and included in a recent report released by Virginia Housing (formerly, Virginia Housing Development Authority) and the Department of Housing and Community Development[1].

[1] HB 854 Statewide Housing Study Report (January 2022)



Source: National Renewable Energy Laboratory, Low-Income Energy Affordability Data (LEAD) Tool, 2018.

The data from the U.S. Department of Energy (chart above) provides several important insights:

First, renters and owners residing in residential structures built since 2000 are below the 6% "energy cost burdened" threshold, with two exceptions: (i) Owner households in structures built between 2000 and 2009 are slightly over the 6% energy cost burdened threshold; (ii) Owners and renters with incomes below 30% of AMI residing in structures built between 2000 and 2019 are experiencing extremely high energy cost burdens. More analysis is needed to understand the latter - there are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Second, the highest "energy cost burdened" households (owner and renter) are residing in structures built prior to 1980's/1990's. The most "energy cost burdened" demographic – regardless of age of structure – are households earning under 30% AMI. Again, more analysis is needed to understand this dynamic. There are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Conclusion:

Data from the U.S. Department of Energy shows that residential structures constructed in the last 20 years are significantly more energy efficient than older homes, which has reduced household energy costs to levels considered sustainable for individuals and families across the income spectrum. The data also reflects the reality that efforts to reduce household energy cost burdens would be best focused on older, existing structures occupied by individuals and families at the lower end of the income spectrum.

Several energy proposals submitted during the 2021 code cycle seek to impose stricter energy efficiency requirements on all new homes, thus increasing the upfront cost of all new homes and exacerbating an issue raised by the Virginia Joint Legislative Audit and Review Commission's recent report on housing affordability: "Rising prices make it more difficult for low- and middle-income households to afford to purchase homes because of the increased monthly mortgage costs, as well as the increased upfront costs associated with purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes.[2]"

[2] Joint Legislative Audit and Review Commission: Affordable Housing in Virginia (2021)

REC-R401.2.5-21

Proponents: Ben Rabe (ben@newbuildings.org); Diana Burk (diana@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

R103.2.4 Electrification system.. The construction documents shall provide details for additional electric infrastructure, including branch circuits, conduit, or pre-wiring, and panel capacity in compliance with the provisions of this code.

R105.2.5 Electrical rough-in inspection. Inspections at electrical rough-in shall verify compliance as required by the code and the approved plans and specifications as to the locations, distribution, and capacity of the electrical system.

Revise as follows:

~~R105.2.5~~ **R105.2.6 Final inspection.** The *building* shall have a final inspection and shall not be occupied until *approved.* The final inspection shall include verification of the installation of all required *building* systems, equipment and controls and their proper operation and the required number of high-efficacy lamps and fixtures.

Add new text as follows:

ALL-ELECTRIC BUILDING. . A *building* that contains no *combustion equipment* , or plumbing for *combustion equipment*, installed within the *building*, or *building site.*

APPLIANCE. A device or apparatus that is manufactured and designed to utilize energy and for which this code provides specific requirements.

COMBUSTION EQUIPMENT. Any*equipment* or *appliance* used for space heating, *service water heating* , cooking, clothes drying, or lighting that uses *fuel gas* or *fuel oil* .

EQUIPMENT. Piping, ducts, vents, control devices and other components of systems other than appliances that are permanently installed and integrated to provide control of environmental conditions for buildings. This definition shall also include other systems specifically regulated in this code.

FUEL GAS. A natural gas, manufactured gas, liquified petroleum gas or a mixture of these.

FUEL OIL. Kerosene or any hydrocarbon oil having a flash point not less than 100°F (38°C).

MIXED-FUEL BUILDING. A *building* that contains *combustion equipment* or includes piping for *combustion equipment* .

Revise as follows:

R401.2.5 Additional energy efficiency. This section establishes additional requirements applicable to all compliance approaches to achieve additional energy efficiency.

1. For *all-electric buildings* ~~buildings~~ complying with Section R401.2.1, one of the additional efficiency package options shall be installed according to Section R408.2.
2. For *mixed-fuel buildings* ~~buildings complying under with Section R401.2.2~~ complying with Section R401.2.1, the building shall be required to install either R408.2.1 or R408.2.5 of the additional efficiency package options, and any two of R408.2.2, R408.2.3, or R408.2.4 of the additional efficiency package options.~~, the building shall meet one of the following:~~

   ~~2.1. One of the additional efficiency package Options in Section R408.2 shall be installed without including such measures in the proposed design under Section R405; or~~

   ~~2.2. The proposed design of the building under Section R405.3 shall have an annual energy cost that is less than or equal to 95 percent of the annual energy cost of the standard reference design.~~

3. For buildings complying with Section R401.2.2, the building shall meet one of the following:
   3.1 *All-electric buildings* shall have one of the additional efficiency package options in Section R408.2 and shall be installed without including such measures in the proposed design under Section R405; or
   3.2 The proposed design of the *all-electric building* under Section R405.3 shall have an annual energy cost that is less than or equal to 95 percent of the annual energy cost of the standard reference design; or
   3.3 *Mixed-fuel buildings* shall have either R408.2.1 or R408.2.5 of the additional efficiency package options, and any two of R408.2.2, R408.2.3, or R408.2.4 of the additional efficiency package options installed without including such measures in the proposed design under Section R405; or
   3.4 The proposed design of the *mixed-fuel building* under Section R405.3 shall have an annual energy cost that is less than or equal to 85 percent of the annual energy cost of the standard reference design.

~~3.~~ 4. ~~For buildings complying with the Energy Rating Index alternative Section R401.2.3, the~~ The Energy Rating Index value shall be at least 5 percent less than the Energy Rating Index target specified in Table R406.5.

The option selected for compliance shall be identified in the certificate required by Section R401.3.

R401.3 Certificate. A permanent certificate shall be completed by the builder or other *approved* party and posted on a wall in the space where the furnace is located, a utility room or an *approved* location inside the *building*. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory *label*, service disconnect *label* or other required labels. The certificate shall indicate the following:

1. The predominant *R*-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, *basement walls*, *crawl space walls* and floors and ducts outside *conditioned spaces*.
2. *U*-factors of fenestration and the *solar heat gain coefficient* (SHGC) of fenestration. Where there is more than one value for any component of the building envelope, the certificate shall indicate both the value covering the largest area and the area weighted average value if available.
3. The results from any required duct system and building envelope air leakage testing performed on the building.
4. The types, sizes, fuel sources, and efficiencies of heating, cooling and service water-heating equipment. Where a gas-fired unvented room heater, electric furnace or baseboard electric heater is installed in the residence, the certificate shall indicate "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be indicated for gas-fired unvented room heaters, electric furnaces and electric baseboard heaters.
5. Where on-site *photovoltaic panel* systems have been installed, the array capacity, inverter efficiency, panel tilt and orientation shall be noted on the certificate.
6. For buildings where an Energy Rating Index score is determined in accordance with Section R406, the Energy Rating Index score, both with and without any on-site generation, shall be listed on the certificate.
7. The code edition under which the structure was permitted and the compliance path used.
8. The fuel sources for cooking and clothes drying equipment.
9. Where combustion equipment is installed, the certificate shall indicate information on the installation of additional electric infrastructure including which equipment and/or appliances include additional electric infrastructure, capacity reserved on the electrical service panel for replacement of each piece of combustion equipment and/or appliance.

R402.1 General. The *building thermal envelope* shall comply with the requirements of Sections R402.1.1 through R402.1.5.

Exceptions:

1. The following low-energy *buildings*, or portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this section shall be exempt from the *building thermal envelope* provisions of Section R402.
   1.1. Those containing no combustion equipment with a peak design rate of energy usage less than 3.4 Btu/h × ft^2 (10.7 W/m^2) or 1.0 watt/ft^2 of floor area for space-conditioning purposes.
   1.2. Those containing no combustion equipment that do not contain *conditioned space*.
2. Log homes designed in accordance with ICC 400.

Add new text as follows:

R404.6 Additional electric infrastructure.. *Combustion equipment* shall be installed in accordance with this section.
R404.6.1 Equipment serving multiple units. *Combustion equipment* that serves multiple *dwelling units* shall comply with Section C405.16.

R404.6.2 Combustion water heating. Water heaters shall be installed in accordance with the following:

1. A dedicated 240-volt branch circuit with a minimum capacity of 30 amps shall terminate within 3 feet (914 mm) from the water heater and be accessible to the water heater with no obstructions. Both ends of the branch circuit shall be labeled with the words "For Future Heat Pump Water Heater" and be electrically isolated.

2. A condensate drain that is no more than 2 inches (51 mm) higher than the base of the installed water heater and allows natural draining without pump assistance shall be installed within 3 feet (914 mm) of the water heater.

3. The water heater shall be installed in a space with minimum dimensions of 3 feet (914 mm) by 3 feet (914 mm) by 7 feet (2134 mm) high.

4. The water heater shall be installed in a space with a minimum volume of 700 cubic feet (20,000 L) or the equivalent of one 16-inch (406 mm) by 24-inch (610 mm) grill to a heated space and one 8-inch (203 mm) duct of no more than 10 feet (3048 mm) in length for cool exhaust air.

R404.6.3 Combustion space heating. Where a building has combustion equipment for space heating, the building shall be provided with a designated exterior location(s) in accordance with the following:

1. Natural drainage for condensate from cooling equipment operation or a condensate drain located within 3 feet (914 mm), and

2. A dedicated branch circuit in compliance with IRC Section E3702.11 based on heat pump space heating equipment sized in accordance with R403.7 and terminating within 3 feet (914 mm) of the location with no obstructions. Both ends of the branch circuit shall be labeled “For Future Heat Pump Space Heater.”

Exception: Where an electrical circuit in compliance with IRC Section E3702.11 exists for space cooling equipment.

R404.6.4 Combustion clothes drying. A dedicated 240-volt branch circuit with a minimum capacity of 30 amps shall terminate within 6 feet (1829 mm) of natural gas clothes dryers and shall be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words “For Future Electric Clothes Drying” and be electrically isolated.

R404.6.5 Combustion cooking. A dedicated 240-Volt, 40A branch circuit shall terminate within 6 feet (1829 mm) of natural gas ranges, cooktops and ovens and be accessible with no obstructions. Both ends of the branch circuit shall be labeled with the words “For Future Electric Range” and be electrically isolated.

R404.6.6 Other combustion equipment. *Combustion equipment* and end-uses not covered by Sections R404.6.2-5 shall be provided with a branch circuit sized for an electric *appliance* , *equipment* or end use with an equivalent capacity that terminates within 6 feet (1829 mm) of the *appliance* or *equipment* .

Revise as follows:

TABLE R405.2 REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE

SECTION[a]	TITLE
General	
R401.2.5	Additional energy efficiency
R401.3	Certificate
Building Thermal Envelope	
R402.1.1	Vapor retarder
R402.2.3	Eave baffle
R402.2.4.1	Access hatches and doors
R402.2.10.1	Crawl space wall insulation installations
R402.4.1.1	Installation
R402.4.1.2	Testing
R402.5	Maximum fenestration U-factor and SHGC
Mechanical	
R403.1	Controls
R403.3, including R403.3.1, except Sections R403.3.2, R403.3.3 and R403.6	Ducts
R403.4	Mechanical system piping insulation
R403.5.1	Heated water circulation and temperature maintenance systems
R403.5.3	Drain water heat recovery units
R403.6	Mechanical ventilation
R403.7	Equipment sizing and efficiency rating
R403.8	Systems serving multiple dwelling units
R403.9	Snow melt and ice systems
R403.10	Energy consumption of pools and spas
R403.11	Portable spas
R403.12	Residential pools and permanent residential spas
Electrical Power and Lighting Systems	
R404.1	Lighting equipment
404.2	Interior lighting controls
R404.6	Additional electric infrastructure

a. Reference to a code section includes all the relative subsections except as indicated in the table.

TABLE R406.2 REQUIREMENTS FOR ENERGY RATING INDEX

SECTION[a]	TITLE
General	
R401.2.5	Additional efficiency packages
R401.3	Certificate
Building Thermal Envelope	
R402.1.1	Vapor retarder
R402.2.3	Eave baffle
R402.2.4.1	Access hatches and doors
R402.2.10.1	Crawl space wall insulation installation
R402.4.1.1	Installation
R402.4.1.2	Testing
Mechanical	
R403.1	Controls
R403.3 except Sections R403.3.2, R403.3.3 and R403.3.6	Ducts
R403.4	Mechanical system piping insulation
R403.5.1	Heated water calculation and temperature maintenance systems
R403.5.3	Drain water heat recovery units
R403.6	Mechanical ventilation
R403.7	Equipment sizing and efficiency rating
R403.8	Systems serving multiple dwelling units
R403.9	Snow melt and ice systems
R403.10	Energy consumption of pools and spas
R403.11	Portable spas
R403.12	Residential pools and permanent residential spas
Electrical Power and Lighting Systems	
R404.1	Lighting equipment
404.2	Interior lighting controls
R404.6	Additional electric infrastructure
R406.3	Building thermal envelope

a. Reference to a code section includes all of the relative subsections except as indicated in the table.

TABLE R406.5 MAXIMUM ENERGY RATING INDEX

CLIMATE ZONE	~~ENERGY RATING INDEX~~ All-Electric Building	Mixed Fuel Building
0-1	52	52
2	52	52
3	51	51
4	54	54
5	55	47
6	54	46
7	53	46
8	53	53

R408.2.3 Reduced energy use in service water-heating option. The hot water system shall meet one of the following efficiencies:

1. Greater than or equal to 82 EF fossil fuel service water-heating system.
2. Greater than or equal to 2.0 EF electric service water-heating system.
3. Greater than or equal to 0.4 solar fraction solar water-heating system.
4. Greater than or equal to 82 EF instantaneous fossil fuel service water-heating system and drain water heat recovery unit meeting the requirements of Section R403.5.3 installed on at least one shower.

Reason Statement: In order to meet the state's 2045 carbon neutrality goal, Virginia must not only reduce energy use through energy efficiency and move to utility scale and on-site renewable energy, but also begin to transition away from using combustion equipment in buildings that runs on fossil fuels to electric equipment. Therefore it is crucial that new buildings today can be cost-effectively retrofitted in the future with electric equipment so that emissions are not "locked-in" by gas-dependent building infrastructure. Fortunately, heat pump technology has dramatically improved over the last few decades, giving contractors and building owners access to highly efficient electric heating and cooling, and water heating technologies.

One of the biggest expenses of electrification retrofits – and therefore barriers to electrification in existing buildings - is running electrical infrastructure through a completed and enclosed building that has combustion equipment. This significant future cost can be greatly reduced through making simple, low-cost modifications to buildings during construction that enable easier electrification in the future. The requirements in this proposed amendment ensure that the electrical infrastructure is in place so that building owners can convert to an all-electric building in the future and ensures that unitized gas water heaters can be replaced with high-performance heat pump water heaters (HPWHs). Because all-electric buildings are more efficient than mixed-fuel buildings, this code amendment also requires buildings with combustion equipment to be as or more efficient than all-electric buildings.

Electric Infrastructure:

The addition of R404.6 ensures the electrical plugs and physical space exists so that a building owner can cost effectively replace their gas equipment and appliances with electric equipment in the future. This language is based on the approach adopted in the electrification reach codes adopted by various California cities.

As described in R404.6.1, this proposal is limited to gas equipment that serves individual dwelling units. Equipment that serves multiple dwelling units is directed to a similar proposed code amendment in the commercial section. If LARA choses to adopt this amendment and not the electric-readiness amendment for commercial, this amendment should be revised accordingly.

R404.6.2 is focused on ensuring that water heater locations are physically capable of incorporating a future heat pump water heater (HPWH). Requirement 1 ensures that there is a branch circuit ready to support the future installation of a HPWH. Requirement 2 ensures that the condensate generated by a HPWH compressor can be easily drained away. Requirement 3 ensures that the water heater location is physically large enough to accommodate HPWHs that are frequently wider and/or taller than code-minimum gas water heaters. Requirement 4 ensures that a future HPWH has access to sufficient air volume to effectively operate. These requirements are based on the requirements adopted in several CA jurisdictions electrification reach codes.

R404.6.3 ensures the electric infrastructure for combustion space heating is present so that a heat pump can be installed in the future. The section references IRC Section E3702.11 which sets the requirement for sizing a branch circuit serving a heat pump and relies on the size of the actual equipment to be installed. Since there is not an actual equipment size to reference and equipment size can vary depending on the size of the home and the climate, the section also references Section R403.7 to establish the size of the heat pump equipment that would be required for the specific home.

R404.6.4 and R404.6.5 requires combustion clothes drying and cooking to have plugs nearby so that a homeowners can replace them with electric equipment cost effectively in the future. IRC Section E3702.9.1 requires a 240V/40A branch circuit for a standard 8.75 kVA or larger electric residential range and has been used as the basis for the sizing of the branch circuit. Six feet is cited per requirements from IRC Section E3901.5 requiring appliance receptacles to be within 6 feet of the intended appliance.

This section and others rely on new definitions for appliance, equipment, fuel gas and fuel oil which are mirrored from 2021 IMC to be useful in defining combustion equipment.

Inspection, Construction Documents and Efficiency

R401.3 requires builders to note the electric infrastructure in place on the compliance certificate to both allow for easier enforcement of these provisions and to ensure current or future homeowners are aware that they can easily replace combustion equipment and appliances with electric equipment and appliances.

Because all-electric newly constructed homes typically use less energy when compared to newly constructed mixed-fuel homes. Revisions to R401.2.5 seeks to encourage electrification and more evenly weigh the impact of the additional efficiency credits by requiring the mixed-fuel home to select a total of three packages from the options while the all-electric home is required to select one package. Of the three packages required for the mixed-fuel home, one must address the envelope (improved envelope or reduced infiltration plus better ventilation) while the remaining two impact HVAC (better equipment or more efficient ducts) and water-heating (better equipment) requirements). Since mixed fuel buildings will be required to select more package options, the amendment also adds a fourth service hot water package that combines the efficiency benefits of an instantaneous gas water heater with a drain water heat recovery unit. This package is based on analysis conducted by the Northwest Energy Efficiency Alliance[1] (NEEA). Modifications to requirement 3 under R401.2.4 applies this same concept to the performance path.

Low-energy buildings

Low energy buildings are currently exempt from thermal envelope requirements. The revision to R402.1 requires low-energy buildings that choose not to install insulation to be all-electric to reduce their greenhouse gas impact.

ERI and Performance Pathway

The proposal also includes a modification to the mandatory table in R405 and R406 to ensure that projects using the ERI or performance method will also comply with electric-readiness requirements. An additional modification to R406 encourages homes following the ERI performance path to be all-electric by setting more stringent ERI values for mixed-fuel homes. This is needed as Standard 301, which sets the calculation methodology for calculating ERI, claims to be fuel agnostic. The ERI values for mixed-fuel homes match those from ASHRAE 90.2 and Appendix RC Zero Energy Residential Building Provisions as published in the 2021 IECC. The ERI values for all-electric homes are the same as the values published in Table R406.5 of the 2021 IECC.

Cost Impact: The code change proposal will increase the cost of construction
Virginia buildings that are all-electric would have no change in construction costs. Mixed fuel buildings would be slightly more expensive to build because they would both have to be electric-ready and be more efficient. Electric-ready requirements are anticipated to be nominal. Recent analysis by NBI and partners using cost data from RSMeans indicates that additional electrical infrastructure costs for water-heating, space-heating, and cooking cost $440. Cost data from Grainger indicates additional energy efficiency measures required by mixed-fuel buildings would raise construction costs by $1,350.

However if a homeowner were to have to retrofit their home from using combustion equipment to natural gas equipment costs without these requirements in place, costs could be exorbitant. For example, upgrading the electrical panel could cost upwards of $6,000 if it is not sized appropriately.

Resiliency Impact Statement: This proposal will increase Resiliency
Electric ready infrastructure allows single-family and small multifamily homes the ability to take advantage of the greening grid while spreading out the costs. As noted in the reason statement, they will likely transition from fossil fuel to electric appliances over their lifespan. Although these buildings will require more electricity from the grid than their fossil fuel burning counterparts as they transition, they will be able to operate entirely on clean renewable energy.

By constructing electric-ready, homeowners will additionally be given the tools they need to make decisions on the timing to switch fuel sources. As the costs of fuels change over time, owners will be ready to remove themselves from the volatility and geopolitics of the fossil fuel market.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: REC-R401.2.5-21

This proposal doesn't have any public comments.

Proposal # 1059

REC-R401.2.5-21 – Staff Summary

Proponent: Ben Rabe (New Buildings Institute); Diana Burk (New Buildings Institute)

Brief Description:

The proposal requires the installation of additional electrical infrastructure for potential future use, in buildings with combustion equipment; and excludes buildings containing combustion equipment from the thermal envelope exemptions applicable to low-energy buildings.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman: Sierra Club - Virginia Chapter
  - (Comments from similar proposal: REC-R401.2) He opined that the proposal will save money for residents, it will reduce pollution, it's a critical measure for climate change, and will create a healthier house without the fumes from burning fossil fuels. *Note:* in response to some of the opposing statements noted below, he indicated that he does not think that the proposal conflicts with the net-zero path Virginia is currently on.
- Laura Baker (alternate for Eric Lacey): Responsible Energy Codes Alliance
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)
  - (Comments from similar proposal: REC-R401.2) He indicated that HBAV is unequivocally opposed to the proposal and shared concerns that this proposal is in potential conflict with other state laws, the Virginia Energy Plan and the net-zero path that Virginia is currently on.
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)
- Brian Clark: Habitat for Humanity

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- K.C. Bleile: Viridiant

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note:* partial attendance. Not in attendance during REC-R401.2.5-21 discussion and voting.
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during REC-R401.2.5-21 discussion and voting.
- Jim Canter: Virginia Building & Code Officials Association (VBCOA)
- Bettina Bergoo: Virginia Department of Energy
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter

Statements from other stakeholders (Comments from similar proposal: REC-R401.2) in support of the proposal:

- Ross Shearer, representing self, noted that there are countless environmental, health and safety issues associated with natural gas. Earlier this week the Washington Post reported a story of family experiencing illnesses including nausea. It turned out to be carbon monoxide leaking from a loose connection to the exhaust line of the gas furnace. Natural gas should not be used for any new construction.

Statements from other stakeholders (Comments from similar proposal: REC-R401.2) in opposition to the proposal:

- John Ainslie (HBAV alternate), in response to statements by proponents suggesting that it is cleaner to use electricity than fuel gas, he argued that he has read that homes burning gas leave a smaller carbon footprint than those using electric.
- Michael O'Connor, Virginia Petroleum and Convenience Marketers Association (VPCMA) and Virginia Propane Gas Association (VAPGA) recorded their opposition to the proposal and expressed concerns related to the more than 60,000 generators in operation in Virginia fueled by natural gas and propane serving hospitals, first responders nursing homes and other buildings; and how would those essential sectors be served in times of emergency when the electricity is not available.
- Morgan Whayland, Virginia Natural Gas, noted their opposition and stated that natural gas, which is affordable for the consumer, is a critical part in the effort to achieve net-zero. When we think about energy efficiency, we have to think about the entire supply chain. Natural gas is a more efficient energy source than electricity.

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club

- William Penniman, Sierra Club, expressed support for the proposal and opined that electrification is essential to meet climate goals and is healthier for people.

Opposition:

Names: Andrew Clark, HBAV; Mike O'Connor, Virginia Petroleum Marketers and Convenience Stores; Virginia Propane Gas Association.

- Andrew Clark, HBAV, opposed the proposal and stood on the reasons stated during the Energy Sub-Workgroup meeting on March 24, 2022.
- Mike O'Connor, Virginia Petroleum and Convenience Marketers Association and Virginia Propane Gas Association, opposed the proposal and stood on the reasons stated during the Energy Sub-Workgroup meeting on March 24, 2022.

DHCD Staff Notes:

Given the similarities between this proposal and proposal REC-R401.2-21, which was discussed immediately prior (during the Energy Sub-Workgroup meeting as well as the General Stakeholders Workgroup meeting), the supporting and opposing parties rested on their testimony for REC-R401.2-21 which has been included as a convenience in the "STUDY GROUP OR SUB-WORKGROUP INFORMATION" section above.

Meeting summaries and proposal related information: Tab 10 - Page 41; Tab 11 - Page 18.

REC-R403.1.1.1-21

Proponents: Ben Rabe (ben@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

DEMAND RESPONSE SIGNAL. A signal that indicates a price or a request to modify electricity consumption for a limited time period.

DEMAND RESPONSIVE CONTROL. A control capable of receiving and automatically responding to a *demand response signal* .

R403.1.1.1 Demand responsive thermostat controls. **R403.1.1.1 Demand responsive thermostat controls.** The thermostats shall be provided with *demand responsive controls* that comply with AHRI 1380 capable of the following:

1. Automatically increasing the zone operating cooling set points by a minimum of 4°F (2.2°C)
2. Automatically decreasing the zone operating heating set points by a minimum of 4°F (2.2°C)
3. Automatically decreasing the zone operating cooling set points by a minimum of 2°F (1.1°C)
4. Automatically increasing the zone operation heating set points by a minimum of 2°F (1.1°C)
5. Both ramp-up and ramp-down logic to prevent the building peak demand from exceeding that expected without the DR implementation.

The thermostat shall be capable of performing all other functions provided by the control when the *demand responsive controls* are not available.

Exception: Assisted living facilities.

Reason Statement: According to a new report from the National Association of Home Builders (NAHB), in 2021, homeowners will be seeking out features for their homes that improve comfort, wellness and efficiency. One of these common home features homeowners are seeking out are ways to improve their overall home energy use. To help lower energy bills, home builders install a smart thermostat to regulate temperatures and install ENERGY STAR appliances. Major builders D.R. Horton and Toll Brothers are both partners with smart home technology which are installed in the homes they build (these include smart thermostats). Grid-integrated controls for thermostats are added based on language from California Title 24 and integrated into the current requirement for thermostats. Any thermostat listed as “Title 24 compliant” would meet this requirement, and are available directly through major retailers.
Smart thermostat demand response is becoming one of the most pervasive utility offering throughout the country. In their 2019 Demand Response Market Snapshot, SEPA found that 58 utilities had smart thermostat offerings, comprising 1 GW of connected load. In their assessment of US national potential for load flexibility, Brattle found that smart thermostats were the largest single program offering in their estimated 200 GW of potential by 2030. As shown in the figure below, LBNL modeling for the DOE GEB roadmap shows that demand response thermostats can reduce building peak demand by up to 30%. The substantial savings impact variability is because LBNL modeled impacts at times driven by typical utility peak hours based on the utility grid region but that does not necessarily align with building peak hours. If the two are aligned, the impacts are maximized; if impacts are misaligned impacts may be shown as negative. Therefore, these impacts should not be considered to be “typical” or “maximum” in each case. To ensure the inclusion of demand response controls are treated as mandatory the thermostat requirements are added to the tropical compliance list under R407.2.

Cost Impact: The code change proposal will increase the cost of construction
In 2011, demand response thermostats (which were estimated to cost $68 more than a programmable thermostat) were found to be extremely cost effective.3 It was estimated that for every dollar spent on a grid-integrated thermostat in 2011 yielded between $2 to $9 in operating cost savings over a 15-year period. In the 10 years since, equipment prices have decreased. One can purchase a basic grid-integrated thermostat for $63 compared to a basic 7-day programmable thermostat which costs $42. Including labor costs and a 35% markup to account for direct and indirect costs of construction, the incremental construction cost of installing a demand responsive thermostat is currently estimated to be $40 making this measure even more cost effective than estimated previously. Not only will this measure result in cost savings to consumers, but it will also result in other significant societal benefits. According to DOE’s report, “A National Roadmap for Grid-Interactive Efficient Buildings”, every watt in peak demand savings was found to create 17 cents in annual electric grid system value. This value included energy savings, capacity savings, transmission deferral and ancillary services. A single-family home with a grid-integrated thermostat which is estimated to reduce peak demand savings between 0.26 to 1.09kW would result in $43 to $181 in annual electric grid system value. Grid-integrated thermostats which allow grid operators to reduce demand on the grid during the times when the carbon intensity of the electric grid is high also results in reduced carbon emissions generating additional significant societal benefits.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. As we see increasing number of severe weather events, the electric grid’s ability to withstand these events will become increasingly important. Demand controlled thermostats will help integrate building loads with available production, lowering energy demand. Therefore, this proposal increase resiliency by reducing overall demand on the grid.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- ☐ Approved
- ☐ Approved with Modifications
- ☐ Carryover
- ☐ Disapproved
- ☐ None

Public Comments for: REC-R403.1.1.1-21

This proposal doesn't have any public comments.

Proposal # 1062

REC-R403.1.1.1-21 – Staff Summary

Proponent: Ben Rabe, New Buildings Institute

Brief Description:

The proposal requires thermostats with demand responsive controls.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, with only one member in support.

Energy Sub-Workgroup member in attendance and supporting the proposal:

- William Penniman: Sierra Club - Virginia Chapter (no specific reason provided for the support)

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)
- Brian Clark: Habitat for Humanity
- K.C. Bleile: Viridiant
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)

Energy Sub-Workgroup member Chelsea Harnish, Virginia Energy Efficiency Council, indicated a neutral position on the proposal but raised some concerns:

- The specific criteria set forth by the proposal might conflict with the existing demand response programs offered by Dominion Energy and other electrical utility providers
- The proposal appears to intend to regulate energy providers through the building code
- How would the program be managed, who would run them
- Not all Virginia electrical utility providers, especially some of the Co-Ops do not offer these demand response programs

Note: The proponent responded that it was not his intent to regulate the electrical utility providers but more so to start a conversation around different opportunities to get demand response, grid controllable ideas in the code.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Laura Baker (alternate for Eric Lacey): Responsible Energy Codes Alliance

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note:* partial attendance. Not in attendance during REC-R403.1.1.1-21 discussion and voting.
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. *Note:* partial attendance. Not in attendance during REC-R403.1.1.1-21 discussion and voting.
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter

Other stakeholders in attendance and opposing the proposal:

- Michael O'Connor, Virginia Petroleum and Convenience Marketers Association and Virginia Propane Gas Association, posted in the Adobe Platform chat box: "*The ramifications of big brother telling Virginia consumers what temprature (sic) they set their homes at go far beyond this proposal"*

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Eric Lacey, representing self; William Penniman, Sierra Club.

- Eric Lacey, representing self, noted that he's familiar with cool keeper and other programs where consumers get a credit on their bill. This proposal doesn't require a big investment, only a thermostat with the capabilities when the home is built. Nobody wants to pay the cost of tearing out an old thermostat and putting in a new one. If the homeowner elects to use it or not, it would be good to install the technology initially. He suggested that it would be good to at least carry over the proposal and continue discussions.
- William Penniman, Sierra Club, expressed support for the proposal and agreed with Eric Lacey's comments. The user could get paid and the system would benefit (from installing demand response thermostats).

Opposition:

Names: Andrew Clark, HBAV

- Andrew Clark, HBAV, stated that he is willing to continue the conversation, but opposed the proposal as of the time of the meeting.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 42; Tab 11 - Page 19.

REC-R403.1.4-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Construction Code

Add new text as follows:

R403.1.4 On-site combustion as primary heat source. On-site combustion of a fossil fuel shall not be used as the primary heat source for space heating, water heating or cooking in new residential construction.

N1103.1.4
On-site combustion as primary source of heat.. On-site combustion of a fossil fuel shall not be used as the primary heat source for space heating, water heating or cooking in new residential construction.

Reason Statement: This proposal would preclude the use of on-site combustion of fossil fuels as the primary source of heat in new residential construction. It would not preclude use of firewood or any form of back-up heating, outdoor grills or fireplaces.
The building code's primary purpose is to protect the health, safety and welfare of residents of the Commonwealth. To fulfill that goal, the Board should use those powers to adopt code provisions that prohibit future installations of appliances that rely on on-site combustion to generate heat for space heating, water heating or cooking.
Electrification of buildings, in place of on-site combustion, is a critical component of decarbonization strategies to reduce climate-pollution (especially CO2 and methane from producing, transmitting and combusting fossil fuels) and to stabilize global warming at or below a 1.5ºC increase over pre-industrial levels. See, e.g., https://www.vox.com/2016/9/19/12938086/electrify-everything; https://rmi.org/eight-benefits-of-building-electrification-for-households-communities-and-climate/ ; https://www.rff.org/publications/explainers/electrification-101/ Shifting to electricity to heat space, water and cooking will reduce indoor and outdoor pollution. Such pollution is harmful to human health and to the climate, particularly since off-site combustion of fuel to generate electricity is being displaced by non-polluting energy sources in Virginia and nationally.

The consequences from global warming are extremely harmful to people, property, infrastructure, the economy and our natural heritage. Virginia is particularly vulnerable to worsening storms and sea level rise, as well as heat illness, cardio-vascular harms.

Indoor, on-site combustion equipment produces harmful indoor air pollution in multiple forms (e.g., carbon monoxide, carbon dioxide, and methane) and pose greater risks of fire and explosions. Indoor pollution (NO2, CO, CO2, methane, etc.) from cooking with natural gas and propane is particularly harmful to residents. [1]

In-home combustion of gas or other fuels is less energy efficient than heating space or water with electric heat pumps due to the higher (300%) coefficient of performance of heat pumps. In addition, electric induction stoves are far more energy efficient than cooking with gas or propane. All on-site combustion (whether gas, oil, coal or other fuel) is dirtier and more harmful than using electric heat pumps. Virginia's electric energy is already cleaner will get cleaner still as Virginia increasingly generates electricity with zero-carbon technologies, a conversion that is planned by Virginia's major utilities.
Methane leaks from all fossil fuel production, as well as from natural gas transportation/deliveries, and combustion appliances. Methane is 86 times worse than CO2 as a greenhouse gas over 20 years. [2] It is thus a particular danger during this period in which we must dramatically reduce greenhouse gas emissions in order to avoid catastrophic warming. We cannot afford to keep adding fossil fuel users that contribute to greenhouse gas emissions. Propane also leaks (along with methane) when produced, transported, delivered to storage tanks, and used.

In addition, combustion furnaces are more costly in Virginia compared to heat pumps taking into account costs of piping inside and outside a dwelling (including to gas mains), storage in the case of propane or fuel oil, the need to install a separate air conditioner, and fuel costs.In sum,lower total costs, the growing climate crisis and the importance of reducing indoor and outdoor air pollution warrant implementation of this limitation on using combustion heating as the primary heat source in new dwellings.

[1] Although combustion furnaces are generally designed to vent emissions outdoors, they still pose risks of carbon monoxide, carbon dioxide, methane and other fumes, and installing a natural gas furnace will increase the probability that a gas stove will also be installed. Gas stoves are a particularly large source of indoor air pollution. https://rmi.org/insight/gas-stoves-pollution-health .

[2] "The drilling and extraction of the fuel from wells, as well as its processing, transmission, distribution, and storage, also result in the leakage of methane—a primary component of natural gas that is 34 times stronger than carbon dioxide at trapping heat over a 100-year period and 86 times stronger over 20 years (Myhre et al. 2013)." Union of Concerned Scientists, The Natural Gas Gamble: A Risky Bet on America's Clean Energy Future (March 2015), p. 16. The report adds: "Although there is still uncertainty about the precise quantity of these so-called fugitive methane emissions, preliminary studies and field measurements range from 1 to 9 percent of total natural gas production.

Cost Impact: The code change proposal will decrease the cost of construction
Installing an electric heat pump is cheaper than installing both an electric air conditioner and a fossil-fuel combustion furnace with its associated infrastructure (piping, venting and storage). (A builder's choice to install a hybrid system would require incurrence of those infrastructure costs.)

Once installed, the operating efficiencies and operating costs favor electric heat pumps in Virginia, which will result in a net cost savings to residents. Reducing pollution from on-site combustion will also result in a cleaner, healthier dwelling and in a cleaner and healthier environment. Reducing environmental harms will reduce costs and harms to the public.

Thus, installing and operating an electric heat pump is likely to save money and improve lives when all factors are considered.

Resiliency Impact Statement: This proposal will increase Resiliency
The proposed measure will save energy; increase reliance on zero-carbon energy sources for heating; help mitigate climate impacts; and prepare Virginia's buildings and economy for a future that requires the least energy usage and related pollution possible. Climate change is already harming Virginia and the harms will get much worse if we do not sharply reduce GHG emissions (particularly CO2 and methane). Growing climate dangers include harms to communities, infrastructure, people, property and the economy from rising seas, worsening storms and more severe rainfall events. Growing dangers also include rising atmospheric and water temperatures that threaten worsening heat related illnesses, limits on economic activity, agriculture, fisheries, and our natural heritage. The likelihood of mitigating and recovering from those harms declines the longer we delay maximizing energy savings and minimizing GHG pollution.

Since both rely on electricity, neither heat pumps nor gas furnaces would operate during a power outage.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: REC-R403.1.4-21

This proposal doesn't have any public comments.

Proposal # 987

REC-R403.1.4-21 – Staff Summary

Proponent: William Penniman, Sierra Club – Virginia Chapter

Brief Description:

The proposal prohibits the use of on-site combustion of fossil fuels as the primary source for space heating, water heating or cooking in new residential buildings.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on May 12, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman: Sierra Club - Virginia Chapter
- Eric Lacey (Laura Baker alternate): Responsible Energy Codes Alliance

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)
- K.C. Bleile: Viridiant
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter
- Brian Clark: Habitat for Humanity

Other stakeholders in attendance and supporting the proposal:

- Ben Rabe: New Building Institute (NBI)
- Steve Sunderman
- Ross Shearer

Other stakeholders in attendance and opposing the proposal:

- Michael O'Connor: Virginia Petroleum and Convenience Marketers Association and Virginia Propane Gas Association
- John Ainslie: HBAV
- David Owen: Home Building Association of Richmond

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Ben Rabe, NBI

- Ben Rabe, NBI, expressed support for the proposal as a good way to allow for the transition towards heat pumps without going all in when the technology is not quite there yet.

Opposition:

Names: David Beahm, Warren County; Andrew Clark, HBAV.

- David Beahm, Warren County, expressed opposition to the proposal as it is geared at prohibiting the use of fossil fuel for space heating, water heating and cooking.
- Andrew Clark, HBAV, opposed the proposal and shared David Beahm's concerns.

DHCD Staff Notes: The Energy Sub-Workgroup members did not offer any specific reasons for supporting or opposing the proposal during the Sub-Workgroup's May 12th meeting.

Meeting summaries and proposal related information: Tab 10 - Page 82; Tab 11 - Page 33.

REC-R403.1.4(2)-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Energy Conservation Code

Add new text as follows:

R403.1.4 Heat Pumps for Cooling and Heating. An electric heat pump system shall be installed as the primary space cooling and heating system in any dwelling in which central, ducted air conditioning would otherwise be installed. A ductless heat pump system shall be installed to serve any portion of a dwelling in which a ductless heating or cooling system would otherwise be installed.

2018 Virgina Residential Code

Add new text as follows:

N1103.1.4 Heat Pumps for Cooling or Heating. An electric heat pump system shall be installed as the primary space cooling and heating system in any dwelling in which central, ducted air conditioning would otherwise be installed. A ductless heat pump system shall be installed to serve any portion of a dwelling in which a ductless heating or cooling system would otherwise be installed.

Reason Statement: This proposal addresses new dwellings in which air conditioning is to be installed. It will provide both construction and operational efficiencies. Although heat pumps with electric auxiliary and emergency heating would be better, the proposal does not restrict the source of auxiliary or emergency heating for periods in which heat pumps need supplementation due to very cold weather or power outages. Heat pumps will still reduce energy consumption and pollution, and improved heat pump performance should minimize the periods in which on-site combustion occurs on a back-up basis.

Electric heat pumps are highly energy efficient for both heating and cooling in Virginia. The combination of heating and cooling in a heat pump will greatly reduce energy consumption and energy costs, as well as construction costs, compared to installing and operating separate air conditioning and other heating systems. Heat pumps use the same technology as air conditioners for space cooling and also for heating. They are are much more energy efficient than either combustion or resistance units for space heating. Energy efficiencies are up to 300% of resistance heat and potentially more compared to combustion heat.

Electric heat pumps conserve energy and provide year round comfort and better quality indoor air than combination systems that use electricity for air conditioning but combustion or resistance heat for space heating.

Importantly, electric heat pumps also reduce air pollution, climate harms and water pollution compared to combustion-based space heating. Cooling and heating with electric heat pumps is vital for achieving the Commonwealth's and the world's goals for reducing GHG emissions. Recent reports confirm that rapid reductions of CO2 and other GHG emissions are critical, and shifting to heat pumps is vital to achieving those goals. https://www.sierraclub.org/articles/2020/04/new-analysis-heat-pumps-slow-climate-change-every-corner-country ; https://www.vox.com/2016/9/19/12938086/electrify-everything; https://rmi.org/eight-benefits-of-building-electrification-for-households-communities-and-climate/ ; https://www.rff.org/publications/explainers/electrification-101/ .

The proposal would help to implement Virginia's stated Clean Energy Policy (§ 45.2-1706.1. (Effective October 1, 2021) Commonwealth Clean Energy Policy) which supports decarbonization and states that it is "the policy of the Commonwealth to: ...8. Promote building and construction practices that reduce emissions associated with built environment, including energy efficiency targets, new building standards, and transit-oriented and other sustainable development practices...."

Cost Impact: The code change proposal will decrease the cost of construction
The proposal will reduce construction costs by providing cooling and heating with a single system rather than separate equipment for each. It will also save residents money in their year round costs of space conditioning while providing greater comfort and a cleaner environment both indoors and outdoors.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal will increase resiliency by reducing carbon and other greenhouse gas emissions, which are increasingly harming our lives, property, economy and natural heritage. These dangers are not theoretical for Virginia. Sea level rise, more intense rainfall events, more severe storms, increased heat-illness and asthma are already impacting Virginians, their infrastructure and property. Forecasts for sea level rise now reach 2 feet by 2050, if GHG emissions are not drastically reduced.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: REC-R403.1.4(2)-21

This proposal doesn't have any public comments.

Proposal # 1104

REC-R403.1.4(2)-21 – Staff Summary

Proponent: William Penniman, Sierra Club – Virginia Chapter

Brief Description:

The proposal requires electric heat pump systems to be used as the primary space cooling and heating systems in dwellings where central air conditioning systems are installed.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on May 12, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman: Sierra Club - Virginia Chapter
- Eric Lacey (Laura Baker alternate): Responsible Energy Codes Alliance

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- K.C. Bleile: Viridiant

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter
- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter
- Brian Clark: Habitat for Humanity

Other stakeholders in attendance and supporting the proposal:

- Ben Rabe: New Building Institute (NBI)
  - It is better than having separate heating and cooling systems.
- Steve Sunderman

Other stakeholders in attendance and opposing the proposal:

- Michael O'Connor: Virginia Petroleum and Convenience Marketers Association and Virginia Propane Gas Association
- David Owen: Home Building Association of Richmond

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Ben Rabe, NBI

- Ben Rabe, NBI, expressed support for the proposal and opined that this makes a lot of sense for Virginia's climate of very hot summers and mild winters. The heat pumps would do just fine in those circumstances.

Opposition:

Names: David Beahm, Warren County; Andrew Clark (HBAV).

- David Beahm, Warren County, expressed opposition to the proposal as it doesn't give builders or consumers a choice, and opined that it could actually increase the cost of construction.
- Andrew Clark (HBAV), expressed opposition to the proposal, noted that these types of proposals are aspirational and agreed that it would cost the consumers.

DHCD Staff Notes:

The Energy Sub-Workgroup members did not provide any specific reasons for supporting or opposing the proposal.

Meeting summaries and proposal related information: Tab 10 - Page 82; Tab 11 - Page 33.

REC-R403.5.4-21

Proponents: Ben Rabe (ben@newbuildings.org)

2021 International Energy Conservation Code

Add new text as follows:

DEMAND RESPONSE SIGNAL. A signal that indicates a price or a request to modify electricity consumption for a limited time period.

DEMAND RESPONSIVE CONTROL. A control capable of receiving and automatically responding to a *demand response signal* .

R403.5.4 Demand Responsive water heating.. Electric storage water heaters with a rated water storage volume between 40 and 120 gallons and a nameplate input rating equal to or less than 12kW shall be provided with *demand responsive controls* that comply with ANSI/CTA-2045-B Level 2, except “Price Stream Communication” functionality as defined in the standard, or another equivalent *approved demand responsive control* .

Revise as follows:

ANSI

American National Standards Institute
25 West 43rd Street, 4th Floor
New York, NY 10036

ANSI/CTA-2045-B	Modular Communications Interface for Energy Management .

Reason Statement: With increasing penetrations of intermittent renewable energy, volatile wholesale power prices, and subsequent growth in dynamic rates/demand response programs, grid-interactive end uses present an opportunity to help homes manage their bills, participate in programs, and support efficient grid operations. Water heaters can provide many services to the grid, including generation, transmission, and distribution capacity, energy arbitrage, and ancillary services.
As electricity systems transform to include more variable wind and solar energy, demand flexibility becomes increasingly critical to both grid operation and further transformation. Building systems that can use energy when it is abundant, clean, and low-cost not only help decarbonize the entire energy system, they also insulate their owners from future increases in demand charges and peak hour energy rates – a current and accelerating trend. Water heaters offer an unparalleled opportunity for load shifting: tanks full of hot water are inherently energy storage devices. Including the controls necessary to take advantage of this opportunity is relatively simple and affordable in new construction. Compared to other energy storage technologies such as batteries, smart, grid-integrated water heater controls can deliver substantial dispatchable (that is, reliable to the grid operator) energy flexibility. The controls specified by ANSI/CTA-2045-B ensure negligible risk of occupant disruption (that is, the hot water will not run out). Water heaters provide a particularly attractive option as they have inherent thermal storage that allows energy consumption to be shifted with little to no impact to the end user. This capability has been demonstrated in several contexts, most recently through regional demonstrations conducted by EPRI and BPA.

In their Grid-interactive and Efficient Buildings (GEBs) Roadmap, the US Department of Energy estimates that approximately 15 GW of additional load flexibility is expected to be added to the system under reference case assumptions. Combined with energy efficiency, this is expected to provide $13 billion/year of peak demand savings to the power system and its customers. Through a comprehensive literature review and interviewing dozens of national experts, the USDOE team found that one of the biggest barriers was the lack of interoperability. A key tool to solve this problem is building codes, which can help to ensure that interoperable devices and controls are installed at the time of construction. USDOE cited explicitly the use of codes and standards as one of its recommended pathways to enable greater adoption of GEBs technologies.

ANSI/CTA-2045-B standardizes the socket, and communications protocol, for electric water heaters so they can communicate with the grid, and with demand response signal providers. In addition, 2045-B adds control and communications requirements for mixing valves in water heaters, which enable them to provide greater storage capacity to support increased load shifting while eliminating scalding risk.

Cost Impact: The code change proposal will increase the cost of construction
Demand controls for water heaters which costs around $173 [AM1] become cost effective when enrolled in a demand response program. Armada Power customers in Ohio who enrolled their water heaters in a demand response program saved $184 annually by enrolling in the program. If utilities nationwide instituted a similar program to shape demand, a customer could reap $12 in energy cost savings for every $1 spent on the additional controls. Customer cost savings are likely to increase in many locations as utilities deploy more time-of-use rate structures, increase demand charges, and expand the daily and seasonal periods during which these rate components apply.

Not only will this measure result in cost savings to consumers, but it will also result in other significant societal benefits. According to DOE’s report, “A National Roadmap for Grid-Interactive Efficient Buildings”, every watt in peak demand savings was found to create 17 cents in annual electric grid system value. This value included energy savings, capacity savings, transmission deferral and ancillary services. A 3-bedroom, 2-bath apartment with a grid-integrated water heater is estimated to reduce peak demand savings by 0.3kW, which would result in $51 in annual electric grid system value. Grid-integrated water heaters which allow grid operators to reduce demand on the grid during the times when the carbon intensity of the electric grid is high, which also results in reduced carbon emissions – generating additional significant societal benefits.

Resiliency Impact Statement: This proposal will increase Resiliency
Demand responsive controls allow for utilities to send and buildings to receive signals to ramp up or down set points based on a variety of conditions. This communication ability is a critical aspect of resilience for our communities. Storage water heaters have a unique capability to act as thermal storage "batteries". By allowing water heaters to receive a signal from the grid, water can be heated at a time when overall demand, price signals or carbon emissions are at their lowest. Pre-heating water in this way can help to lessen peak demands on the grid, creating grid resiliency, reduce costs for consumers, creating financial resiliency, and help absorb excess renewable generation, or at a minimum engage during the cleanest hours of generation, reducing carbon emissions and climate impact of water heating.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: REC-R403.5.4-21

This proposal doesn't have any public comments.

Proposal # 1063

REC-R403.5.4-21 – Staff Summary

Proponent: Ben Rabe, New Buildings Institute

Brief Description:

The proposal requires electric storage water heaters with a rated water storage volume between 40 and 120 gallons and a nameplate input rating equal to or less than 12kW to be provided with demand responsive controls.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, with only one member in support.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman: Sierra Club - Virginia Chapter
  - Demand response on water heaters is very simple technology. Could the demand response be used by other than the utility?
    Note: the proponent responded by clarifying that although it is implied, the intent is that the utility would be the best to control the demand response.

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)
- Brian Clark: Habitat for Humanity
- K.C. Bleile: Viridiant
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
  - Indicated that no utility in VA has a DR hot water heater program.
- Laura Baker (alternate for Eric Lacey): Responsible Energy Codes Alliance

Energy Sub-Workgroup members not in attendance:

- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter

- Andy McKinley: American Institute of Architects – Virginia Chapter. *Note:* partial attendance. Not in attendance during REC-R403.5.4-21 discussion and voting.
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association. Note: partial attendance. Not in attendance during REC-R403.5.4-21 discussion and voting.

Other stakeholders in attendance and opposing the proposal:

- Michael O'Connor: Virginia Petroleum and Convenience Marketers Association and Virginia Propane Gas Association

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club

- William Penniman, Sierra Club, expressed support for the proposal based on reasons he previously stated in connection with similar proposals (REC-R403.1.1.1-21), reproduced here for convenience:
  - William Penniman, Sierra Club, expressed support for the proposal and agreed with Eric Lacey's comments (see below). The user could get paid and the system would benefit (from installing demand response thermostats).
  - Eric Lacey, representing self, noted that he's familiar with cool keeper and other programs where consumers get a credit on their bill. This proposal doesn't require a big investment, only a thermostat with the capabilities when the home is built. Nobody wants to pay the cost of tearing out an old thermostat and putting in a new one. If the homeowner elects to use it or not, it would be good to install the technology initially. He suggested that it would be good to at least carry over the proposal and continue discussions.

Opposition:

Names: Andrew Clark, HBAV

- Andrew Clark, HBAV: no specific reasons provided.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 42; Tab 11 - Page 19.

REC-R404-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Energy Conservation Code

Add new text as follows:

RE404.2-18

VECC: R404.2 (N1104.2) (New), R404.2.1 (N1104.2.1) (New), R404.2.2 (N1104.2.2) (New), R404.2.3 (N1104.2.3) (New); VRC: N1104.2 (New),

N1104.2.1 (New), N1104.2.2 (New), N1104.2.3 (R404.2.3) (New)
Electric Readiness for Appliances. Add new text as follows:
R404.2 (N1104.2) Electric readiness (Mandatory) Systems combusting gas, propane or liquid fuels for water heaters, clothes dryers, or conventional cooking equipment to serve individual dwelling units shall comply with the requirements of Sections R404.2.1 through R404.2.3. All water heating systems shall comply with the space requirements of Section R404.2.3 B.

R404.2.1 (N1104.2.1) Household Ranges and Cooking Appliances An individual branch circuit and outlet with a minimum rating of 250-volts, 40-amperes shall be installed within 3 feet from each gas or propane range or permanently installed cooking appliance. Alternatively, a clearly labeled raceway sized in accordance with NFPA 70 for at least a 40-amperes branch circuit shall be installed from the electrical panel to an electrical box located within 3 feet from each gas or propane range or permanently installed cooking appliance. A label stating the intended future purpose and the location of the raceway shall be placed on the panel and the electrical box.

R404.2.2 (N1104.2.2) Household Clothes Dryers and Water Heaters An individual branch circuit and outlet with a minimum rating of 250-volts,30-amperes shall be installed within three feet of each gas or propane clothes dryer and water heater or any water heater using fuel oil. Alternatively, a clearly labeled raceway sized in accordance with NFPA 70 for at least a 30-amperes branch circuit shall be installed from the electrical panel to an electrical box located within 3 feet from each gas or propane clothes dryer or water heater or any water heater using fuel oil. A label stating the intended future purpose and the location of the raceway shall be placed on the panel and the electrical box.

R404.2.3 (N1104.2.3) Electrification-ready circuits or raceways and water heater space.

A. Unused conductors installed pursuant to Sections R404.2.1 or R404.2.2 shall be labeled with the word "spare" and be electrically isolated. The ends of unused raceways, if any, shall be visible or located behind a plate where the appliance outlet will go and shall be labeled with the intended use. Space shall be reserved in the electrical panel in which the branch circuit originates (or will originate if a raceway is initially installed) for the installation of an overcurrent device. Capacity for the circuits described by Sections R404.2.1 or R404.2.2 shall be included in the load calculations of the original installation.

B. An indoor space that is at least 3 feet by 3 feet by 7 feet high shall be available within 3 feet of the water heater. **Exception:** The water heater space requirement does not need to be met where a heat pump water heater is installed.

Add new text as follows:

N1104.2 Electric readiness (Mandatory) Systems using gas or propane water heaters, dryers, or conventional cooking equipment to serve individual dwelling units shall comply with the requirements of Sections N1104.2.1 (R404.2.1) through N1104.2.3 A. All water heating systems shall comply with Section N1104.2.3 B (R404.2.3 B).

N1104.2.1 Household Ranges and Cooking Appliances An individual branch circuit and outlet with a minimum rating of 250-volts, 40-amperes shall be installed within three feet of each household range and permanently installed cooking appliance. Alternatively, a clearly labeled raceway sized in accordance with NFPA 70 for at least a 40-amperes branch circuit shall be installed from the electrical panel to an electrical box located within 3 feet from each gas or propane clothes dryer or water heater. A label stating the intended future purpose and the location of the raceway shall be placed on the panel and the electrical box.

N1104.2.2 Household Clothes Dryers and Water Heaters An individual branch circuit and outlet with a minimum rating of 250-volts, 30-amperes shall be installed within three feet of each gas or propane clothes dryer and water heater or any water heater using fuel oil. Alternatively, a clearly labeled raceway sized in accordance with NFPA 70 for at least a 30-amperes branch circuit shall be installed from the electrical panel to an electrical box located within 3 feet from each gas or propane clothes dryer or water heater or any water heater using fuel oil . A label stating the intended future purpose and the location of the raceway shall be placed on the panel and the electrical box.

N1104.2.3 (R404.2.3) Electrification ready circuits and water heater space.

A. Unused conductors installed pursuant to Sections N1104.2.1 (R404.2.1) and N11.04.2.1 (R404.2.2) shall be labeled with the word "spare" and be electrically isolated. The ends of unused raceways, if any, shall be visible or located behind a plate where the appliance outlet will go and shall be labeled with the intended use. Space shall be reserved in the electrical panel in which the branch circuit originates (or will originate if a raceway is initially installed) for the installation of an overcurrent device. Capacity for the circuits described by Sections N1104.2.1 and N1104.2.2 shall be included in the load calculations of the original installation.

B. An indoor space that is at least 3 feet by 3 feet by 7 feet high shall be available within 3 feet of the water heater.

Exception: The water heater space requirement does not need to be met where a heat pump water heater is installed.

Reason Statement: This proposal enhances customer choice and save energy by making it easy for property owners to switch to electric appliances in the future. When a dwelling is being constructed, it is easy and inexpensive to installing wiring and equipment with appropriate capacities or, alternatively, under this proposal, a raceway and related equipment may be installed. During construction, walls are open, wiring is being routed, and tradesmen are present. Retrofitting would be much more costly and could require opening and repairing walls.

By ensuring that a dwelling built to rely on fossil fuel combustion can easily accommodate future electric appliances and equipment, this proposal protects homeowners from future conversion costs if a customer decides to switch to electric energy for any reason.

There are several potential reasons an occupant may wish to switch in the future. For example, gas prices fluctuate more than electric rates and could become less affordable than in the past. Electric heat pump water heaters and induction cook tops have a much higher level of energy efficiency compared to combustion technology. Electric heating and cooking offer pollution reduction benefits over onsite gas combustion, and those benefits will grow as the use of heat pump water heaters and electric induction stoves continue to rise and as Virginia's electricity generation transitions from fossil fuels to zero-carbon sources. Virginia's largest utilities are now required to steadily shift to zero-carbon generation, close coal plants, and achieve all zero-carbon generation by 2045. In addition to fire hazards, onsite fuel combustion also poses dangers from indoor air pollution, including CO, CO_2 and methane--which is increasingly recognized. https://rmi.org/insight/gasstoves-pollution-health

Electrification of buildings, in place of on-site combustion, is one critical component of decarbonization strategies to reduce climate-pollution (especially CO_2 and methane from producing, transmitting and combusting fossil fuels) and stabilize global warming at or below a 1.5ºC increase over pre-industrial levels. See, e.g., https://www.vox.com/2016/9/19/12938086/electrify-everything; https://rmi.org/eight-benefits-of-building-electrification-for-households-communities-and-climate/ ; https://www.rff.org/publications/explainers/electrification-101/ .

Increasingly, customers are concerned about climate and health impacts from fossil fuel combustion, in addition to energy efficiency and bills. As a result, they may want to transition from fossil fuels to electric appliances to take advantage of the climate and efficiency benefits. Further, federal, state, and local environmental and public health policies may encourage, or even require the transition from fossil fuels in some areas over the life of the building. Although burning gas may be cleaner than coal, it is dirtier than using electricity particularly as the electric grid shifts to non-polluting generation. In addition to combustion emissions of CO_2 and other pollutants, methane emissions occur at every stage of the process, including in homes. Methane is a fire hazard and a much more powerful greenhouse gas than carbon dioxide per unit emitted. UCS, *The Natural Gas Gamble: A Risky Bet on America's Clean Energy Future* (March 2015).

In sum, this *electric-ready* requirement is a low-cost measure designed to protect customers' options, health and pocketbooks and promote the public's interest in reducing carbon emissions. It is consistent with Virginia's stated Clean Energy Policy (§ 45.2-1706.1. (Effective October 1, 2021) Commonwealth Clean Energy Policy) which supports decarbonization and states that it is "the policy of the Commonwealth to: ,,,8. Promote building and construction practices that reduce emissions associated with built environment, including energy efficiency targets, new building standards, and transit-oriented and other sustainable development practices...."

Cost Impact: The code change proposal will increase the cost of construction
The proposal will not impact costs for all-electric dwellings, while slightly increasing the cost of construction for dwellings using fossil-fuel fired appliances and only with respect to those appliances. With respect to homes using fossil-fuel appliances, the cost of meeting these electric-ready requirements are low when the house is being built, walls are open, and the trades are already on-site. Wiring will already be extended to gas, oil or propane appliances, and this amendment would merely require either installing wiring capable of handling a heavier loads of the identified appliances or, at least, installing raceways to facilitate future branch circuit connections. In comparison, the cost of retrofitting a building to install new branch circuits after walls have been closed can be orders of magnitude higher and require opening, patching and repainting walls. While requiring full electrification of new dwellings, at the outset, would provide greater benefits to customers and the public, adopting this electric-ready requirement for new buildings would, at least, reduce cost barriers to future conversions to electric heating and cooking appliances. As noted, the need to convert to electricity will grow over time since electrification is a critical component of strategies to decarbonize the economy in order to combat climate change. Helping residents minimize future retrofits, would reduce barriers to customers' choosing clean energy sources with the accompanying health, welfare and resiliency benefits.

Resiliency Impact Statement: This proposal will increase Resiliency
Adopting this proposal will facilitate a smoother transition to clean energy sources and reductions of GHG emissions that are threatening Virginia's citizens, property, heritage and economy.
Climate change poses an ever-greater resiliency threat the longer we fail to reduce greenhouse gas emissions. The need to swiftly reduce carbon emissions has been recognized by scientists worldwide and by the governments of Virginia, the U.S. and nearly every country on the globe.
Virginia's coastal communities, economy, agriculture and human health are increasingly being harmed by climate change and its impacts.
Combustion of fossil fuels is the primary source of GHG emissions that are driving climate changes.
Electrification helps to address.those climate risks by reducing GHG emissions, and the pollution-reduction benefits will grow as more electricity is generated by zero-carbon energy sources. Virginia's major utilities have committed to increase their use of zero-carbon sources steadily into the future, so they generate zero carbon emissions by 2045. Other forms of pollution will decline as well. That shift to zero-carbon electricity production will steadily increase the already substantial health, welfare and resiliency benefits from switching to all-electric appliances.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: REC-R404-21

This proposal doesn't have any public comments.

Proposal # 988

REC-R404-21 – Staff Summary

Proponent: William Penniman, Sierra Club – Virginia Chapter

Brief Description:

The proposal requires the installation of additional electrical infrastructure, for potential future use, in buildings with combustion equipment.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on May 12, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman: Sierra Club - Virginia Chapter
- Eric Lacey (Laura Baker alternate): Responsible Energy Codes Alliance
    - It provides future options, and it doesn't rule anything out. He asked those opposed to give a reason for their opposition.
- K.C. Bleile: Viridiant

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance

Other stakeholders in attendance and supporting the proposal:

- Ben Rabe, New Buildings Institute (NBI)
    - Supports this proposal. Much less expensive and more convenient than switching with new conduit later.

- Steve Sunderman
    - In a 2018 code change, there was an outlet required in case someone wanted to install a generator later. This is in line with that change, it makes sense, and helps homeowners prepare for the future.
      Note: the 2018 code change proposal referred to was not approved by the Board of Housing and Community Development.

Other stakeholders in attendance and opposing the proposal:

- Michael O'Connor: Virginia Petroleum and Convenience Marketers Association and Virginia Propane Gas Association
- John Ainslie, Coastal Virginia Builders Association (CVBIA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Ben Rabe, NBI

- Ben Rabe, New Building Institute, expressed support for the proposal and opined that readiness is more cost effective than tearing out walls to install something later.

Opposition:

Names: David Beahm, Warren County; Andrew Clark, HBAV.

- David Beahm, Warren County opposed the proposal and indicated that the change would increase the cost of construction for something that may never be used.
- Andrew Clark, HBAV, expressed opposition based on reasons similar to previous code proposals.

DHCD Staff Notes:

It appears that Andrew Clark was referring to proposals REC-R401.2-21 and R401.2.5-21 which point back to his testimony during the Energy Sub-Workgroup meeting on March, 24, 2022. Comments reproduced here for convenience:

- He indicated that HBAV is unequivocally opposed to the proposal and shared concerns that this proposal is in potential conflict with other state laws, the Virginia Energy Plan and the net-zero path that Virginia is currently on.

Meeting summaries and proposal related information: Tab 10 - Page 43; Tab 10 - Page 83; Tab 11 - Page 20.

REC-R503.1.2.1-21

Proponents: Ben Rabe (ben@newbuildings.org)

2018 Virginia Existing Building Code

Add new text as follows:

601.4.8 Controls. New heating and cooling equipment that are part of the alteration shall be provided with controls that comply with Section R403.1 and R403.2 of the VECC.

Reason Statement: The IECC only requires that new portions of HVAC systems comply with the requirements for new construction. This leaves unaltered portions of the HVAC system unaffected, including controls. Controls are a vital component of effective and efficient operation of heating and cooling systems and older controls that do not meet current code requirements significantly hamper efficiency in buildings. Obsolete controls also increase the operational costs for building owners and tenants. The IECC has relied on HVAC controls as a cost-effective means of delivering energy efficiency in buildings, so this is a significant missed opportunity. Equipment replacement is an ideal time to also upgrade controls. Contractors are onsite, operation of the HVAC system is already disrupted, and the cost of controls would generally be a small line-item cost in the project.
This proposal requires that thermostats be brought into compliance with current control requirements when equipment is replaced. The proposal does not require the installation of new controls, so if the existing controls already meet current code requirements, they would already be in compliance with this new section.

Cost Impact: The code change proposal will increase the cost of construction
Cost will vary depending on the type of control and how obsolete existing controls are. In most systems subject to this requirement, compliance would require replacing one thermostat with another. Modern, wireless thermostats can be used to control costs when existing control wiring is insufficient to support modern controls. Utilities have consistently found thermostat retrofits to be cost effective efficiency incentive measures.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. Requiring thermostat controls in alterations to meet the same requirements as new construction helps to reduce overall home energy use. This reduces the home’s overall reliance on energy, reducing carbon emissions directly and indirectly, lessening the impact on climate change and climate related events. By reducing overall energy use, this measure may contribute to a reduction in peak demand increasing the resiliency of the grid during high usage events.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: REC-R503.1.2.1-21

Discussion by Florin Moldovan

Jun 13, 2022 19:10 UTC

See attached floor modification discussed at the GSWG meeting on 06/09/2022.
Attachments: https://va.cdpaccess.com/proposal/1072/discuss/175/file/download/782/REC-R503.1.2.1+Floor+Modification.pdf

REC-R503.1.2.1-21 – Staff Summary

Proponent: Ben Rabe, New Buildings Institute

Brief Description:

The proposal requires new heating and cooling equipment that are part of the alteration to be provided with controls as required for new construction.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed and supported by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on May 12, 2022.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
    - We support this proposal and think that it is sensible to have effective controls on new systems. He would expect that programmable thermostats are included anyway by the builders and remodelers; and opined that it is good to have it in the code as it incorporates cost effective improvements of existing buildings.
- K.C. Bleile: Viridiant
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)
- William (Bill) Penniman: Sierra Club; Virginia chapter

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance

Other Stakeholders in attendance and supporting the proposal:

- Steve Sunderman

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William (Bill) Penniman: Sierra Club - Virginia chapter

- William (Bill) Penniman: Sierra Club; Virginia chapter, expressed support.

Opposition:

Names: Andrew Clark, HBAV

- Andrew Clark, HBAV, apologized for not catching this during the Sub-Workgroup meeting and opposed the proposal on the premise that alterations of existing buildings should be incentivized and not be made more costly.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 83; Tab 11 - Page 35.

REC-R503.1.2.1

601.4.8 Controls.

New heating and cooling equipment that are part of the *alteration* shall be provided with controls that comply with Section R403.1 and R403.2 of the VECC.

REC-R1104.2-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virgina Residential Code

Add new text as follows:

N202 **General Definitions.** Add following definitions:
ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, electric motorcycles and the like, which is primarily powered by an electric motor that draws current from a rechargeable storage battery. A “plug-in hybrid” is a type of electric vehicle which relies on a combination of a rechargeable storage battery and another source of motive power.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors, and the Electric Vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or charging apparatus installed specifically for the purpose of transferring energy between the premises wiring and the Electric Vehicle.

EVSE INSTALLED SPACE. A designated parking space which is provided with EVSE, including an energized branch circuit with at least 40-ampere, 208/240 volts capacity that connects electric panel capacity to charging apparatus located within three feet of the parking space.

EV CAPABLE SPACE. A designated parking space which is provided with reserved electrical panel space to support a minimum 40-ampere, 208/240-volt branch circuit for EVSE and with an adequately-sized raceway for such a branch circuit from the panel to a clearly identified location within three feet of the parking space, to support future EVSE.

EV READY SPACE. A designated parking space which is provided with reserved electric panel capacity and space to serve at least a 40-ampere, 208/240-volt dedicated branch circuit to electrify EVSE. The circuit shall terminate in a suitable termination point, such as a power outlet, junction box, or EVSE apparatus, located within three feet of the parking space.

N1104.2 **Electric Vehicle Readiness.** New construction shall install or facilitate future installation and use of Electric Vehicle Supply Equipment (EVSE) in accordance with the National Electrical Code (NFPA 70) and N1104.2.1. **Exception:** EV supportive spaces are not required where no parking spaces are provided to residents.

N1104.2.1 **EV Ready Installations.** For each dwelling unit, provide at least one EV Ready Space or EVSE Installed Space in a garage or outdoor parking area. Additional EVSE Ready or EVSE Installed or EV Capable Spaces may be provided. The branch circuit for an EV Ready Space shall be identified as “EV Ready” in the service panel or subpanel directory, and the termination location shall be marked as “EV Ready”. The outdoor conduit for an external EV Ready Space, EVSE Installed Space or EV Capable Space shall be located underground and be protected from water. Construction documents shall identify the location and capacity of branch circuits and raceways and the document the adequacy of electric panel and service capacity.

2018 Virginia Energy Conservation Code

Add new text as follows:

R202 (N202) **General Definitions.**
Add the following definitions;
ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, electric motorcycles and the like, which is primarily powered by an electric motor that draws current from a rechargeable storage battery. A “plug-in hybrid” is a type of electric vehicle which relies on a combination of a rechargeable storage battery and another source of motive power.
ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors, and the Electric Vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or charging apparatus installed specifically for the purpose of transferring energy between the premises wiring and the Electric Vehicle.
EVSE INSTALLED SPACE. A designated parking space which is provided with EVSE, including an energized branch circuit with at least 40-ampere, 208/240 volts capacity that connects electric panel capacity to charging apparatus located within three feet of the parking space.
EV CAPABLE SPACE. A designated parking space which is provided with reserved electrical panel space to support a minimum 40-ampere, 208/240-volt branch circuit for EVSE and with an adequately-sized raceway for such a branch circuit from the panel to a clearly identified location within three feet of the parking space, to support future EVSE.
EV READY SPACE. A designated parking space which is provided with reserved electric panel capacity and space to serve at least a 40-ampere, 208/240-volt dedicated branch circuit to electrify EVSE. The circuit shall terminate in a suitable termination point, such as a power outlet, junction box, or EVSE apparatus, located within three feet of the parking space.

R404.2 (N1104.2) **Electric Vehicle Readiness.** New construction shall install or facilitate future installation and use of Electric Vehicle Supply Equipment (EVSE) in accordance with the National Electrical Code (NFPA 70) and R404.2.1. **Exception:** EV supportive spaces are not required where no parking spaces are provided to residents.

R404.2.1 (N1104.2.1) **EV Ready Installations.** For each dwelling unit, provide at least one EV Ready Space or EVSE Installed Space in a garage or outdoor parking area. Additional EVSE Ready or EVSE Installed or EV Capable Spaces may be provided. The branch circuit for an EV Ready Space shall be identified as "EV Ready" in the service panel or subpanel directory, and the termination location shall be marked as "EV Ready". The outdoor conduit for an external EV Ready Space, EVSE Installed Space or EV Capable Space shall be located underground and be protected from water. Construction documents shall identify the location and capacity of branch circuits and raceways and the document the adequacy of electric panel and service capacity.

Reason Statement: This provision is designed to provide electric charging readiness for the growing use of electric vehicles (EVs) and to meet the essential need to offer at-home charging to residents many of whom own EVs or will own EVs in the next few years. It is designed to minimize costs through phasing of EV development, with an emphasis on installing infrastructure during initial construction. Parking provided for one and two family dwellings and townhouses will only require the basic wiring and panel capacity of a single parking space. The owner can add the charger or outlet when needed. The capacity of the EV Ready circuit is at least 40 Amp, 208-240 Volts (adequate for what is commonly called "Level 2" charging), which is sufficient for timely vehicle charging. (Nothing is required if parking spaces are not provided to residents.)

The proposal will benefit residents and the public, saving money and cutting pollution. Providing access to home charging is important as a matter of practicality, money saving, a cleaner environment and equity. As a practical matter, EV charging takes time and is mostly done using at-home chargers. EVSE Ready spaces afford the ability to install "Level 2" chargers assures the ability to achieve a full battery charge overnight, providing users' range confidence and reducing costs by charging during utilities' off-peak hours. A builder may choose to add the charger to create an EVSE Installed space. (The developer may also installed additional EV Capable Spaces which only require the raceway capacity for Level 2 charging.)

EVs save money on fuel and maintenance. Annual savings were estimated at up to $1900--before gas prices jumped over $4/gallon. [1] While all EV users will benefit from fuel and maintenance savings, rural users are at the higher end of the potential savings because they tend to use more fuel for driving, and costs. All will also benefit by reducing the inconvenience of routine oil changes and other maintenance. Although the purchase cost of EVs is currently higher than the low end of vehicles with combustion engines, the purchase price is expected to fall as competition grows and, more importantly, the EV savings in fuel and maintenance costs more than pay for the initial price difference over time.

As more fully discussed in the Resiliency discussion, mitigation of climate change and air pollution generally are strong additional reasons to facilitate the shift to EVs. While EV sales and leases are growing due to their operating cost savings and other operating benefits, they will continue to grow in importance as climate risks encourage (or compel) shifting to vehicles that do not emit pollution. Vehicles are Virginia's largest source of carbon-dioxide emissions from fossil fuel combustion.[2] Even based on today's mix of generation in Virginia, DOE estimates that EVs would reduce CO_2 emissions by roughly two-thirds compared to vehicles combusting gasoline.[3] Emissions from generation that supplies EVs will decline more as utilities' zero-carbon renewable energy replaces fossil-fuel generation. EVs' direct emissions are non-existent, which also has substantial health and pollution benefits compared to gasoline or diesel vehicles, which is particularly important to low-income residents who are disproportionately impacted by air pollution from traditional vehicles. The harms to Virginians from climate change are present now and growing faster the longer we fail to slash emissions of CO_2. methane and other greenhouse gases.
At-home charging increases EV charging during off-peak periods, which opens the door to lower off-peak rates for users and to a reduction of electric rates to all utility customers.[4]

There is a national goal to have 50% of new vehicles to be EVs by 2030.[5] Major vehicle manufacturers have committed to shift production to EVs over the next 10 years with a number of manufactures committing to shift to 100% EV production in the next 5-10 years.[6]At-home charging in conjunction with single or multifamily parking is particularly important to meeting the needs of EV owners and to encourage charging during utilities' off-peak periods. According to research by JD Power, "80% of EV charging is done at home—almost always overnight—or while a car is parked during the workday" and EV users strongly prefer Level 2 (220/240V) charging. [7] The capability for at-home charging will substantially reduce barriers to EV adoption that arise from the inconveniences that EV charging is slower than pumping gasoline, the public infrastructure for charging is still limited, and drivers have limited ability to take advantage of off-peak rates without home-charging.Already Ford is advertising that its F-150 EV pickup will be able to provide back-up power for households. Going forward, utilities may get the added benefit of being able to draw on the batteries of parked electric vehicles in order meet peak demands and balance fluctuating loads.
Installing the wiring and basic infrastructure during construction when walls are open and workers are present is much cheaper than retrofitting which may damage wall board and require more difficult extensions of wiring. Experience shows that installing a simple 220V/40 Ampere branch circuit (comparable to a dryer or stove outlet) for "Level 2" EV charging, in a garage or outside close to parking spaces (e.g., on a wall near a single-family driveway), will enable an EV owner to reliably charge an EV at home, scheduling it at night or otherwise outside the utilities peak demand period for the lowest rates. The presence of the wiring from the beginning would permit low-cost installation of a different charging system preferred by the EV owner. Failure to install the EV during infrastructure will create barriers to EV adoption and raise long-term costs to residents.

.[1] *See* Consumer Reports, "EVs Offer Big Savings Over Traditional Gas-Powered Cars" (October 2020); Union of Concerned Scientists, https://www.ucsusa.org/about/news/rural-communities-could-benefit-most-electric-vehicles (up to $1900/year savings for rural EV owners); https://augustafreepress.com/deq-launches-clean-air-communities-program-aimed-at-driving-investment-in-electric-vehicle The police department of Westport Connecticut achieved operating and maintenance savings of over $17,000 in its first year of using a Tesla Model 3 police car instead of a fossil fuel vehicle. Among the department's conclusions: after four years the Tesla will have saved enough money to buy another Tesla, and each EV avoids emission of over 23 tons of CO_2 per year and saves $8763 in environmental and health costs. https://www.teslarati.com/tesla-model-3-westport-police-department-financial-analysis/ Those studies were based on much lower gas prices than exist today, which means that today's savings would be much larger.

[2]https://www.epa.gov/sites/production/files/2019-11/documents/co2ffc_2017.pdf

[3] DOE estimates that an EV in Virginia emits (via electric generation) less than a third as much CO_2 as a gasoline-driven vehicle. https://afdc.energy.gov/vehicles/electric_emissions.html ; https://evtool.ucsusa.org/

[4] See June 23, 2020 Comments of the Sierra Club to the State Corporation Commission in SCC Docket PUR-2020-00051, Electrification of Motor Vehicles. As the comments explain, with managed off-peak charging and efficient rate structures, rising EV loads can drive down rates to all customers. Regarding operating costs, an EV has very little maintenance costs and EV's electricity cost equivalent to a gallon of gasoline, in Virginia, was $1.16 versus roughly $4.00/gallon today. https://www.energy.gov/maps/egallon

[5] https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/fact-sheet-president-biden-announces-steps-to-drive-american-leadership-forward-on-clean-cars-and-trucks/

[6] EV sales are already increasing, and every major vehicle manufacturer has committed to expand EV production and even to go all-electric over the next decade or so. Electric pick-up trucks will soon be available and there are long waiting lists for pick-ups. *See* https://www.reuters.com/business/autos-transportation/us-automakers-say-they-aspire-up-50-ev-sales-by-2030-sources-2021-08-04/ https://www.forbes.com/wheels/news/automaker-ev-plans/ ; https://www.cnbc.com/2022/01/05/chrysler-kicks-off-plans-to-go-all-electric-by-2028-with-airflow-concept.html ; https://www.electrive.com/2021/08/05/us-carmakers-aim-for-40-50-ev-sales-by-2030/

[7] https://www.forbes.com/wheels/news/jd-power-study-electric-vehicle-owners-prefer-dedicated-home-charging-stations/ See also James Walkinshaw, Washington Post, Jan. 23, p.C4 (explaining the importance of home charging relative to public charging). Utilities' energy sales are lowest and cheapest in off-peak hours, particularly at night. A common utility strategy is to offer time-of-use rates with low night-time prices to encourage off-peak EV charging. For EV customers to make use of such incentives, they will need access to overnight charging at home where they spend the night.

Cost Impact: The code change proposal will increase the cost of construction
The code change proposal will slightly increase the cost of residential construction, but the increase will be very small compared to the total cost of construction and to the savings and other benefits to residents and the public. EVs with home charging will save occupants money and avoid the higher costs of retrofitting in the future.
It is easy to install the wires, panel capacity and conduits for electric vehicle charging--along with the rest of a dwelling's wiring--when a single or multifamily dwelling is built. It is much harder and much more expensive to do so as a retrofit. The branch circuit would cost a few dollars per foot. In a single-family dwelling garage or carport, for example, a branch circuit would need to be run from the circuit breaker, which is simple when other circuits and outlets are being installed during construction. However, as a retrofit, this basic wiring could require much higher costs from complicated feeding of a line and the potential need to open walls and repair wall damage.
The incremental cost of installing the branch circuit and related equipment during construction residence is constructed (likely 0.0005-0.003 or less of the cost of an average new home). If an electric panel is located in a garage, the added cost of EV readiness could easily be less than $100.

Resiliency Impact Statement: This proposal will increase Resiliency
Expanding EV utilization will enhance resiliency in multiple ways.

EVSE can be designed to deliver electricity back to a dwelling, which would protect residents during periods of power outages. https://www.ford.com/trucks/f150/f150-lightning/2022/ It is anticipated that EV batteries can also be connected to the grid to provide grid balancing and back up in the future.

Switching to EVs is also critical to resiliency because it will reduce CO_2, CO, SO_2, particulates, methane, and other harmful emissions from fossil-fuel combusting vehicles and from producing and delivering gasoline and diesel fuel for use in vehicles. Unlike traditional vehicles with internal combustion engines ("ICE"), electric vehicles emit no air pollution and are much more energy efficient than ICE vehicles. As Virginia's electric grid shifts to zero-carbon generation, the emission reduction benefits will grow.

According to Virginia's DEQ, "[t]he transportation sector is now the largest contributor of air pollutants and greenhouse gases in Virginia," and "[v]ehicle emissions are the largest single source of toxic and smog-forming air pollution in Northern Virginia and much of the rest of the country." https://www.deq.virginia.gov/air/clean-vehicles . Transportation accounts for 48.6% of Virginia's CO_2 emissions. https://www.eia.gov/environment/emissions/state/

Polluting emissions from internal combustion vehicles compound the risks of climate change and adversely impact public health. CO_2 and other emissions from fossil fuel combustion and production are the primary drivers of climate change. The most recent IPCC report confirms that rapid reductions of greenhouse gas emissions is essential to avoid catastrophic climate impacts around the world. IPCC Sixth Assessment Report (February 2022), https://www.ipcc.ch/report/ar6/wg2/ Substantial harm has already occurred nationally and locally from global warming and much worse will follow without rapid reductions of greenhouse gases (particularly CO_2 and methane associated with fossil fuel production and combustion).

Virginia's coastal areas are among the most vulnerable to sea level rise and destructive storms. They already experience "sunny day flooding," and sea level rise is accelerating. https://www.vims.edu/newsandevents/topstories/2020/slrc_2019.php Climate change is already harming Virginia and the harms will get much worse if we do not sharply reduce GHG emissions (particularly CO_2 and methane associated with fossil fuel production and combustion). The most recent report from NOAA indicates that Virginia may face 2 feet of sea level rise by 2050 due to worsening climate change from human greenhouse gas emissions. https://www.noaa.gov/news-release/us-coastline-to-see-up-to-foot-of-sea-level-rise-by-2050 Virginia faces climate-driven sea level rise of 6.69 feet this century; the rate of sea level rise is accelerating; the danger of climate-driven severe storms, storm-surges and flooding are rising; and climate change will increasingly harm human health and lives, agriculture, businesses, military installations, private and public property, and Virginia’s economy. http://www.vasem.org/reports/2021-the-impact-of-climate-change-on-virginias-coastal-areas/

Climate dangers, however, are not limited to coastal areas. https://www.wvtf.org/news/2022-04-28/study-shows-virginia-at-increased-risk-for-flash-floods-and-landslides Growing dangers also include rising atmospheric and water temperatures that worsen heat-related illnesses, disruptions of economic activity, and harms to agriculture, fisheries, and our natural heritage.

Because atmospheric CO_2 from emissions is cumulative, Virginia has less chance of mitigating and recovering from those harms the longer we delay maximizing energy savings and minimizing greenhouse gas pollution.

Shifting to EVs is a critical piece of the solution to global warming. Continuing to construct buildings that will not support use of clean EVs will make it harder to achieve climate goals, particularly since the buildings will likely remain in place for 70 years or more. Constructing buildings that cannot provide electric charging will also delay residents' ability to access large economic and energy savings from EV usage.

Building codes already recognize that fumes from traditional vehicles are dangerous. More broadly, small particle, SO_2 and other pollution from vehicles burning fossil fuels increases heart and lung disease, as well as cognitive and other disorders. https://blog.ucsusa.org/dave-reichmuth/air-pollution-from-cars-trucks-and-buses-in-the-u-s-everyone-is-exposed-but-the-burdens-are-not-equally-shared/ As Virginia's electric grid shifts to zero-carbon generation, the emission reduction benefits will grow particularly if we shift vehicles to clean electricity. Local air pollution harms caused by vehicle pollution will also be reduced which will particularly benefit high-traffic areas, including low-income urban areas.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: REC-R1104.2-21

This proposal doesn't have any public comments.

Proposal # 1159

REC-R1104.2-21 – Staff Summary

Proponent: William Penniman, Sierra Club – Virginia Chapter

Brief Description:

The proposal requires electrical vehicle charging readiness for one- and two-family dwellings, townhouses and low-rise (three stories or less above grade plane) residential buildings.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup at their May 19, 2022, meeting. The Sub-Workgroup members decided to not take an official position on the proposal as the stakeholders were hopeful that consensus might be reached by the time of the General Stakeholders Workgroup meeting in June.

Energy Sub-Workgroup May 19, 2022, meeting highlights:

- Andrew Clark, Home Builders Association of Virginia (HBAV)
    - There's non-consensus now, but he hopes to get consensus before the Workgroup meeting. If pending projects already have a load letter from the electrical power provider, it may cause a problem for them if this proposal is adopted.

  Note: the proponent responded stating that if only the conduit was installed with no wiring, it wouldn't affect the load letter. The proposal gives the customers an option to make their life easier and cheaper if there's a space available, and they decide later to add a charging station.

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: KC Bleile, Viridiant

- KC Bleile, Viridiant, indicated support for the proposal and expressed interest in continuing to work with the proponent, Home Builders Association of Virginia (HBAV), electrical power providers and others in reaching agreement on this proposal.

Opposition:

Names: Andrew Clark, HBAV; David Beahm, Warren County.

- Andrew Clark, HBAV, opposed the proposal at the time of the meeting but indicated that they will continue to work and explore potential areas of agreement with the proponent up until the Board of Housing and Community Development meeting in September. Some of the concerns shared were related to existing developments that already have a load letter from the electrical power provider.
- David Beahm, Warren County, opposed the proposal and expressed concerns with parking spaces that could potentially be located hundreds of feet away from the house (he referred to an example in his locality where the parking space was located 300' away from the house) but on the same property. In those instances, it would be very costly to comply with this proposal,

and the owner might not ever own an electrical vehicle. He also shared concerns about providing electrical vehicle ready spaces within garages given the recalls issued by some of the electric vehicle manufacturers which, as he indicated, warned against parking the electrical vehicle in garage due to fire concerns.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 84; Tab 11 - Page 34; Tab 11 - Page 41

EB805.3-21

Proponents: Ben Rabe (ben@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org); Energy Sub-Workgroup

2018 Virginia Existing Building Code

Revise as follows:

805.3 Commercial compliance. Commercial *additions* shall comply with ~~Section~~ the following:
1. Sections 805.3.1 or 805.3.2.

Exception: Commercial *additions* complying with ANSI/ASHRAE/IESNA 90.1.

2. Sections 805.3.3. through 805.3.5.

Add new text as follows:

805.3.3 Mechanical systems acceptance testing. New mechanical systems that serve additions shall comply with Sections C408.2.2, C408.2.3 and C408.2.5 of the VECC.

Exceptions:

1. Mechanical systems and service water heater systems in buildings where the total mechanical equipment capacity is less than 480,000 Btu/h (140.7 kW) cooling capacity and 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.

2. Systems included in Section C403.5 of the VECC that serve individual dwelling units and sleeping units .

805.3.4 Service hot water systems acceptance testing. New service hot water systems that serve additions shall comply with Sections C408.2.3 and C408.2.5 of the VECC.

Exceptions:

1. Service water heater systems in buildings where the total mechanical equipment capacity is less than 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.

2. Systems included in Section C403.5 of the VECC that serve individual dwelling units and sleeping units.

805.3.5 Lighting acceptance testing. New lighting systems that serve additions shall comply with Section C408.3 of the VECC.

Reason Statement: Due to the way that the charging language in the IECC is structured, new mechanical, water heating and lighting systems in additions do not need to meet the commissioning / acceptance testing requirements that the same systems in new construction would need to meet. This allows new systems in additions to go without this vital installation step and leaves them vulnerable to poor performance from installation. This proposal closes that loophole.
The proposal includes specific references to the appropriate commissioning /acceptance testing requirements in section C408:

- The balancing (C408.2.2), functional testing (C408.2.3) and documentation (C408.2.5) requirements for HVAC systems.
- The functional testing (C408.2.3) and documentation (C408.2.5) requirements for water heating systems
- The functional testing, documentation and reporting requirements for lighting (C408.3).

It repeats the system-size thresholds in the charging language in C408. The proposal also does not include references to the commissioning plan requirement (C408.2.1) for HVAC equipment. In this way, it has the same scope as the requirements for new construction. Since it references only new equipment in the addition itself, it avoids potentially requiring changes to the existing building systems.

Cost Impact: The code change proposal will increase the cost of construction
The proposal will increase the cost of construction. However, these requirements have already been found to be sufficiently cost effective to be included in the code for new construction.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. Commissioning for existing building alterations helps building owners to understand the operations of their building systems and areas or operating sequences of concern. By understanding how systems will

respond under a variety of operation conditions, building managers will be better equipped to adjust schedules or settings if needed in response to a climate, emergency, or resilience event. Systems that are commissioned additionally are operating at optimized conditions, meaning parts and pieces of the system will not “short-cycle” or run longer or more frequently than intended in design. This will provide for overall longevity of the building systems as well – creating a different type of resilience and reliability for everyday operations and the building owner.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐Approved
☐Approved with Modifications
☐Carryover
☐Disapproved
☐None

Public Comments for: EB805.3-21

This proposal doesn't have any public comments.

Proposal # 1067

EB805.3-21 – Staff Summary

Proponent: Ben Rabe, New Buildings Institute; Kimberly Newcomer, New Buildings Institute.

Brief Description:

The proposal requires new HVAC, water heating and lighting systems serving additions, to meet the same commissioning/acceptance testing requirements as those serving new construction.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was heard by the Energy Sub-Workgroup members at the Sub-Workgroup's meetings on May 12 and 19, 2022. A vote taken at the May 19th meeting resulted in four members supporting the proposal and one abstention.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey (Lara Baker alternate): Responsible Energy Codes Alliance
- K.C. Bleile: Viridiant
- William Penniman: Sierra Club - Virginia Chapter

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)
- Bettina Bergoo: Virginia Department of Energy
- Eric Lacey (Lara Baker alternate): Responsible Energy Codes Alliance
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter
- Brian Clark: Habitat for Humanity

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club; Andrew Grigsby, Viridiant.

- William Penniman, Sierra Club, noted that additions can and should be constructed to meet the new code requirements and ensure they are energy efficient, this is a sensible proposal and Sierra Club supports it.
- Andrew Grigsby, Viridiant, stated that these are common sense measures to save people money and those that support housing affordability should support this proposal. He acknowledged that the proposal increases the cost of construction but the building occupants will save on energy bills over time as shown on multiple reviews of the International Energy Conservation Code by national laboratories and other groups.

Opposition:

Names: Steve Shapiro, AOBA and VAMA; Allison Cook, VBCOA; Richard Grace, VPMIA.

- Steve Shapiro, AOBA and VAMA, expressed his opposition and indicated that he does not believe the purpose of the existing building code is to impose these types of requirements for additions.
- Allison Cook, VBCOA, wanted to get her opposition on the record and pointed out that this proposal increases the cost of construction.
- Richard Grace, VPMIA, wanted to record their opposition to the proposal.

DHCD Staff Notes:

The Sub-Workgroup members supporting the proposal during the May 19th meeting, did not provide any specific reasons for the support.

Meeting summaries and proposal related information: Tab 10 - Page 73; Tab 11 - Page 37; Tab 11 - Page 42.

EB805.3(2)-21

Proponents: Ben Rabe (ben@newbuildings.org); Kimberly Newcomer (kim@newbuildings.org); Energy Sub-Workgroup

2018 Virginia Existing Building Code

Add new text as follows:

805.3 Commercial compliance. Commercial additions shall comply with the following:

1. Sections 805.3.1 or 805.3.2.

Exception: Commercial additions complying with ANSI/ASHRAE/IESNA 90.1.

2. Sections 805.3.3. through 805.3.5.

805.3.3 Mechanical system acceptance testing. Where an alteration requires compliance with Section C403 of the VECC or any of its subsections, mechanical systems that serve the alteration shall comply with Sections C408.2.2, C408.2.3 and C408.2.5 of the VECC.

Exceptions:

1. Mechanical systems and service water heater systems in buildings where the total mechanical equipment capacity is less than 480,000 Btu/h

(140.7 kW) cooling capacity and 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.

1. Systems included in Section C403.5 VECC that serve individual dwelling units and sleeping units.

805.3.4 Service hot water system acceptance testing. Where an alteration requires compliance with Section C404 of the VECC or any of its subsections, service hot water systems that serve the alteration shall comply with Sections C408.2.3 and C408.2.5 of the VECC.

805.3.5 Lighting acceptance testing. Where an alteration requires compliance with Section C405 of the VECC or any of its subsections, lighting systems that serve the alteration shall comply with Section C408.3 of the VECC.

Reason Statement: The IECC requires that new mechanical, hot water and lighting systems comply with the acceptance testing requirements of C408. However, the IECC commentary for C503 states that unaltered portions of systems do not have to be brought into compliance with the code. This means that the requirements of C408 only apply to the new portions of existing systems. However, the whole purpose of C408 is to ensure that building systems meet and document a minimum level of system configuration. Even when only part of a system is replaced, there is still the need to ensure this minimum level of system configuration for the whole building. Even in like-for-like replacements, new equipment can have different operating characteristics. It is therefore important to ensure that the whole system is operating appropriately after new components are installed, not just the new components.

Additionally, all systems see their performance degrade over time as components wear, operational parameters change and modifications accumulate. The installation of new portions of equipment also presents the most reasonable and cost-effective opportunity to recalibration the system based on current operations. Therefore, this proposal requires that the whole system meet relevant C408 requirements, rather than just the new components. The proposal is tailored to focus on the parts of C408 that are relevant to existing buildings rather than just a blanket reference to C408 and includes specific references to the appropriate commissioning /acceptance testing requirements:

- The balancing (C408.2.2), functional testing (C408.2.3) and documentation (C408.2.5) requirements for HVAC systems.
- The functional testing (C408.2.3) and documentation (C408.2.5) requirements for water heating systems
- The functional testing, documentation and reporting requirements for lighting (C408.3).
- It repeats the system-size thresholds in the charging language in C408. In this way, it has the same scope as the requirements for new construction.

The proposal does not include references to the commissioning plan requirement (C408.2.1) for HVAC and SHW equipment (C408.2.4) since these requirements are most appropriate for new construction.

Retro-commissioning and building re-tuning is generally accepted as one of the most cost-effecting energy efficiency measures for existing buildings. Average savings for building re-tuning is 12%, and studies have found savings as high as 52%.1,

Cost Impact:
Retro-commissioning and building re-tuning is generally accepted as one of the most cost-effecting energy efficiency measures for existing buildings. Average savings for building re-tuning is 12%, and studies have found savings as high as 52%. According to “Improving Commercial Building Operations through Building Re-tuning: Meta-Analysis,” the median costs for building re-tuning was $0.16/sf.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. Requiring energy efficiency through lighting controls in alterations helps to reduce overall building energy use. This reduces the buildings overall reliance on energy, reducing carbon emissions directly and indirectly, lessening the impact on climate change and climate related events. For the building’s own resilience, the proposed efficiency credits focus on more efficient systems overall – even in an event like a black out, these more efficient systems require less energy to run, making any back up generation energy source last longer – providing extended comfort and safety to building users. For energy infrastructure resilience, the electric grid’s ability to deliver capacity to an increasing number of buildings will become increasingly important. By reducing overall energy use, this measure may contribute to a reduction in peak demand increasing the resiliency of the grid during high usage events.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: EB805.3(2)-21

This proposal doesn't have any public comments.

Proposal # 1066

EB805.3(2)-21 – Staff Summary

Proponent: Ben Rabe, New Buildings Institute; Kimberly Newcomer, New Buildings Institute.

Brief Description:

The proposal requires existing HVAC, water heating and lighting systems altered by the scope of work for additions to meet the commissioning provisions of the International Energy Conservation Code.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was heard by the Energy Sub-Workgroup members at the Sub-Workgroup's meetings on May 12 and 19, 2022. A vote taken at the May 19th meeting resulted in three members supporting the proposal and two abstentions.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey (Lara Baker alternate): Responsible Energy Codes Alliance
- William Penniman: Sierra Club - Virginia Chapter

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)
- K.C. Bleile: Viridiant

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter
- Jim Canter: Virginia Building & Code Officials Association (VBCOA)
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)
- Bettina Bergoo: Virginia Department of Energy
- Eric Lacey (Lara Baker alternate): Responsible Energy Codes Alliance
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter
- Brian Clark: Habitat for Humanity

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club.

- William Penniman, Sierra Club, spoke in support of the proposal and indicated that he finds the idea of energy efficiency being an afterthought, objectionable. Energy efficiency saves money and improves the comfort for people which assume that our building codes will protect them with respect to matters like energy efficiency. If the codes do not do that, the problem will last for future residents as well as current residents.

Opposition:

Names: Steve Shapiro, AOBA and VAMA; Allison Cook, representing self; Richard Grace, VPMIA; Mike O'Connor, Virginia Petroleum and Convenience marketers and Virginia Propane Gas Associations.

- Steve Shapiro, AOBA and VAMA, recorded his opposition to the proposal and noted that while imposing these requirements for additions is bad, doing so with alterations is even worse.
- Allison Cook, representing self, expressed her opposition to the proposal and highlighted that the Virginia Existing Building Code (VEBC) works really, really hard to not deter building owners from performing alterations on existing buildings. Requiring potential upgrades of existing mechanical systems that are not affected by alterations, increases construction costs and could discourage building owners from upgrading old, degrading buildings. The intent of the VEBC is to make buildings safer today that they were yesterday. She invited the proponents to approach energy proposals during future code cycles with the intent of the VEBC in mind.
- Richard Grace, VPMIA, opposed the proposal and agreed with Allison Cook. He reemphasized that the scope of the VEBC is to encourage the use of existing buildings and not force building owners to make upgrades that are required by code changes like this one.
- Mike O'Connor, Virginia Petroleum and Convenience marketers and Virginia Propane Gas Associations, recorded their opposition via Adobe Connect platform chat.

DHCD Staff Notes:

The Sub-Workgroup members supporting the proposal during the May 19th meeting, did not provide any specific reasons for the support.

Meeting summaries and proposal related information: Tab 10 - Page 73; Tab 11 - Page 37; Tab 11 - Page 42.

Tab 4

USBC Non-Consensus Proposals That Exceed Existing 2018 Virginia Regulations (Amendments)

B918.1-21

Proponents: Andrew Milliken (amilliken@staffordcountyva.gov)

2018 Virginia Construction Code

Revise as follows:

918.1 General. For localities utilizing public safety wireless communications, dedicated infrastructure to accommodate and perpetuate continuous in-building emergency communication to allow *emergency public safety personnel* to send and receive emergency communications shall be provided in new *buildings* and *structures* in accordance with this section.
Exceptions:

1. *Buildings* of Use Groups A-5, I-4, within *dwelling units* of R-2, R-3, R-4, R-5, and U.
2. Buildings of Types IV and V *construction* without basements, that are not considered unlimited area *buildings* in accordance with Section 507.
3. Above grade single story buildings of less than 20,000 square feet (1858 m^2).
4. *Buildings* or leased spaces occupied by federal, state, or local governments, or the contractors thereof, with security requirements where the *building official* has *approved* an alternative method to provide emergency communication equipment for *emergency public safety personnel*.
5. Where the *owner* provides technological documentation from a qualified individual that the *structure* or portion thereof does not impede emergency communication signals.
6. ~~*Buildings* in *localities* that do not provide the additional communication *equipment* required for the operation of the system.~~

918.1.1 Installation. ~~The *building owner* shall install radiating cable, such as coaxial cable or equivalent. The radiating cable shall be installed in dedicated conduits, raceways, plenums, attics, or roofs, compatible for these specific installations as well as other applicable provisions of this code. The *locality* shall be responsible for the installation of any additional communication *equipment* required for the operation of the system.~~ Where provided, an in-building two-way emergency responder communication coverage system shall be designed, installed and tested in accordance with section 510.4 and 510.5 of the International Fire Code. In-building, two-way emergency responder communication coverage within the building shall be based on the existing coverage levels of the public safety communication systems utilized by the jurisdiction, measured at the exterior of the building. This section shall not require improvement of the existing public safety communication systems.

918.1.3 Inspection. In accordance with Section 113.3, all installations shall be inspected prior to concealment.

Delete without substitution:

~~**918.1.2 Operations.** The *locality* will assume all responsibilities for the operation and maintenance of the emergency communication *equipment*. The *building owner* shall provide sufficient operational space within the *building* to allow the *locality* access to and the ability to operate in-building emergency communication *equipment*.~~

~~**918.2 Acceptance test.** Upon completion of installation, after providing reasonable notice to the *owner* or their representative, *emergency public safety personnel* shall have the right during normal business hours, or other mutually agreed upon time, to enter onto the property to conduct field tests to verify that the required level of radio coverage is present at no cost to the *owner*. Any noted deficiencies in the installation of the radiating cable or operational space shall be provided in an inspection report to the *owner* or the *owner's* representative.~~

Reason Statement: At present, 47 states as well as Washington, DC and Puerto Rico have mandatory requirements for emergency responder communication systems in new buildings. None, other than Virginia, share the responsibility of the system with the locality. This proposal revises outdated technology, language and responsibilities for providing in-building emergency responder communication systems. **This proposal was supported by a majority of members of the Study Group convened to look into this topic.**
The effectiveness and reliability of emergency responder communication is one of if not the most important aspects of successful emergency response and protection of public safety. In fact, as wireless technologies advance and community hazards expand, these public safety communication tools quickly become the backbone of incident response for not only fire and rescue personnel but also law enforcement and other first responders. Just as the water provided in building standpipes is critical to firefighting operations in large buildings, clear and dependable communications is vital to the safety of first responders in these buildings. This is in keeping with the philosophy inherent in the model codes that, when a facility grows too large or complex for effective fire response, fire protection features must be provided within the building. Building construction features and materials can absorb or block the radio frequency energy used to carry the signals inside or outside the building. Blockage or absorption of the radio frequency signal can prevent a critical message from an emergency responder from being received and acknowledged. Depending on the incident, this loss of information can place other emergency responders in greater danger or may prevent an injured or disoriented emergency responder from communicating for assistance.

The current VCC language requires the use of out-dated technology and in some cases the installation of equipment that may never be used. Unless meeting one of the exemption requirements, building owners are required to route hundreds of feet of likely disconnected cabling throughout the building including in areas where existing coverage may already be adequate. This proposal does NOT remove or modify any of the five building exemptions currently indicated by the current code (VCC 916.1) so as to maintain consistency throughout Virginia. In addition, the current VCC language provides no recognition as to the current level of public safety communication strength currently on site. Without additional guidance, this could suggest that a building owner is responsible for providing a higher level of radio coverage than what currently is present in reality - a cost that is not fair to be burdened by the building owner or developer. The proposed language ensures that the building is only required to maintain the existing level of public safety radio communication coverage available at the exterior of the building.

Furthermore, just as building standpipe systems, fire hydrant systems, fire alarm systems and other fire protection systems are required to be provided as part of the building infrastructure for emergency responder use, the reliability and dependability of emergency radio enhancement systems demand that they be similarly connected to and monitored by the building fire alarm system. Finally, the current VCC language does not provide any reference standard for the installation or testing of such systems. This proposal includes a reference to the IFC for these details to ensure that they are capable, compatible and interoperable for emergency response at any time or location.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
Since this proposal does not remove or modify any of the five building exemptions from providing in-building communication infrastructure, this proposal only applies to the same buildings where infrastructure is already required to be provided. Althought the responsibility for the system installation moves to the building owner, the costs have not increased. In fact, this proposal provides the ability of building owners and developers to utilize cost-effective technology to accomplish the requirement with less labor and materials. Moreover, it also works to ensure that such technology is only provided where it is found to be needed and only to the level at which the public safety system currently provides at the exterior of the building. These cost-saving efforts are expected to equal or exceed any added cost to monitor such system by the building fire alarm system. Also, since the proposal is based on national and international standards that have been in place for years, most large construction projects already anticipate these costs for construction around the country.

Resiliency Impact Statement: This proposal will increase Resiliency
As compared to the ineffective and in some cases unnecessarily burdensome code language currently present in the VCC, this proposal represents a tremendous increase in building and public safety resiliency. Ensuring that first responders are able to effectively communicate is invaluable to the successful outcome of emergency response incidents and the protection of lives and property. The assurance for emergency responder radio coverage that this proposal provides does so not only for the major, or once-in-a-lifetime catastrophes but also many times over in the daily smaller "routine" emergencies that occur throughout buildings.

Attached Files

- **BDA_White_Paper_-_Final.pdf**
  https://va.cdpaccess.com/proposal/985/1552/files/download/663/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐Approved
☐Approved with Modifications
☐Carryover
☐Disapproved
☐None

Public Comments for: B918.1-21

This proposal doesn't have any public comments.

Proposal # 985

B918.1-21 – Staff Summary

Proponent: Andrew Milliken

Brief Description:

The proposal requires the design, installation and testing of In-Building Two-Way Emergency Responder Communication Coverage Systems to be in accordance with Sections 510.4 and 510.5 of the International Fire Code (IFC); and shifts the entire responsibility of providing the system to building owners.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

Proposal discussed by the In-Building Emergency Communications Study Group.

The following Study Group members expressed support for the proposal:

- Troy Knapp: Virginia Department of General Services
- Dana Buchwald: Backhaul Engineering
- Jamie Wilks: Virginia Building & Code Officials Association
- Gerry Maiataco: Virginia Fire Prevention Association
- Andrew Milliken: Virginia Fire Chiefs Association

The following Study Group members expressed opposition to the proposal:

- Tread Willis: International Association of Electrical Inspectors - Virginia Chapter
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)
- Robert Melvin: Virginia Restaurant, Lodging & Travel Association

The following Study Group members did not voice an opinion:

- Jonah Margarella: American Institute of Architects – VA Chapter
- Joshua Davis: Virginia Department of Fire Programs/State Fire Marshal's Office
- Jim Crozier: Virginia Association of Counties
- Dwayne Tuggle: Virginia Municipal League
- Debbie Messmer: Virginia Department of Emergency Management
- Patrick Green: Virginia State Police
- Tammy Breski: Department of Housing and Community Development – Communications Engineer
- Jodi Roth: Virginia Retail Federation

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Allison Cook, Arlington County

- Allison Cook, Arlington County, indicated that what the proposal intends to achieve is already happening at the national level, in Arlington and other Virginia localities.

Opposition:

Names: Steve Shapiro, AOBA and VAMA.

- Steve Shapiro noted that AOBA and VAMA are in opposition to this proposal. The owner should not be responsible to provide all aspects of the system. The owner is ok with providing the cabling and referencing the IFC Sections 510.4 and 510.5 for installation. However, it should be the locality that's responsible to install the systems.

DHCD Staff Notes:

See attached "In-Building Emergency Communications Study Group Final Report" for more information related to this and other proposals covering the same subject matter.

Meeting summaries and proposal related information: Tab 10 - Page 62; Tab 13: In-Building Emergency Communications Study Group Report.

Why Emergency Radio Communications Enhancement Systems (ERCES)?

NOTIFIER®
by Honeywell

The Issue

Two-Way Radio Dead Spots for First Responders

In an emergency, we depend on First Responders to mitigate the problem and help survivors. These firefighters, EMTs and law enforcement officers rely on two-way radios for communications, especially in multi-story buildings when responders can be located on different floors while trying to save lives. For that reason, radio signals within buildings need to be strong to support two-way communications in an emergency situation.

Buildings can weaken the radio signals that First Responders rely on to orchestrate emergency responses, evacuations, and other life-saving protocols. Concrete, glass windows, metal structures, below-grade build outs, among others impacting radio propagation can cause emergency radio communications to become unreliable or drop altogether.

This is unfortunately a common problem. A 2017 International Association of Fire Chiefs Survey shows:

- 98.5% of Fire Departments reported dead spots in buildings due to poor radio frequency coverage
- 56% of First Responders have experienced a communications failure within a building during an emergency incident within the past 24 months

Codes require an approved level of radio coverage in a building which can be achieved by enhancing the in-building public radio frequency signal coverage with an ERCES (Emergency Radio Communications Enhancement Systems) which comprises of a BDA (Bi-Directional Amplifier) / Signal Booster and Distributed Antenna System (DAS). **But not all key stakeholders know about the code requirements and are putting First Responders at risk when buildings are not outfitted with proper radio frequency signal coverage.**

The Regulatory Response

ERCES and Code Review

This challenge was most famously evident during September of 2001 when the World Trade Center buildings were brought down in terrorist attacks. Because of this the National Institute of Standards and Technology (NIST) studied the disaster and developed recommendations to improve public safety.

The NIST WTC investigation was conducted under the authority of the National Construction Safety Act. The final 2011 NIST WTC report (http://wtc.nist.gov) published a summary of findings, including recommended revisions to current codes, standards, and practices to improve public safety.

In a key conclusion (Recommendation #22), NIST:

> *"…recommends the installation, inspection, and testing of emergency communications systems, radio communications, and associated operating protocols to ensure that the systems and protocols: (1) are effective for large- scale emergencies in buildings with challenging radio frequency propagation environments; and (2) can be used to identify, locate, and track emergency responders within indoor building environments and in the field."*

This resulted in a new section being added to the 2009 edition of the International Fire Code (IFC) that requires all buildings to have approved radio coverage for emergency responders within buildings. Approved is a defined term in the IFC which means acceptable to the *fire code official*. The 2010 edition of NFPA 72, National Fire Alarm and Signaling Code, further defined Two-Way Radio Communications Enhancement Systems requirements for technical coverage and signal strengths under Section 24.5.2*

*These requirements were then relocated from the 2016 Edition of NFPA 72 to NFPA 1221, Section 9.6.

The Result

ERCES and Code Updates

Enhancing in-building radio frequency signal coverage with an Emergency Radio Communication Enhancement System (ERCES) comprised of a BDA (Bi-Directional Amplifier) / Signal Booster and Distributed Antenna System (DAS) is now a key requirement for buildings. Most current adopted Fire and Building Codes require Emergency Responder Radio Signal strength and coverage to be measured in all new and some existing construction. ERCES are required by IBC (International Building Code), IFC and NFPA 1. These codes require ERCES to be installed, serviced and maintained in accordance with NFPA 1221 and NFPA 72. A snapshot of the current IFC and NFPA Codes include:

Conditions	NFPA 1221 Section 9.6 - 2016 Edition	IFC 510 - 2015 Edition (2018 Ed. Avail. Oct. 2017)
Antenna Malfunction	Applicable - System and BDA	Not specifically - AHJ may require
Signal Booster Failure	Yes	Yes
Low Battery 70%	Yes	Not specifically - AHJ may require
Loss of Normal A.C.	Yes	Yes
Failure of Battery Charger	Yes	Not specifically - AHJ may require
Backup Duration	12 Hours	24 Hours* (12 hours 2018 IFC)
Signal Coverage	>=95 dBm (DAQ3.0 2016 Edition) / 90% / 99%	>=95 dBm (DAQ3.0) / 95%
Monitoring / Maintenance	Yes	Yes
Battery Backup Cabinets	NEMA4	NEMA4 (NEMA3R 2018 IFC)

1. IFC Section 510 – Emergency Responder Radio Coverage

The 2018, 2015, 2012, 2009 editions dictate that all new and existing buildings shall have approved radio coverage for emergency responders. Approval is based upon the existing coverage levels of the public safety communication systems utilized by the jurisdiction and measured at the exterior of the building.

> *The 2018 edition (IFC 510.4.1)* ***requires 95% coverage of all areas on each floor of the building*** *and the same signal strength as outlined in NFPA.*

In addition, Bi-Directional Amplifier (BDA) components must be contained in a NEMA-4 type enclosure. Correlating battery backups must be contained in a NEMA 3R or higher-rated cabinet (per 2018 edition), or a NEMA 4-type cabinet. The system requires a battery backup of either 12 hours (2018 edition) or 24 hours. Under all system operating conditions, isolation must be maintained between the donor antenna and all inside antennae and be no less than 20dB greater than the system gain under all operating conditions (2018 edition). It also requires oscillation prevention circuitry for the BDA.

FCC certification is required for the BDA, whose status must be monitored by the fire alarm system with a supervised communications link.

IFC requires system designers and lead installation personnel to have both a valid FCC-issued General Radio Operators License (GROL) and to be certified in-building system training by either the equipment manufacturer or an approved organization/school. IFC also requires inspection and annual testing of ERCES, or whenever structural changes occur that could materially change the original field performance tests.

2. NFPA 1221 & 72 – National Fire Alarm and Signaling Code

NFPA 1221 Section 9.6 (2016 edition) and NFPA 72 Section 24.5.2 (2013, 2010 edition) dictates that **radio coverage shall be provided with 90% floor area in general building areas, and 99% floor area in critical areas**. Critical areas include command centers, fire pump rooms, exit stairs and passageways, elevator lobbies, standpipe cabinets, sprinkler sectionals, valve locations, and other areas specifically identified by an Authority Having Jurisdiction (AHJ).

For signal strength or quality of audio delivered, NFPA 1221 2016 Edition requires the system to provide a Minimum Delivered Audio Quality (DAQ 3.0) and NFPA 72 requires minimum inbound and outbound signal strength of -95 dBm. NFPA requires the system must be capable of all radio system frequencies assigned by AHJ.

NFPA includes system component requirements stating that signal boosters/BDA units must have FCC certification prior to installation and be compatible with both analog and digital communications simultaneously at time of installation. BDA components should be contained in NEMA-4 or 4X type enclosure(s). The system requires a battery backup of 12 hours. Isolation must be maintained between the donor antenna and all internal antennae to ensure non-interference and non-degradation of Public Safety Systems.

A dedicated annunciator panel must be housed within the emergency command center to annunciate status of any signal booster(s). The monitoring panel must provide visual and labeled indications of the following for each signal booster: (1) Normal AC power, (2) Signal booster trouble, (3) Loss of normal AC power, (4) Failure of battery charger, (5) Low-battery capacity and (6) Antenna failure. The BDA status must be monitored by the fire alarm system via a supervised communications link.

3. IBC

IBC Section 916 (2015 edition) and IBC Section 915 (2012 edition) dictate that radio coverage shall be provided in all new buildings in accordance with IFC Section 510.

4. NFPA

NFPA 1 Section 11.10 dictates in all new and existing buildings, minimum radio signal strength for fire department communications shall be maintained at a level determined by the AHJ. Where required by the AHJ, two-way radio communication enhancement systems shall comply with NFPA 1221.

5. Other

Local Ordinances - Many cities and counties have additional ordinances requiring BDA systems. These ordinances are defined by the Authority Having Jurisdiction (AHJ). Specifications set by the AHJ are required and must be met.

FCC - FCC rules apply to all radio frequency (RF) emitters including BDAs. All BDAs must be FCC certified to be legally sold in the USA. Furthermore, all systems must be installed in accordance with applicable FCC rules and regulations. Similarly, in Canada Industry Canada (IC) certification is required.

The Newest Requirements

Performance Compliance – UL 2524

Product performance listings and standards were only recently introduced for ERCES. Prior to the new standards, AHJs, architects, engineers, and building owners could not be 100% certain that systems were code compliant and whether they would perform as claimed by manufacturers. Today, code regulates performance standards and listings provide all necessary parties the certainty that installed BDA systems will provide reliable communications for emergency responders.

UL 2524 for In-building 2-Way Emergency Radio Communication Enhancement systems was introduced as an Outline of Investigation (OOI) on December 21, 2017. An OOI is essentially a draft version of a product standard.

UL 2524 Timeline

- December 2017: UL 2524 published as an Outline of Investigation
- December 2017: Product testing begins
- Spring 2018: Standards Technical Panel (STP) formed for US/CAN
- June – July 2018: UL 2524 proposal balloted
- August 2018: STP meets to review negative ballots and public comments
- August – October 8: Recirculation of revisions to proposal
- October 2018: Published 1st edition on October 18th
- January 2019: 2nd edition published - Bi-National Standard

UL 2524 covers the products (e.g., repeater, transmitter, receiver, signal booster components, external filters, and battery charging components) used for ERCES/BDA systems installed in a location to improve wireless communication at that location. It does not cover passive RF components which includes antennas, splitters, couplers, coaxial cable and connectors.

UL 2524 addresses the following areas:

- Safety (risk of fire and risk of shock) requirements – construction and testing
- Compliance with specific performance requirements in accordance with the IFC-2018 and NFPA 1221-2016 (2019)
- Reliability performance requirements applicable for life safety systems – construction and testing
- Product marking and installation documentation

Product assessment is done by an OSHA accredited, independent third-party organization and successful investigation results in product listing for the purpose.

NOTE: UL 2524 listed products and their certification information can be accessed with UL Product iQ™ https://iq.ulprospector.com/info/ by using the UL Category Control Number UTMH in the search filter.

The Impact

ERCES for AHJs, Architects, Engineers, Contractors, Building Owners

What does this mean for AHJs?

- An AHJ's fundamental requirement is to ensure the safety of the population within its jurisdiction. With national consensus model codes and installation standards that govern the installation, testing and maintenance of ERCES and UL 2524 listing for product performance in place, it is in the AHJ's best interest to implement these requirements at their local level. Not only will this serve their community and safety personnel at a higher level, it will also mitigate risk and cost of retrofits down the road for the building owners once the code and listing has been mandated locally.

What does this mean for Architects & Engineers?

- With inevitable changes to jurisdictional requirements forthcoming from AHJ's, Architects and Engineers are in a prime position to include forward thinking life-safety specifications in their design proposals. Addressing code compliant and UL 2524 listed ERCES during the design portion of a new build drives inclusion during contract and construction phases.
- Recommending ERCES during the design phase will save clients retrofit costs once the standard has been recorded
- With specific knowledge of new code and listing requirements, Architects and Engineers can position themselves as industry leaders and trusted potential partners

What does this mean for Fire Safety Engineers?

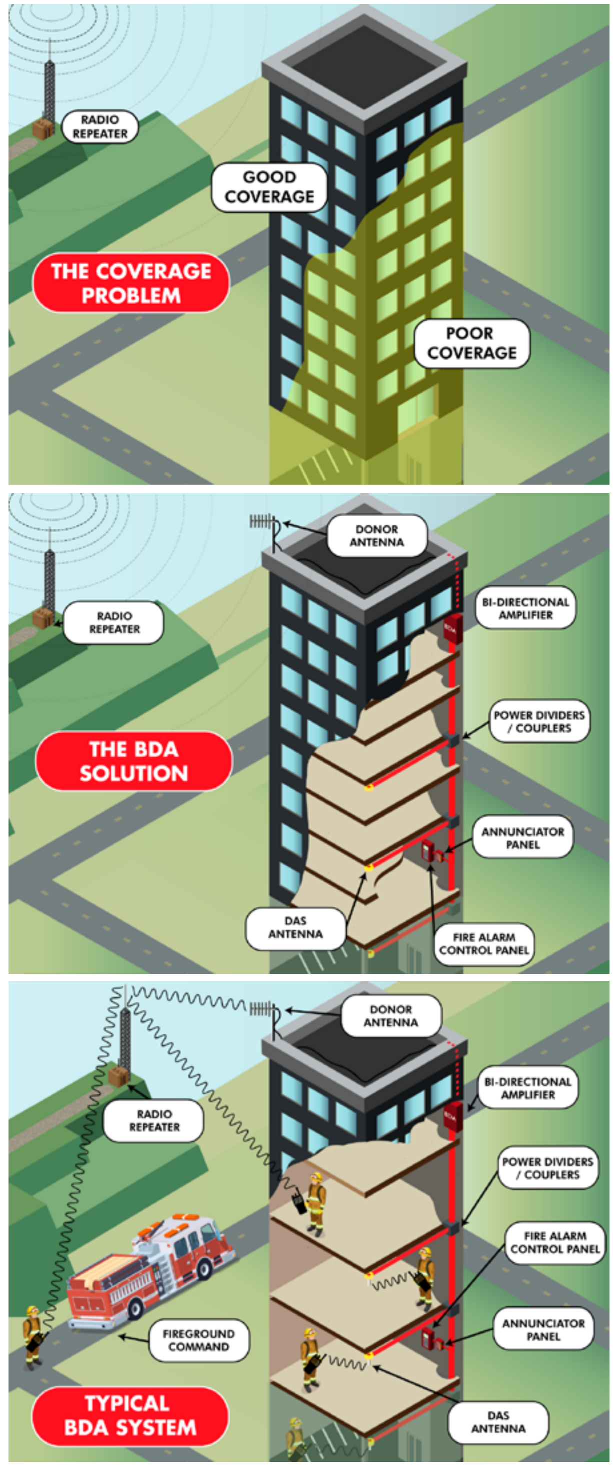
- As experts in fire safety and standards, Fire Safety Engineers are leaned upon by the design team to provide best-practice recommendations. By being aware of code changes, performance listings and their future implications, Fire Safety Engineers help mitigate risk and stay ahead of current safety standards.

What does this mean for General and Electrical Contractors?

- Both General and Electrical Contractors are expected to be familiar with current code and understand how future code and product standards affect the life span of a building. Including a code compliant and UL 2524 listed ERCES system ahead of time will save construction costs, when compared to making changes in the field, or retroactively.
- By being aware of national consensus model codes and installation standards, and recent product performance listing standards and their eventual trickle down to the local level, contractors can make sure to partner with the right fire safety experts during installation.

What does this mean for Building Owners or Developers?

- Building Owners/Developers are required to build structures that are capable of meeting the mandated radio performance criteria in order to receive their certificate of occupancy (CO). By including a code-compliant and UL 2524 listed system from the earliest stages of a project, Builders/Owners can forgo unnecessary delays in tenant occupancy and fire safety upgrade costs.
- External and environmental changes can also impact the emergency radio performance throughout a building's lifetime, which would need to be amended after each year's inspection. This can be mitigated by adding a code-compliant and UL 2524 listed ERCES system during the design process.
- Safety is a significant selling point to future tenants or owners. A more sophisticated life safety system will provide not only peace-of-mind, but also minimize tenant build-out retrofit costs.



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RB313.1-21

Proponents: Andrew Milliken (amilliken@staffordcountyva.gov)

2018 Virgina Residential Code

Revise as follows:

R313.1 Townhouse automatic fire sprinkler systems. ~~Notwithstanding the requirements of Section 103.3, where installed, an~~ An automatic residential fire sprinkler system ~~for *townhouses*~~ shall be ~~designed and installed in accordance with NFPA 13D or Section P2904.~~ installed in *townhouses.*

> **Exception:** An automatic residential fire sprinkler system shall not be required when additions or alterations are made to existing *townhouses* that do not have an automatic residential fire sprinkler system installed.

R313.1.1 Design and installation. Automatic ~~residential fire~~ sprinkler systems for *townhouses* shall be designed and installed in accordance with Section P2904 or NFPA 13D~~, 13, or 13R~~.

Reason Statement: This proposal is the same townhouse fire sprinkler requirement initially approved by the Board of Housing and Community Development during the 2018 Code Development Cycle. Recognizing that townhomes require homeowners to put their trust in their neighbors for fire safety, requiring fire sprinklers in townhomes provides active and built-in protection for homeowners against that risk for each townhome in the row.
Home fires are fast; sprinklers are faster. According to Underwriters Laboratories, modern home furnishing burn tests have measured the burn rates and times of older home furnishings, made up of materials using solid wood, wool and down, and compared them with today's home furnishings that contain mostly synthetic materials and electronics in addition to open-floor plans, larger homes and engineered lumber. The results? Today's home fires burn much faster, leaving less time for residents to get out of structures and posing new challenges for firefighters (www.youtube.com/watch?v=aDNPhq5ggoE).

Home fires are deadly; sprinklers save lives. According to National Fire Protection Association statistics for 2020, 74% of fire deaths occur in the home. Home fire sprinklers can save lives and property from fire. They respond quickly and effectively to fire, often extinguishing the fire before the fire department arrives. Only the sprinkler closest to the fire will activate, spraying water on the fire.

Homes need to be affordable; sprinklers are too. The national average for installing automatic fire sprinklers in new homes is $1.35 per sprinklered square foot. Putting that figure in perspective, people pay similar amounts for carpet upgrades, whirlpool baths, or granite countertops.

MYTH: "A smoke alarm provides enough protection." FACT: Smoke alarms alert occupants to the presence of danger, but do nothing to extinguish the fire. Home fire sprinklers respond quickly to reduce heat, flames, and smoke from a fire, giving residents valuable time to get out safely. Having a working smoke alarm cuts the chances of dying in a reported fire in half. However, if you have a reported fire in your home, the risk of dying decreases by about 85% when sprinklers are present.

MYTH: "Newer homes are safer homes; the fire and death problem is limited to older homes." FACT: Age of housing is a poor predictor of fire death rates. Yes, new construction codes allow for tighter construction and better draft-stopped homes, which help slow the spread of fire. However, these safeguards have not completely mitigated the home fire problem. The majority of home fires are caused by candles, smoking materials, cooking, arcing, and other occupant-based activities. These types of fires happen in old and new construction alike. Moreover, new methods of construction negatively impact occupant and firefighter life safety under fire conditions. The National Research Council of Canada (NRC) tested the performance of unprotected floor assemblies exposed to fire. The findings of the study, "The Performance of Unprotected Floor Assemblies in Basement Fire Scenarios," assert that these structures are prone to catastrophic collapse as early as six minutes from the onset of fire. The same UL study found that the synthetic construction of today's home furnishings add to the increased risk by providing a greater fuel load. Larger homes, open spaces, increased fuel loads, void spaces, and changing building materials contribute to: faster fire propagation, shorter time to flashover, rapid changes in fire dynamics, shorter escape time, shorter time to collapse

MYTH: "Home fire sprinklers are expensive and will make housing unaffordable, especially for first-time buyers moving to our area." FACT: The fact is that home fire sprinklers are affordable. In 2013, the Fire Protection Research Foundation issued its updated Home Fire Sprinkler Cost Assessment report, which revealed that the cost of installing home fire sprinklers averages $1.35 per sprinklered square foot for new construction. That's down from $1.61 per sprinklered square foot that was in the Foundation's 2008 report. To put the cost of sprinklers into perspective, many people pay similar amounts for carpet upgrades, a paving stone driveway, or a whirlpool bath. Installing home fire sprinklers can help residents significantly reduce property loss in the event of fire, cut homeowner insurance premiums, and help support local fire service efforts.

MYTH: "We don't need sprinkler requirements; they can be installed in homes voluntarily."FACT: Fire sprinklers are a U.S. model building code requirement for all new, one- and two-family homes. If a new home is lacking this safety feature, it is not adhering to national model building codes, and should therefore be considered substandard. Adopting this requirement to sprinkler new homes provides a greater overall level of safety in communities. By requiring this technology, you are ensuring that a large number of residents can enjoy the same level of safety found in many offices, schools, apartments, and public buildings. Beyond the life-saving benefits of home sprinklers, there are other incentives; cities can reduce the strain on fire service personnel, limit damage to property, and help conserve municipal water resources by reducing the amount of water needed to fight fires.

MYTH: "Home fire sprinklers often leak or activate accidentally." FACT: Leaks from fire sprinklers are very rare. Scottsdale, Arizona, for instance, has had an ordinance for home fire sprinklers since 1986. According to *NFPA's "U.S. Experience with Sprinklers" report, a*

survey conducted there found that the majority of residents living in sprinklered homes had never experienced a leak or maintenance problem. The report also noted that sprinklers operated in 94 percent of home fires in which sprinklers were present and fires were considered large enough to activate them. They were effective at controlling the fire in 96 percent of fires in which they operated. In three of every five home fires in which sprinklers failed to operate, the system had been shut off.

MYTH: "If you want your home fire sprinklers to be reliable, they will need frequent, expensive maintenance." FACT: The standard design for home fire sprinklers is much simpler than the design for more traditional sprinklers used in commercial buildings. If you install home fire sprinklers, the only "inspection and maintenance" you need to do are simple tasks outlined by the Home Fire Sprinkler Coalition, including simple flow tests and visual inspections.

MYTH: "When a fire occurs, every sprinkler will activate and everything in the house will be ruined." FACT: In the event of a fire, typically, only the sprinkler closest to the fire will activate, spraying water directly on the fire, leaving the rest of the house dry and secure. Roughly 85 percent of the time, only one sprinkler activates during a fire.

MYTH: "The water damage caused by fire sprinklers will be more extensive than fire damage." FACT: Home fire sprinklers can significantly reduce property loss and damage due to a fire. The sprinkler will quickly control the heat and smoke from the fire, limiting damage to other areas of the house and giving residents valuable time to get out safely. Any resulting impact from the sprinkler will be much less severe than the damage caused by water from fire-fighting hose lines. Fire departments use up to eight-and-a-half times more water to extinguish a home fire as fire sprinklers would use to extinguish the same fire.

MYTH: "Home fire sprinklers are not practical in colder climates, as the pipes will freeze and cause water damage." FACT: With proper installation, home fire sprinklers will not freeze in cold settings. NFPA 13D, Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes, sets forth guidelines on proper insulation to avoid pipes freezing.

MYTH: "Home fire sprinklers are unattractive and will ruin the aesthetics of our residents' homes."FACT: New home fire sprinkler models are very unobtrusive, can be mounted flush with walls or ceilings, and can be concealed behind decorative covers.

MYTH: "Any time a smoke alarm goes off it will activate the home fire sprinklers." FACT: Each individual sprinkler is designed and calibrated to activate only during the heat from a fire. They do not operate in response to smoke, burned toast, cooking vapors, steam, or an activating smoke alarm.

https://ul.org/new-demonstration-video-shows-you-only-have-three-minutes-escape-home-fire

https://www.nfpa.org/Public-Education/Staying-safe/Safety-equipment/Home-fire-sprinklers/Fire-Sprinkler-Initiative/Take-action/Free-downloads/Myths-vs-facts

Cost Impact: The code change proposal will increase the cost of construction
According to a 2013 study by the Fire Research Foundation, the national average cost for installing a residential sprinkler system is $1.35 per square foot or $3,375 for a 2,500-square-foot home. A copy of that report is available at https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Suppression/HomeFireSprinklerCostAssessment2013.ashx. With the average construction cost of a new home at $114 per square foot in 2019, that's paying a little more than 1% of a home's value for 24/7 fire protection.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal will increase the minimum life safety infrastructure of new residential townhouses such that they are more resilient to the impact of fire. It ensures that fire sprinkler protection is built-in with each townhome and remains for the life span of the structure.

Attached Files

- **Fact Sheet - water supply.pdf**
  https://va.cdpaccess.com/proposal/1134/1684/files/download/659/
- **Fact Sheet - Townhouses.pdf**
  https://va.cdpaccess.com/proposal/1134/1684/files/download/658/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: RB313.1-21

Discussion by Paul Messplay
Aug 18, 2022 12:06 UTC

Proponents: Keith Brower, representing Self, as a former Fire Chief and Father with interests in VA (bayfisher17@gmail.com) requests As Submitted

Commenter's Reason: I urge the Board of Housing and Community Development to move RB313.1-21 for approval.
1. Home fires are the leading cause of death and injury in the United States. Roughly 3 out of every 4 civilian fire deaths and injuries occur in the home.

2. Today's home fires are burning faster and hotter than ever before. This is due to the use of synthetic materials in most home furnishings and fixtures. The effect is a reduced occupant escape time, even with properly located and functioning smoke alarms. The risk is magnified with populations at most risk- the very young, the elderly and those who are incapacitated and incapable of self preservation.

3. Smoke alarms are passive fire protection. They only alert to the presence of a fire. Sprinklers represent active fire protection. They extinguish the fire at the incipient stage before is grows to flashover, which is not survivable. Temperatures and toxicity levels are maintained at at a survivable level and occupants have more time to escape.

4. Sprinklers flow less water than a fire hose. It is often cited that sprinklers cause excessive water damage. The math suggests otherwise as sprinklers flow at the 14-28 gallons per minute rate. A fire hose flows between 150- 250 gallons per minute.

5. Sprinklers are affordable. They cost on average $1.35- $1.60 SF when installed during construction. When that cost is amortized over a 30-year mortgage the impact is less than $50.00 per month (2,000 SF home, 5.67% interest rate).

6. Sprinklers may be installed where no municipal water supply is practical. This cost is higher, but is still affordable. My home sprinkler system, using a 250 gallon water storage tank (purchased at Home Depot) and a 50 gallon per minute pump, was installed for $6,000.00 to protect 1,800 SF.

The Board report outlines the many myths that are associated with sprinklers. My summary is simple. Sprinklers have a proven track record of saving lives. Those of civilians as well as firefighters, who are at less risk when responding to a home fire. The national model codes have required sprinklers in 1 and 2-family dwellings and townhouses since 2008. We have daily success stories where fire in sprinklered homes have resulted in no lives lost. Likewise we have daily stories about fire deaths in unsprinklered homes. It's time for Virginia to become the leader, and approve this proposal.

W. Keith Brower, Jr.

Fire Chief (Retired) Loudoun County, VA

843-929-9558

Cost Impact: The net effect of the public comment and code change proposal will increase the cost of construction
As cited, the cost of installing sprinklers in new home construction is $1.35- $1.60 SF .

Discussion by Paul Messplay
Aug 18, 2022 12:05 UTC

Proponents: Robby Dawson, representing National Fire Protection Association (rdawson@nfpa.org) requests As Submitted

Commenter's Reason: The National Fire Protection Association has published the concept of the Fire and Life Safety Ecosystem, one of the components of this system is the adoption of the most current model building codes and safety standards. These national model consensus codes and standards are considered the least safe way to build any structure – residential or commercial. NFPA believes that anytime the model code is weakened, safety is compromised. To view more about the NFPA Fire and Life Safety Ecosystem, visit www.nfpa.org/ecosystem.

For this reason, NFPA is opposed to eliminating any provision of the IRC – specifically related to this proposal is residential sprinklers in one- and two-family dwellings – from the International Residential Code. While this provision has been removed from the IRC in Virginia since its inclusion in the model codes in 2006, safety advocates have continually tried to add this proven and affordable fire safety provision back into the Uniform Statewide Building Code. These efforts have been widely attended, however some of the challenges are new individuals entering the discussions and these groups having to re-hash time and time again many of the false and inaccurate impressions about these systems – all of which were dispelled at the national level when sprinklers were added to the IRC.

Additionally, the NFPA Fire and Life Safety Policy Institute has surveyed the home buying public. That research shows that, “86% of respondents reported that they felt confident that if they bought a newly construction home, it would meet the most up-to-date fire and electrical safety codes.” (see attached NFPA Journal article for the details of the survey and results). Elimination of fire sprinklers from single family homes clearly does not meet the most up-to-date fire safety code.

While it is clear that smoke alarms have been a significant safety provision since their inclusion in the building codes, the fire environment has changed greatly over the years with the presence of synthetic and plastics. This has resulted much faster fire spread and faster flashover in homes, which means there I very little time to escape. The residents of homes are also changing. With an aging population, the challenge of hearing impairment, mobility challenges, and health issues only exacerbate the problem and make these basic life safety systems even more important.

The National Fire Protection Association believes the most appropriate proposal before ethe Board of Housing and Community Development is RB313.1(2)-21 submitted by Mr. Glenn Dean as this reverts the USBC to the national model code, which is also in place in Maryland, and should be approved As Submitted. However, in the spirit of compromise, and given the greater fire hazards present in townhomes, RB313.1-21 submitted by Mr. Andrew Milliken is a reasonable alternative given the cost savings associated with the trade offs of fire ratings, road widths, and required fire protection water required.

The expressed opposition to any of these proposals seems to hinge on the affordability of homes. Given these provisions have been incorporated in the State of Maryland’s building code, and without evidence from that state showing the negative impact to housing starts, growth, or affordability, this argument is without merit.

In closing, NFPA requests the Board of Housing approve As Submitted either RB313.1(2)-21 or RB313.1-21 in order for new homes to meet the national standard for home fire safety.

Bibliography: As noted in the original proposal.

Cost Impact: The net effect of the public comment and code change proposal will not increase or decrease the cost of construction
Given the reduction in other provision of the code due to these systems, the costs will be offset by the savings.

Discussion by Paul Messplay
Aug 18, 2022 12:05 UTC

Proponents: Brian Beaulieu, representing Fire Marshals Office (brian.beaulieu@loudoun.gov) requests As Submitted

Commenter's Reason: With the construction materials growing more lightweight and the increase in the rapid-fire growth due to more synthetic fabrics, I feel it is imperative that we require sprinklers in all townhouses.

Cost Impact: The net effect of the public comment and code change proposal will increase the cost of construction
With the slight increase in cost for the installation of sprinklers, the amount of life and property that could be saved is well worth it.

Discussion by Paul Messplay
Aug 18, 2022 12:03 UTC

Proponents: Micah Kiger, representing Loudoun County Fire and Rescue - Fire Marshal's Office (micah.kiger@loudoun.gov) requests As Submitted

Commenter's Reason: Requiring sprinklers in newly constructed townhouses, regardless of the number of adjoining units, needs to be a priority in Virginia. The pro's of requiring these changes far outweighs any potential con's associated with requiring sprinklers to be added to new construction.

Cost Impact: The net effect of the public comment and code change proposal will increase the cost of construction
While there will be a slight increase in the cost of construction, the cost of retrofitting sprinklers into townhouses that do not have them if a major change occurs in the future would be significantly higher. While no one can put a numerical value on someone's life, investing around $5K into a newly constructed townhouse would certainly be a good investment that will help save lives...and those lives may be a next-door neighbor or someone that lives units away.

Having incentives for builders to include sprinklers into newly constructed townhomes would be a good step to help show support for this change.

Discussion by Paul Messplay
Aug 18, 2022 12:02 UTC

Proponents: Keith Johnson, representing Loudoun County Fire and Rescue; Virginia Fire Chiefs Association; Virginia Fire Services Board (keith.johnson@loudoun.gov) requests As Submitted

Commenter's Reason: Virginia Board of Housing and Community Development
c/o Department of Housing and Community Development

600 East Main Street, Suite 300

Richmond VA 23219

Dear Board:

I am writing in support of Proposal RB313.1-21 in the 2021 *Virginia Residential Code*. Although this proposal is listed as non-consensus, a coalition of stakeholder groups in the Residential Sprinklers Study Group established by the Department of Housing and Community Development made significant progress working together to carry on the work as directed during the 2018 code development process. We did exactly what Board of Housing members asked for in the last code cycle; study the issue and report factual and vetted information for consideration in the 2021 *Virginia Residential Code*. The purpose of RB313.1-21 is to amend the 2018 *Virginia Residential Code* to provide a requirement for automatic fire sprinklers in new Townhouses. This is not a retroactive requirement, thus only affecting new construction. This requirement would allow residential sprinklers in townhouses to be constructed to the residential P2904 or NFPA 13D design, not the more expensive application of NFPA 13 or 13R.

In September 2008 at the International Code Council (ICC) Final Action Fire and Building Code Hearings in Minneapolis, Minnesota, one of the most significant accomplishments for the safety of citizens was the passage of a national residential building code requiring residential fire sprinklers in all new one- and two-family dwellings. The passage of a residential fire sprinkler provision in the 2009 edition of the *International Residential Code* contained language requiring active fire suppression systems in one- and two-family dwellings, to include townhouses. This one single component of building safety had the potential to be the greatest improvement in residential fire safety since smoke alarm code requirements were introduced in the 1970's.

When the 2009 edition of the *International Residential Code* was published, it would have ushered in a milestone in public safety but only if this code change was adopted by the Virginia Board of Housing and Community Development. As we know, this revolutionary and lifesaving requirement that was adopted by a national process, was not adopted by the Virginia Board of Housing and Community Development and was removed from the code. This single action in 2009 and subsequent code cycle years has caused the loss of countless lives, the loss of millions of dollars of property, thousands of hours of lost time from work, millions of dollars of economic development loss to localities, and numerous personal injuries to citizens and firefighters.

Members of the fire service have been working for years on the adoption of this residential fire sprinkler code; however, past efforts, mostly by the building industry who submitted formal challenges to the Board of Housing and Community Development, have not allowed this life saving code requirement to be enacted in Virginia. The mandatory residential fire sprinkler requirement adopted in the 2009 *International Residential Code* has not been approved. Support throughout the Commonwealth of Virginia by the fire service industry, area localities, and citizens is mounting in support of residential sprinklers.

During the 2021 code adoption process, collective fire service efforts were altered to attempt to compromise with the building industry, not requiring residential sprinklers in all one- and two-family homes, but only requiring them in newly constructed townhouses.

You see, townhouses place significantly increased demand on fire service resources as compared to single family detached dwellings. Townhouses increase the complexity of rescue operations and firefighting operations are hampered because no there are no access openings in party walls allowing firefighters to pass back and forth between opposite sides when fighting a fire. Rescue operations must be conducted separately in each unit and unit-to-unit fire spread cannot be easily followed by firefighters performing interior suppression operations. In townhouses, owners and occupants are dependent on your neighbor being fire safe and living in a manner that promotes safety. None of us can guarantee that, and all residents in a row of townhouses are dependent on each other.

As contained in the DHCD Residential Sprinklers Study Group Final report dated June 9, 2022, when residential sprinkler systems are installed in townhouses, the *Virginia Residential Code* allows for relief from certain other code requirements, such as: reduced minimum distance to property lines; emergency escape and rescue openings are not required; the fire wall between units does not have to be structurally independent; and a reduction in the minimum required fire-resistance-rating of the firewall between units.

While ultimately the study group did not reach consensus on the feasibility of mandating sprinkler systems in townhouses, the following reasons for support were noted:

•Sprinklers save lives

•Sprinklers reduce injury to occupants and firefighters

•Sprinklers reduce building damage and repair costs associated with fires

•Today's building components and furnishings are much more flammable

•Incentives are available when sprinklers are installed, which could offset the cost

•Sprinklers have been required by the model codes for over a decade

Many of the reasons for opposition have centered around cost, specifically reduced housing affordability. Testimony and evidence were provided that estimated the cost of installing a residential sprinkler system in a townhouse at $3,000 per unit which can be offset by the incentives described above, thus making it cost neutral to require a valuable life safety component. While smoke alarms are still a first line of defense, there is no smoke alarm that will control a fire and prevent it from extending, thus providing an escape route for the occupant(s) of a burning home.

On October 6, 2019, a 9-1-1 call came into the Loudoun County Emergency Communications Center just before 3:00 a.m., reporting a house fire in the 200 block of Giles Place in Sterling. Firefighters arrived to find smoke coming from a two-story townhouse and one adult outside suffering from burn injuries. Once inside, firefighters located an adult male who was brought outside to waiting EMS crews. Paramedics immediately began advanced life support care and transported the victim to a local hospital where he was pronounced dead. The cause of this fatal fire was unattended cooking, meaning a pot of food was left on the stove which not only caused $144,000 damages to the home, one occupant died from a pot burning on the stove, clearly something that a residential sprinkler system would have controlled. This is where the Board of Housing and Community Development can, in fact, save lives! This occupant died and others surely will if the Board of Housing and Community Development doesn't do the RIGHT thing and approve the mandatory requirement for residential sprinklers in townhouses as contained in proposal RB313-21.

Sincerely,

Keith H. Johnson, Chief

Loudoun County Combined Fire and Rescue System

Immediate Past President, Virginia Fire Chiefs Association

Chair, Virginia Fire Services Board

Bibliography: This proposal will increase the minimum life safety infrastructure of new residential townhouses such that they are more resilient to the impact of fire. It ensures that fire sprinkler protection is built-in with each townhome and remains for the life span of the structure.
Home fires are fast; sprinklers are faster. According to Underwriters Laboratories, modern home furnishing burn tests have measured the burn rates and times of older home furnishings, made up of materials using solid wood, wool and down, and compared them with today's home furnishings that contain mostly synthetic materials and electronics in addition to open-floor plans, larger homes and engineered lumber. The results? Today's home fires burn much faster, leaving less time for residents to get out of structures and posing new challenges for firefighters (www.youtube.com/watch?v=aDNPhq5ggoE).

Home fires are deadly; sprinklers save lives. According to National Fire Protection Association statistics for 2020, 74% of fire deaths occur in the home. Home fire sprinklers can save lives and property from fire. They respond quickly and effectively to fire, often extinguishing the fire before the fire department arrives. Only the sprinkler closest to the fire will activate, spraying water on the fire.

Homes need to be affordable; sprinklers are too. The national average for installing automatic fire sprinklers in new homes is $1.35 per sprinklered square foot. Putting that figure in perspective, people pay similar amounts for carpet upgrades, whirlpool baths, or granite countertops.

Cost Impact: The net effect of the public comment and code change proposal will increase the cost of construction
According to a 2013 study by the Fire Research Foundation, the national average cost for installing a residential sprinkler system is $1.35 per square foot or $3,375 for a 2,500-square-foot home. A copy of that report is provided as an attachment for reference. With the average construction cost of a new home at $114 per square foot in 2019, that's paying a little more than 1% of a home's value for 24/7 fire protection.

Virginia Townhouse Sprinkler Price Survey - Compiled by Jeffrey Shapiro, P.E., FSFPE, IRC Fire Sprinkler Coalition 12/7/2020

The information below has been provided by two sprinkler contractors who were asked to provide Virginia-specific price histories for townhouse projects built in Virginia in the past few years. These are the prices charged to builders, exclude any builder markup that might increase the actual cost to consumers, and exclude permit fees that may be charged in addition to the base building permit cost.

Response from Contractor 1

• The following data reflects costs for 10 projects constructed between 2016 and 2019. Prices do not include added costs associated with local amendments exceeding what is required by the nationally recognized standard.

Job Location

Reston, VA Reston, VA Reston, VA Haymarket, VA Haymarket, VA Haymarket, VA Leesburg, VA Leesburg, VA Alexandria, VA Alexandria, VA

• Fairfax County average price is $1.26 per square foot (NFPA 13D).

• Prince William County average price is $1.18 per square foot (NFPA 13D).

• Loudon County average price is $1.23 per square foot (NFPA 13D).

• Arlington County average price is $1.31 per square foot (NFPA 13D). Response from Contractor

• Loudoun County average price is $1.71 per square foot (NFPA 13R). $1.71 figure represents the average price for over 500 units constructed by four different builders in the past five years. Loudoun permits a modified NFPA 13R design, that does not require a fire department connection and permits a design based on 2 sprinklers operating, rather than 4, which is ordinarily required under NFPA 13R.

• Fairfax County average price is $1.86 per square foot (NFPA 13R). The $1.86 figure represents the average price for 220 units constructed by three different builders in the past four years. Costs provided by this contractor exceed what would be expected to comply with the proposed Virginia Residential Code because the costs reflect systems that were designed to the NFPA 13R standard, not the NFPA 13D standard, which the residential code will permit. NFPA 13R systems are typically used to protect large residential complexes and are more expensive than NFPA 13D systems, which are forprotection of townhouses and one- and two-family dwellings.

Discussion by Florin Moldovan
Jun 22, 2022 11:22 UTC

See attached floor modification discussed at the GSWG meeting on June 14th.
Attachments: https://va.cdpaccess.com/proposal/1134/discuss/181/file/download/787/RB313.1-21%20Floor%20Modification.pdf
Discussion by Paul Messplay
Jun 6, 2022 12:44 UTC

Attached are public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.

Attachments:
https://va.cdpaccess.com/proposal/1134/discuss/147/file/download/735/HBAV%20Public%20Comment_Residential%20Fire%20Sprinklers%20%2805

RB313.1-21 – Staff Summary

Proponent: Andrew Milliken

Brief Description:

The proposal requires the installation of either P2904 or NFPA 13D compliant automatic sprinkler systems in townhouses.

STUDY GROUP OR SUB-WORKGROUP INFORMATION.

The proposal was discussed during the May 17th meeting of the Residential Sprinklers Study Group. No official position was taken by the study group on this proposal. The discussions surrounding this proposal led to the proponent limiting the allowable systems to P2904 and 13D systems and modifying the language from “Automatic residential fire sprinkler systems” to “automatic sprinkler systems” to align with national nomenclature around these systems.

Residential Sprinklers Study Group members in attendance:

- Andrew Clark: Home Builders Association of Virginia (HBAV)
- Keith Johnson: Virginia Fire Chiefs Association; Virginia Fire Services Board
- Mike Nannery: Local Utility Department (Chesterfield County)
- Ron Clements: Virginia Building and Code Officials Association (VBCOA)
- Jason Laws (Alternate for Mike Eutsey): VBCOA
- Jimmy Csizmadia: Virginia Fire Prevention Association (VFPA)

Residential Sprinklers Study Group members not in attendance:

- Garrett Dyer: Virginia Department of Fire Programs (VDFP), State Fire Marshal’s Office (SFMO)
- Mike Poole: American Institute of Architects – Virginia Chapter (AIA-VA)
- Mike Eutsey: Virginia Building and Code Officials Association (VBCOA)
- Reid Walters: Local Government – General (Town of Independence)
- Robbie McCraw: Local Government - Elected Official (Carroll County)
- Meredith Raetz: Private Water Company (Virginia American Water)
- Overton McGehee: Affordable Housing (Habitat for Humanity)
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

- **Names:** William Penniman, Sierra Club - Virginia Chapter; Jeff Shapiro, International Residential Code Fire Sprinkler Coalition (IRCFSC) and Consultant to the Fire Sprinkler Industry.

- William Penniman, Sierra Club, stated his support for this proposal was to make sure the proposal went forward as non-consensus instead of consensus for disapproval.
- Jeff Shapiro, IRCFSC and Consultant to the Fire Sprinkler Industry, indicated that he prefers his own proposal [RB313.1(3)-21] and argued (in response to Andrew Clark's comments below) that 1" water meters or water service pipe are not required.

Opposition:

Names: Andrew Clark, HBAV; David Beahm, Warren County; Paula Eubank, representing self.

- Andrew Clark, HBAV, expressed opposition to the proposal, referred to the written comments previously submitted in cdpVA and the Residential Sprinklers Study Group Final Report for additional information, and limited his verbal comments to the fact that this would add too much cost to building new homes and testified that meters and water connection fees, especially those requiring a 1" water meter, can be expensive.
- David Beahm, Warren County, stated that he is in opposition to all of the code change proposals requiring sprinklers in townhouses (and one- and two-family dwellings).
- Paula Eubank, representing self, stated that she is in opposition to this proposal.

DHCD Staff Notes:

- Please see attached Residential Sprinklers Study Group Final Report for additional information surrounding townhouse sprinkler systems.
- Please also see staff summaries for RB313.1(2)-21 and RB313.1(3)-21.

Meeting summaries and proposal related information: Tab 10 - Page 97; Tab 14: Residential Sprinklers Study Group Report; Tab 15 - Page 39.

INTERNATIONAL RESIDENTIAL CODE
FIRE SPRINKLER COALITION

FACT SHEET

Water Supplies for Home Fire Sprinkler Systems

This document has been developed to dispel myths by providing factual information about water supply requirements for home fire sprinkler systems.

MYTH: ***Home fire sprinkler systems require expensive upgrades to a new home's water supply system.***

FACTS: Home fire sprinkler systems have become so efficient that they can often be designed to use the same or even less water than a new home's plumbing system.

- Fire sprinklers typically require only 7 pounds-per-square-inch (psi) to operate, which is less than the minimum required pressure for residential plumbing fixtures.

  Plumbing systems require:
  - 8 psi minimum pressure for any plumbing fixture.[1]
  - 20 psi minimum pressure for temperature controlled shower valves (these are mandatory in new homes).[2]
  - 40 psi minimum pressure for the main supply connection (applies to all homes with indoor plumbing, even those supplied by wells).[3]
- A single fire sprinkler can use as little as 8 gallons-per-minute (gpm). With home fire sprinkler systems typically designed to accommodate two simultaneously flowing sprinklers, 16 gpm may be all that's needed to supply fire sprinklers. This is actually less than the 18 gpm minimum that would be required by the Plumbing Code to supply plumbing fixtures in a typical entry-level home with 3 bedrooms, 2 bathrooms and 2 outdoor hose connections.[4]
- Fire sprinklers will typically require more water in larger, more expensive homes, but such homes tend to have more plumbing fixtures, which require an increased water supply for plumbing as well. One or two sprinklers must flow for a minimum of 7-10 minutes, which can be provided by a well and/or a small tank when sprinklers are not supplied by a water distribution system.

MYTH: ***Home fire sprinkler systems require big, expensive water meters.***

FACTS: When a fire sprinkler system is supplied by a water distribution system, water meter size is based on the required pressure and flow, which as stated above, may actually be greater for plumbing than for fire sprinklers. Fire sprinklers won't lead to increased meter or tap fees when the sprinkler system is able to be supplied by the same size meter that serves household plumbing.

A typical 5/8-inch meter will flow up to 20 gpm, which is adequate to operate a fire sprinkler system in many homes.[5] A 3/4-inch meter, which will flow well over 30 gpm, is capable of handling just about any home fire sprinkler system. Most often, the size of underground pipe leading to a house is much more limiting than the meter itself. Upsizing the underground piping

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[1] International Residential Code (IRC) Table P2903.1
[2] IRC Section P2708
[3] IRC Section P2903.3
[4] IRC Table P2903.6 [17.5 fixture units: 2 bathroom groups, 1 kitchen group, 1 laundry group and 2 hose bibs], and IRC Table P2903.6(1)
[5] IRC Table P2904.6.2(2) [This is the prescriptive allowance for any meter. When a meter of known flow characteristics flows more, the higher flow may be used.]

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between the meter and the house is an easy and inexpensive way to improve pressure and flow for all plumbing, including fire sprinklers, without a larger meter.

It's important to note some meter manufacturers' literature specify lesser flow limits, focusing on the range over which a meter will accurately measure continuous flow. With respect to supplying home fire sprinklers, meter flow limits should be evaluated based on the maximum flow rate rather than continuous flow accuracy limits. Water authorities should recognize that sprinklers will always use less water than fire hoses connected to unmetered fire hydrants that would otherwise be needed to put out a fire, so there is no legitimate value in requiring accurate measurement of sprinkler flow in the event of a fire

MYTH: Fire sprinkler systems require expensive backflow preventers.

FACTS: National plumbing codes never require backflow protection for home fire sprinkler systems fabricated with materials approved for household plumbing, such as CPVC, PEX or copper.[6] Occasionally, a local plumbing authority may nevertheless request a backflow preventer, not recognizing that fire sprinkler systems can be safety connected directly to a potable water supply.

Where backflow prevention is an issue because of a local requirement, there are several options whereby additional backflow controls for fire sprinklers can be avoided.

- Fire sprinklers can be incorporated as part of a multipurpose plumbing system that feeds both sprinklers and plumbing fixtures from a home's cold water plumbing pipes.
- Fire sprinklers can be supplied by a separate water connection, with a toilet connected to the end of sprinkler piping to ensure that the piping is occasionally purged by flushing the toilet to prevent stagnant water. This arrangement is referred to as "passive purge."
- Where a yard irrigation system is installed, backflow prevention will be required because such systems are subject to backflow of non-potable water. Fire sprinklers can share the irrigation backflow preventer; thereby, eliminating the need for an additional device.

MYTH: Rural water distribution systems and wells don't have enough water to supply home fire sprinklers.

FACTS: As indicated above, if the water distribution system or well provides enough water to supply household plumbing needs, the supply may be adequate for fire sprinklers. In some cases a larger pump or tank may be needed for sprinklers, but standard, off-the-shelf pumps and tanks suitable for plumbing systems are permitted. When such upgrades are provided, they actually benefit the owner on a daily basis beyond fire protection, because the home's plumbing system will be more robust. Additional water storage can also be invaluable for emergency use in the event of a natural disaster that interrupts utilities.

It should also be noted that, were a rural water distribution system found to be inadequate to supplying 16 gpm for fire sprinklers, it would probably fall short of the minimum code-required plumbing demand, and it would surely fall far short of the 1,000+ gpm needed from fire hydrants to support a fire department extinguishing a fire in an unsprinklered home.

About IRC Fire Sprinkler Coalition

Founded in 2007, the IRC Fire Sprinkler Coalition has grown to include more than 100 international, national and regional public safety organizations, including associations representing 45 states, all of whom support the mission of promoting residential fire sprinkler systems in new home construction. More information can be found at www.IRCFireSprinkler.org.

[6] IRC Section P2904.1

FACT SHEET
Fire Sprinkler Systems for Townhouses

Beginning with the 2009 edition, the International Residential Code (IRC) requires fire sprinkler systems to be provided as a standard feature in all newly constructed townhouses. This document provides information to dispel myths about the background and costs associated with townhouse fire sprinkler systems.

MYTH: Fire sprinkler systems are an expensive add-on in new townhouses that will negatively impact affordability.

FACTS: The IRC provides numerous financial offsets that reduce the cost of fire sprinklers. For example, townhouse separation walls are permitted to be 1-hour fire rated, rather than 2-hour, when sprinklers are provided. This single incentive can dramatically reduce the overall construction costs, when comparing the total cost of building a sprinklered townhouse with 1-hour separation walls vs an unsprinklered townhouse with 2-hour walls.

According to a 2010 estimate provided by a national "Top 10" multifamily builder, the cost savings associated with reducing a townhouse separation wall from a 2-hour rated assembly to a 1-hour rated assembly is approximately $2.20 per square foot of separation wall. Assuming a 2-story, 1,200 square foot townhouse measuring 20-feet by 30-feet with a pitched roof and attic, the incremental cost of providing a 2-hour wall versus a 1-hour wall would be $1,567. In comparison, the sprinkler system for this building, using the most recent national average cost of $1.35 per square foot cited by the National Fire Protection Research Foundation would be $1,620. Therefore, the firewall incentive alone could reduce the net cost of sprinklers to $53 in this example.

When other factors are considered, such as reduced fire access roadway widths, reduced fire hydrant and water main requirements, and the fact that sprinkler installation costs are often less for townhouses vs. single-family homes due to economies of scale, the overall cost of constructing a sprinklered townhouse community may be less than a non-sprinklered community.

MYTH: Residential sprinkler systems in townhouses are a new and unproven technology that is not yet ready for widespread use.

FACTS: The first residential sprinkler standard was written more than 45 years ago, in 1975, and according to U.S. government statistics, millions of families now live in sprinkler-properties. With respect to townhouses, the **Maryland Building Officials Association**, one of the original proponents of the IRC sprinkler requirement for townhouses in 2008, summed up their extensive experience with fire sprinklers in townhouses in their justification statement, as follows:

> "*Since 1990, townhouses in Maryland have been sprinklered and being so has not been detrimental to the home building industry, but has been a major success to saving lives over the past 18 years. To address reasonable fire protection and affordable housing, many Maryland jurisdictions over the years have permitted townhouse separation of one hour with sprinklers installed in accordance with NFPA 13D. Therefore, based on our past success with sprinklered townhouses with one-hour separations between the townhouses, MBOA is in support of mandatory sprinklers in townhouses with one-hour dwelling unit separations.*

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MYTH: The IRC requirement to install fire sprinklers in townhouses was initiated by the fire service and the fire sprinkler industry and it was forced on builders.

FACTS: The code change proposal that added the IRC fire sprinkler requirement (Proposal RB66-07/08) was actually submitted by a major multifamily builder, AvalonBay Communities, and public comments supporting this change were submitted by the Maryland Building Officials Association and the New York State Building Officials Conference. As a major builder of multifamily residential properties, AvalonBay Communities developed extensive experience in installing fire sprinkler systems in townhouses and concluded that sprinkler systems were desirable, cost-effective and should be required as a standard feature in new townhouses.

MYTH: It's best to give home buyers the right to choose whether or not to have sprinklers, as opposed to having codes mandate these systems in all townhouses.

FACTS: It is a fundamental function of building codes to ensure safe housing. Home buyers don't get to choose whether their homes are built to withstand seismic forces, wind loads or snow loads. Likewise, home buyers aren't given the choice of having or not having safe electrical, plumbing, or mechanical systems or smoke alarms. Codes provide minimum requirements for all of these aspects of safe housing in the interest of public safety.

Fire sprinkler systems are no different. Just as car safety regulations have evolved over time from only requiring seat belts to now requiring air bags and backup cameras, building codes have evolved from requiring only smoke alarms to now requiring sprinkler systems for fire safety.

In the case of townhouses, it particularly makes sense for codes to require sprinkler systems because each family's safety is reliant on their neighbors. An accident or careless behavior in one unit often impacts multiple units in non-sprinklered townhouses. Fire sprinklers are the most effective way to ensure that a fire in one townhouse will not threaten families in adjacent units.

Furthermore, townhouses are typically constructed as "spec homes," without buyer involvement during the design or construction process. Adding sprinklers after-the-fact to a finished townhouse unit would greatly increase the cost and complexity of the installation, if it were feasible at all. Likewise, it makes no sense to allow an initial buyer, or the builder in the case of a speculative home, to opt out of fire sprinklers, knowing that such a choice will deny all future owners the option of having sprinklers, given that retrofit installations are typically not feasible.

About IRC Fire Sprinkler Coalition. Founded in 2007, the IRC Fire Sprinkler Coalition has grown to include more than 100 international, national and regional public safety organizations, including associations representing 45 states, all of whom support the mission of promoting residential fire sprinkler systems in new home construction. More information can be found at www.IRCFireSprinkler.org.

HOME BUILDERS ASSOCIATION of VIRGINIA

May 31, 2022

Board of Housing and Community Development
1111 East Main Street
Suite 1400
Richmond, VA 23218

Subject: Opposition to Residential Fire Sprinkler Proposals: RB313.1-21, RB313.1(2)-21, and RB313.1(3)-21

Members of the Board of Housing and Community Development:

On behalf of the Home Builders Association of Virginia, I am writing to express our industry's opposition to the three code proposals to require residential fire sprinklers systems in new one- and two- family dwellings and townhomes.

Our industry shares the fire service professional's commitment to advancing building code requirements that ensure the health, safety, and welfare of all Virginians in their homes and apartments. That shared commitment has clearly yielded significant progress over the last 40 years: according to the National Fire Protection Association's most recent "Fire Loss in the United States" report, the 2020 estimates of the number of fires were 40% to 64% lower than in 1980 for most of the major incident type categories. Furthermore, the 2020 estimate of total fire deaths was 46% lower than in 1980, home fire deaths were 50% lower, deaths in one- or two-family home fires were 47% lower, and apartment fire deaths were 66% lower[1].

However, the Home Builders Association of Virginia and our members are equally as committed to addressing a crisis which has become *so* entrenched in our Commonwealth that it has remained unaddressed, but not unnoticed, for decades and could arguably have greater short-term and long-term impacts on public safety *and* our local, regional, state and national economies, if left alone: housing affordability. While the objective of the fire sprinkler proposals is certainly laudable, the Home Builders Association of Virginia believes that further advancements in residential fire safety could be accomplished through code requirements – and other initiatives – that are less burdensome on homebuyer's and renter's budgets.

As you know, communities across the country are grappling with the effects of a housing affordability crisis. Over the past three decades, the proliferation of local and state regulatory barriers to new residential development has limited the industry's ability to deliver new units to the market, resulting in a supply-demand imbalance which is widely viewed as a primary driver of rapidly escalating home prices and rents[2].

Unfortunately, Virginia has not been immune to these challenges. Our members often hear from local government officials and community organizations about the growing need for housing that is attainable for households at the lower to middle end of the income spectrum – which is validated by virtually every home

[1] National Fire Protection Association: Fire Loss in the United States During 2020

[2] White House Housing Development Toolkit (2016)

builder's and developer's internal analysis of local and regional housing markets. In partnership with local government officials, our members work to identify and remove locally-enacted impediments to new residential development and propose policy changes to alleviate some of the primary drivers of cost during the land development and construction process.

Although modest progress has been made, a comprehensive report released by the Joint Legislative Audit and Review Commission (JLARC) in 2021 confirms that there is much more work to be done.

JLARC's analysis found that housing costs have been rising in every region of the Commonwealth, "…leading to increased housing instability for Virginians."[3] The report also found nearly 30% of Virginia households (905,000) were "housing cost burdened" in 2019, meaning they spend more than 30% of the income on housing costs, which is the widely accepted threshold where housing costs begin negatively impacting the household's ability to make other necessary expenditures. Furthermore, in just one-year, median home sales prices in Virginia rose between 10% and 41% (see figure below).

	Median home sales prices			Percentage change	
	2016	**2020**	**2021**	**2016 to 2021**	**2020 to 2021**
Northern Virginia	$508,000	$582,000	$650,000	28%	12%
Charlottesville	290,000	319,000	350,000	21	10
Hampton Roads	254,000	234,000	330,000	30	41
Northern Neck	267,000	270,000	325,000	22	20
Central Virginia	210,000	257,000	299,000	42	16
Valley	233,000	241,000	285,000	22	18
Southwest/New River Valley	192,000	196,000	217,000	13	11
Southside	125,000	134,000	177,000	42	32
Far Southwest	98,000	117,000	160,000	63	37
Statewide	$204,000	$234,000	$270,000	32%	15%

SOURCE: JLARC analysis of Monthly Median Sales Prices by County/Independent City, 2016 – present. Virginia REALTORS, updated July 15, 2021.

NOTE: Median cost home sales prices reflect the median prices in July of each year. Adjusted to 2021 dollars.

In short, Virginians are struggling to find affordable homes to purchase or rent – and the three residential fire sprinkler proposals before the Board will add substantially to the cost of housing ***for consumers***, further exacerbating a concern raised in the JLARC report: "Low- and middle-income households may have incomes that could support mortgage payments but lack the savings to cover the upfront costs of purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes."

Residential sprinkler advocates often cite data from the Fire Protection Research Foundation, which shows an average cost of roughly $6,000 to install fire sprinklers. While many home builders in Virginia believe that to be an extremely conservative estimate, if it were assumed to be accurate, it ignores the reality that many Virginians cannot bear thousands of dollars in additional cost. Nationally, a $1,000 increase in the cost of a median-priced new home pushes 117,932 households out of the market. Based on their incomes and standard underwriting criteria, these households would be able to qualify for a mortgage to purchase the home before the price

[3] Joint Legislative Audit and Review Commission Report: Affordable Housing in Virginia

increase, but not afterward. In Virginia, a $1,000 increase in the cost of a home pushes 3,871 households out of the market[4].

Furthermore, the cost estimates from the Fire Protection Research Foundation do not include the cost of increasing the size of a structure's water meter from ¾" or 5/8" to 1" to accommodate the residential fire sprinkler system. Increasing the water meter size, in many localities, results in a significantly higher per-unit water connection or availability fee. The Home Builders Association of Virginia surveyed localities across the Commonwealth to determine to magnitude of the fee increase and found increases ranging from several hundred dollars to over $13,000 per unit.

Although residential sprinkler advocates in Virginia dispute this claim, the issue of water connection fees has garnered the attention of legislators in California after fire marshals across the state reported very broad and disproportionate fee schedules for residential fire sprinklers from jurisdictions. Data collected by the California Residential Water Purveyor and Fire Sprinkler Task Force in 2021 showed that localities were requiring 1" water meters for residential structures and that residential fire sprinkler hook-ups could range in cost from $3,000 per house up to over $60,000 per house.

Additionally, cost estimates from residential sprinkler advocates often overlook two additional "tangible" costs, and one "intangible" cost.

First, in some communities where the static pressure of surrounding waterlines is insufficient, it will be necessary to install a booster pump to provide enough pressure for an effective fire suppression system. Home builders in several regions of the Commonwealth provided cost estimates of $1,260 to $2,600 for these systems.

Second, although NFPA 13D does not itself require the installation of a backflow prevention device, the National Fire Protection Association agrees that many municipal water authorities in Virginia and across the country ***require*** the devices to prevent contaminants from reaching drinking water[5], so it will be a cost borne by the consumer if these proposals are enacted. Home builders in Virginia have provided cost estimates ranging from $450 to $1,000 for these devices.

Lastly, NFPA 13D systems require the review and approval by the Authority Having Jurisdiction (AHJ), which has the potential to extend construction time and place additional burden on localities, many of which are currently struggling to employ enough plan reviewers to keep up with current construction activity levels.

Building code requirements should not be rejected outright because of associated costs to the consumer, however, it is essential for policy makers to weigh the effects of a building code proposal on the supply and access to housing for households across the income spectrum; and furthermore, identify other code requirements that may accomplish an identical public safety benefit through means that are less costly for the consumer.

Data from the National Fire Protection Association (NFPA) demonstrates that states *have* been successful in adopting building codes which are cost-effective for the consumer and result in a significant decrease in residential fires, injuries, and deaths. This includes innovations in building science such as advanced heating and electrical systems, egress windows, and fire-resistant materials and features. The proliferation – and continued improvement – in smoke alarm technology has also played a considerable role in advancing home fire safety. In

[4] National Association of Home Builders – 2022"Priced Out" Report
[5] National Fire Protection Association: Common Questions on Home Fire Sprinkler Installations

fact, our analysis of a recent NFPA report indicates that educating homebuyers about the status and importance of their smoke alarm systems, as well as additional investments in free smoke alarm testing and replacement initiatives, would likely result in increased home fire safety and reduced home fire deaths[6].

Recognizing the ability to advance home fire safety in a manner that is cost-effective for consumers, states have overwhelmingly opted to *remove* the fire sprinkler mandates contained in the International Residential Code. Specifically, according to the National Fire Protection Association[7]:

- Only three states/regions require fire sprinklers in new, one- and two-family homes.
- The majority of states have enacted prohibitions on statewide and local adoption of fire sprinkler requirements for new one- and two-family homes.

Similarly, the vast majority of states have opted to not impose fire sprinkler mandates on townhomes[8]. This is due, in part, to the fact that many localities and housing advocates view townhome development as an important component of their strategy to increase the supply of affordable and “missing middle” housing[9], particularly as demand continues to rise among younger, first-time home buyers and seniors looking to downsize. This is validated by recent U.S. Census data, which shows that townhome construction jumped 28.1% in 2021 now make up nearly 13% of all single-family starts[10]. Several factors are contributing to this trend:

- **Construction Costs**: “In December, new residential construction input prices were up 15.1% over the year, a slightly more moderate pace compared to the month prior. Input prices for single-family construction were up 14.7%, while multifamily registered a 14.6% increase.”
- **Lumber Costs**: “At the start of February, lumber futures contract prices fell below $1,000 per 1,000 board feet, which represents around a 25% decline from the $1,278 seen in January *but is still more than 100% above the lows registered at the end of August*.” (Emphasis added)
- **Land Costs:** Developers, builders, and local government planners frequently cite increasing land costs as a significant factor impacting housing costs and supply. According to FHFA estimates, the median land value of a quarter-acre lot occupied by an existing single-family home was $163,500 in 2019, some 60 percent higher than in 2012. An analysis by the Harvard Joint Center for Housing Studies found significant increases in the price per acre land costs between 2012 and 2017 in many urban, suburban, and rural localities across Virginia, including Alexandria (21.4%), Lynchburg (15.5%), Fredericksburg (16.2%), King George County (42.7%), Rockingham County (37.5%), New Kent County (41.4%), Henrico

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[6] A 2021 report from the NFPA found that nearly 60% of home fire deaths were caused by fires in properties with no smoke alarms (41%) or in properties where the smoke alarms failed to operate (16%). In response, the Home Builders Association of Virginia (HBAV) worked to pass legislation (SB 607) during the 2022 General Assembly Session requiring “…a home inspection and the report on its findings include a determination of whether the home's smoke detectors are in "good working order," The HBAV also worked to introduce budget language to provide additional funding to the Virginia Department of Fire Programs to support local fire department’s free smoke alarm testing and replacement programs. The budget language was ultimately not adopted, but the HBAV will continue pursuing that initiative

[7] National Fire Protection Association: Fire Sprinkler Requirements, State by State

[8] National Association of Home Builders – Fire Sprinkler Mandates, State By State

[9] “Missing Middle” is a term that refers to the range of housing types that fit between single-family detached homes and mid-to-high-rise apartment buildings. Used in this context, “middle” references the size and type of a home, and its relative location – in the middle – on a spectrum of housing types.

[10] National Association of Home Builders – Townhouse Construction Surged in 2021

County (13.6%), Prince William County (43.4%), Stafford County (26.8%), Spotsylvania County (14.2%), and others[11].

The higher density, reduced setbacks and buffers, and smaller building footprints typically associated with townhome development allows for a more efficient use of land and can significantly reduce construction costs, which ultimately benefits consumers through lower sales prices and rents. Imposing this mandate would significantly hinder the ability for townhomes to be an effective tool in combatting the persistent housing affordability crisis in the Commonwealth.

In conclusion, a growing share of Americans say that access to affordable housing is a major problem in their communities. Earlier this year, the Pew Research Center found that 49% of Americans say availability of affordable housing in their local community is a major problem, up 10 percentage points from early 2018. The survey also found that the issue is particularly acute for both younger and older Americans: 55% of adults under the age of 30 now say this is a major problem – a 16 percentage point rise from the 39% who said so in 2018. Additionally, the share of adults ages 30 to 49 who hold this view has risen from 42% in 2018 to 55% last year[12]. There is no question that home fire safety is an important issue, as well. However, decades of data and experience has proven that states have enacted building code requirements that keep individuals and families safe in their homes while not reducing the affordability and availability of housing.

We respectfully request that you oppose these three proposals. Thank you in advance for your consideration and please do not hesitate to contact our office if you have any questions.

Sincerely,

Andrew Clark
Vice President of Government Affairs
Home Builders Association of Virginia

[11] Harvard Joint Center for Housing Studies: https://www.jchs.harvard.edu/son-2019-land-prices-map
[12] Pew Research Center (January 18, 2022): A growing share of Americans say affordable housing is a major problem where they live

RB313.1-21 Floor Modification

VRC: R313.1, R313.1.1

Proponents:

Andrew Milliken (amilliken@staffordcountyva.gov)

2018 Virgina Residential Code

Revise as follows:

R313.1 Townhouse automatic fire sprinkler systems.
An automatic residential fire sprinkler system shall be installed in *townhouses.*

> **Exception:** An automatic residential fire sprinkler system shall not be required when additions or alterations are made to existing *townhouses* that do not have an automatic residential fire sprinkler system installed.

R313.1.1 Design and installation.
Automatic ~~residential fire~~ sprinkler systems for *townhouses* shall be designed and installed in accordance with Section P2904 or ~~NFPA 13D, 13, or 13R.~~ <u>NFPA 13D.</u>

NOTE: the underlined and strikethrough text identifies changes to the cdpVA proposal.

RB313.1(2)-21

Proponents: Glenn Dean

2018 Virgina Residential Code

SECTION R313
AUTOMATIC FIRE SPRINKLER SYSTEMS

Revise as follows:

R313.1 Townhouse automatic fire sprinkler systems. ~~Notwithstanding the requirements of Section 103.3, where installed, an~~ An automatic residential fire sprinkler ~~system for *townhouses*~~ system shall be ~~designed and installed in accordance with NFPA 13D or Section P2904.~~ installed in *townhouses* .

> **Exception:** An automatic residential fire sprinkler system shall not be required when additions or alterations are made to existing *townhouses* that do not have an automatic residential fire sprinkler system installed.

R313.1.1 Design and installation. Automatic residential fire sprinkler systems for *townhouses* shall be designed and installed in accordance with Section P2904 or NFPA ~~13D, 13, or 13R.~~ 13D.

R313.2 One- and two-family dwellings automatic fire sprinkler systems. ~~Notwithstanding the requirements of Section 103.3, where installed, a an~~ An automatic residential fire sprinkler system shall be designed and installed in ~~accordance with Section P2904 or NFPA 13D, 13 or 13R.~~ one- and two-family dwellings.

> **Exception:** An automatic residential fire sprinkler system shall not be required for additions or alterations to existing buildings that are not already provided with an automatic residential fire sprinkler system.

R313.2.1 Design and installation. Automatic residential fire sprinkler systems shall be designed and installed in accordance with Section P2904 or NFPA ~~13D, 13 or 13R.~~ 13D.

Reason Statement: I'm submitting this to revert to model code language because the facts supporting a sprinkler requirement in NEW residential construction have not changed over the years, nor have the falsehoods against it. The facts and falsehoods need not be enumerated – again – in this supporting statement. We already know what they are and have for decades. Because of materials used, lightweight construction, density of housing and so on, newly constructed houses burn quickly making the incorporation of sprinklers more imperative. Having a residential sprinkler system provides time for occupants to vacate before untenable conditions are created as they would be without the presence of sprinklers. The fragility of the construction industry is nothing new either. It has been fragile for decades and will continue to fragile for years to come. The same with the increase of housing costs. That's not new. It's always gone up and will continue to go up. By comparison, what I can't understand is the sacrificial cost of a human life when compared to the now relatively insignificant cost of installing residential sprinklers in new construction.

Cost Impact: The code change proposal will increase the cost of construction
This code change might increase construction cost approximately one percent - OR LESS - particularly in light of the tradeoffs available.

Resiliency Impact Statement: This proposal will increase Resiliency
If construction resiliency means to reduce, respond, adapt or avoid a failure due to a destructive event such as a fire, then yes, this proposal will increase resiliency.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: RB313.1(2)-21

Discussion by Paul Messplay
Aug 18, 2022 12:06 UTC

Proponents: Robby Dawson, representing National Fire Protection Association (rdawson@nfpa.org) requests As Submitted

Commenter's Reason: The National Fire Protection Association has published the concept of the Fire and Life Safety Ecosystem, one of the components of this system is the adoption of the most current model building codes and safety standards. These national model consensus codes and standards are considered the least safe way to build any structure – residential or commercial. NFPA believes that anytime the model code is weakened, safety is compromised. To view more about the NFPA Fire and Life Safety Ecosystem, visit www.nfpa.org/ecosystem.
For this reason, NFPA is opposed to eliminating any provision of the IRC – specifically related to this proposal is residential sprinklers in one- and two-family dwellings – from the International Residential Code. While this provision has been removed from the IRC in Virginia since its inclusion in the model codes in 2006, safety advocates have continually tried to add this proven and affordable fire safety provision back into the Uniform Statewide Building Code. These efforts have been widely attended, however some of the challenges are new individuals entering the discussions and these groups having to re-hash time and time again many of the false and inaccurate impressions about these systems – all of which were dispelled at the national level when sprinklers were added to the IRC.

Additionally, the NFPA Fire and Life Safety Policy Institute has surveyed the home buying public. That research shows that, "86% of respondents reported that they felt confident that if they bought a newly construction home, it would meet the most up-to-date fire and electrical safety codes." (see attached NFPA Journal article for the details of the survey and results). Elimination of fire sprinklers from single family homes clearly does not meet the most up-to-date fire safety code.

While it is clear that smoke alarms have been a significant safety provision since their inclusion in the building codes, the fire environment has changed greatly over the years with the presence of synthetic and plastics. This has resulted much faster fire spread and faster flashover in homes, which means there I very little time to escape. The residents of homes are also changing. With an aging population, the challenge of hearing impairment, mobility challenges, and health issues only exacerbate the problem and make these basic life safety systems even more important.

The National Fire Protection Association believes the most appropriate proposal before ethe Board of Housing and Community Development is RB313.1(2)-21 submitted by Mr. Glenn Dean as this reverts the USBC to the national model code, which is also in place in Maryland, and should be approved As Submitted. However, in the spirit of compromise, and given the greater fire hazards present in townhomes, RB313.1-21 submitted by Mr. Andrew Milliken is a reasonable alternative given the cost savings associated with the trade offs of fire ratings, road widths, and required fire protection water required.

The expressed opposition to any of these proposals seems to hinge on the affordability of homes. Given these provisions have been incorporated in the State of Maryland's building code, and without evidence from that state showing the negative impact to housing starts, growth, or affordability, this argument is without merit.

In closing, NFPA requests the Board of Housing approve As Submitted either RB313.1(2)-21 or RB313.1-21 in order for new homes to meet the national standard for home fire safety.

Bibliography: As noted in the original proposal.

Cost Impact: The net effect of the public comment and code change proposal will not increase or decrease the cost of construction
Given the reduction in fire protection outlined in the current USBC as trade off's, the cost is neutral.

Discussion by Paul Messplay
Jun 6, 2022 12:43 UTC

Attached are public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.

Attachments:
https://va.cdpaccess.com/proposal/1136/discuss/145/file/download/733/HBAV%20Public%20Comment_Residential%20Fire%20Sprinklers%20%2805

RB313.1(2)-21 – Staff Summary

Proponent: Glenn Dean

Brief Description:

The proposal requires the installation of an automatic sprinkler system in townhouses and one- and two-family dwellings.

STUDY GROUP OR SUB-WORKGROUP INFORMATION.

The proposal was discussed but not supported by the Residential Sprinklers Study Group members, at their May 17, 2022 meeting.

The following Study Group members have specifically expressed opposition to the proposal given that it requires the installation of sprinkler systems in one- and two-family dwellings in addition to townhouses, which was the focus of the group.

Residential Sprinklers Study Group members in attendance and specifically expressing opposition:

- Andrew Clark: Home Builders Association of Virginia (HBAV)
- Keith Johnson: Virginia Fire Chiefs Association (VFCA), Virginia Fire Services Board (VFSB)
- Jimmy Csizmadia: Virginia Fire Prevention Association (VFPA)

Residential Sprinklers Study Group members in attendance:

- Andrew Clark: HBAV
- Keith Johnson: VFCA; VFSB
- Mike Nannery: Local Utility Department (Chesterfield County)
- Ron Clements: Virginia Building and Code Officials Association (VBCOA)
- Jason Laws (Alternate for Mike Eutsey): Virginia Building and Code Officials Association (VBCOA)
- Jimmy Csizmadia: Virginia Fire Prevention Association (VFPA)

Residential Sprinklers Study Group members not in attendance:

- Garrett Dyer: Virginia Department of Fire Programs (VDFP), State Fire Marshal's Office (SFMO)
- Mike Poole: American Institute of Architects – Virginia Chapter (AIA-VA)
- Mike Eutsey: VBCOA
- Reid Walters: Local Government – General (Town of Independence)
- Robbie McCraw: Local Government - Elected Official (Carroll County)
- Meredith Raetz: Private Water Company (Virginia American Water)
- Overton McGehee: Affordable Housing (Habitat for Humanity)
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, representing self

- William Penniman, representing self, stated that he supports the proposal to ensure that it will not receive a recommendation of consensus for disapproval. He felt that the proposal has enough merit to be further discussed by the Board of Housing and Community Development (BHCD).

Opposition: David Beahm, Warren County

- David Beahm, Warren County, stated [during the hearings for RB313.1-21 and RB313.1(3)-21] that he is in opposition to all of the code change proposals requiring sprinklers in townhouses (and in one- and two-family dwellings).

DHCD Staff Notes:

- The proposal generated considerable discussion around the need for fire data specific to Virginia. Andrew Clark, HBAV, made the point that fire data specific to Virginia is needed prior to implementing a statewide mandate requiring sprinklers. The data would be beneficial in identifying if past fire events occurred in older homes vs. newer homes; homes with smoke detectors vs. no smoke detectors; homes with non-functional or outdated smoke detectors; etc. He made a plead to all stakeholders to work together in helping the Virginia Department of Fire Programs (VDFP) in collecting, compiling and analyzing the fire data that the localities are sending in; and suggested that perhaps there should be a requirement for all the localities to provide the VDFP with such data.
- Andrew Clark, HBAV, highlighted for the stakeholders that the proposal goes beyond the task the Residential Sprinklers Study Group was charged with – townhouse residential sprinklers. Study Group discussion around requiring sprinklers in one- and two-family dwellings was very limited and the Study Group members were opposed to the idea.
- The proposal is one of three proposals with a similar goal – requiring sprinkler systems in townhouses – although this proposal also requires sprinklers in one- and two-family dwellings. As it was also the case with proposals covering different subject matter (i.e. energy), the stakeholders have normally expressed concerns while the first proposal in a row was discussed and rested on those comments when the subsequent proposals with the same goal were discussed. See summary for RB313.1-21 and RB313.1(3)-21 for additional feedback from stakeholders.
- Although the HBAV representative did not specifically express opposition during the General Stakeholder Workgroup Meeting (GSWG), they have submitted public comments in cdpVA prior to the meeting specifically indicating opposition.
- The proposal received a non-consensus recommendation from the GSWG merely because William Penniman expressed a desire for the proposal to be further discussed by the BHCD. There was no additional reasoning or substantiating information provided for the support.

Absent comments from William Penniman, the proposal would have received a recommendation of consensus for disapproval.

- Please see attached Residential Sprinklers Study Group Final Report for additional information surrounding townhouse sprinkler systems.

Meeting summaries and proposal related information: Tab 10 - Page 97; Tab 14: Residential Sprinklers Study Group Report; Tab 15 - Page 39.

HOME BUILDERS ASSOCIATION of VIRGINIA

May 31, 2022

Board of Housing and Community Development
1111 East Main Street
Suite 1400
Richmond, VA 23218

Subject: Opposition to Residential Fire Sprinkler Proposals: RB313.1-21, RB313.1(2)-21, and RB313.1(3)-21

Members of the Board of Housing and Community Development:

On behalf of the Home Builders Association of Virginia, I am writing to express our industry's opposition to the three code proposals to require residential fire sprinklers systems in new one- and two- family dwellings and townhomes.

Our industry shares the fire service professional's commitment to advancing building code requirements that ensure the health, safety, and welfare of all Virginians in their homes and apartments. That shared commitment has clearly yielded significant progress over the last 40 years: according to the National Fire Protection Association's most recent "Fire Loss in the United States" report, the 2020 estimates of the number of fires were 40% to 64% lower than in 1980 for most of the major incident type categories. Furthermore, the 2020 estimate of total fire deaths was 46% lower than in 1980, home fire deaths were 50% lower, deaths in one- or two-family home fires were 47% lower, and apartment fire deaths were 66% lower[1].

However, the Home Builders Association of Virginia and our members are equally as committed to addressing a crisis which has become *so* entrenched in our Commonwealth that it has remained unaddressed, but not unnoticed, for decades and could arguably have greater short-term and long-term impacts on public safety *and* our local, regional, state and national economies, if left alone: housing affordability. While the objective of the fire sprinkler proposals is certainly laudable, the Home Builders Association of Virginia believes that further advancements in residential fire safety could be accomplished through code requirements – and other initiatives – that are less burdensome on homebuyer's and renter's budgets.

As you know, communities across the country are grappling with the effects of a housing affordability crisis. Over the past three decades, the proliferation of local and state regulatory barriers to new residential development has limited the industry's ability to deliver new units to the market, resulting in a supply-demand imbalance which is widely viewed as a primary driver of rapidly escalating home prices and rents[2].

Unfortunately, Virginia has not been immune to these challenges. Our members often hear from local government officials and community organizations about the growing need for housing that is attainable for households at the lower to middle end of the income spectrum – which is validated by virtually every home

[1] National Fire Protection Association: Fire Loss in the United States During 2020
[2] White House Housing Development Toolkit (2016)

builder's and developer's internal analysis of local and regional housing markets. In partnership with local government officials, our members work to identify and remove locally-enacted impediments to new residential development and propose policy changes to alleviate some of the primary drivers of cost during the land development and construction process.

Although modest progress has been made, a comprehensive report released by the Joint Legislative Audit and Review Commission (JLARC) in 2021 confirms that there is much more work to be done.

JLARC's analysis found that housing costs have been rising in every region of the Commonwealth, "…leading to increased housing instability for Virginians."[3] The report also found nearly 30% of Virginia households (905,000) were "housing cost burdened" in 2019, meaning they spend more than 30% of the income on housing costs, which is the widely accepted threshold where housing costs begin negatively impacting the household's ability to make other necessary expenditures. Furthermore, in just one-year, median home sales prices in Virginia rose between 10% and 41% (see figure below).

	Median home sales prices			Percentage change	
	2016	**2020**	**2021**	**2016 to 2021**	**2020 to 2021**
Northern Virginia	$508,000	$582,000	$650,000	28%	12%
Charlottesville	290,000	319,000	350,000	21	10
Hampton Roads	254,000	234,000	330,000	30	41
Northern Neck	267,000	270,000	325,000	22	20
Central Virginia	210,000	257,000	299,000	42	16
Valley	233,000	241,000	285,000	22	18
Southwest/New River Valley	192,000	196,000	217,000	13	11
Southside	125,000	134,000	177,000	42	32
Far Southwest	98,000	117,000	160,000	63	37
Statewide	$204,000	$234,000	$270,000	32%	15%

SOURCE: JLARC analysis of Monthly Median Sales Prices by County/Independent City, 2016 – present. Virginia REALTORS, updated July 15, 2021.

NOTE: Median cost home sales prices reflect the median prices in July of each year. Adjusted to 2021 dollars.

In short, Virginians are struggling to find affordable homes to purchase or rent – and the three residential fire sprinkler proposals before the Board will add substantially to the cost of housing ***for consumers***, further exacerbating a concern raised in the JLARC report: "Low- and middle-income households may have incomes that could support mortgage payments but lack the savings to cover the upfront costs of purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes."

Residential sprinkler advocates often cite data from the Fire Protection Research Foundation, which shows an average cost of roughly $6,000 to install fire sprinklers. While many home builders in Virginia believe that to be an extremely conservative estimate, if it were assumed to be accurate, it ignores the reality that many Virginians cannot bear thousands of dollars in additional cost. Nationally, a $1,000 increase in the cost of a median-priced new home pushes 117,932 households out of the market. Based on their incomes and standard underwriting criteria, these households would be able to qualify for a mortgage to purchase the home before the price

[3] Joint Legislative Audit and Review Commission Report: Affordable Housing in Virginia

increase, but not afterward. In Virginia, a $1,000 increase in the cost of a home pushes 3,871 households out of the market[4].

Furthermore, the cost estimates from the Fire Protection Research Foundation do not include the cost of increasing the size of a structure's water meter from ¾" or 5/8" to 1" to accommodate the residential fire sprinkler system. Increasing the water meter size, in many localities, results in a significantly higher per-unit water connection or availability fee. The Home Builders Association of Virginia surveyed localities across the Commonwealth to determine to magnitude of the fee increase and found increases ranging from several hundred dollars to over $13,000 per unit.

Although residential sprinkler advocates in Virginia dispute this claim, the issue of water connection fees has garnered the attention of legislators in California after fire marshals across the state reported very broad and disproportionate fee schedules for residential fire sprinklers from jurisdictions. Data collected by the California Residential Water Purveyor and Fire Sprinkler Task Force in 2021 showed that localities were requiring 1" water meters for residential structures and that residential fire sprinkler hook-ups could range in cost from $3,000 per house up to over $60,000 per house.

Additionally, cost estimates from residential sprinkler advocates often overlook two additional "tangible" costs, and one "intangible" cost.

First, in some communities where the static pressure of surrounding waterlines is insufficient, it will be necessary to install a booster pump to provide enough pressure for an effective fire suppression system. Home builders in several regions of the Commonwealth provided cost estimates of $1,260 to $2,600 for these systems.

Second, although NFPA 13D does not itself require the installation of a backflow prevention device, the National Fire Protection Association agrees that many municipal water authorities in Virginia and across the country ***require*** the devices to prevent contaminants from reaching drinking water[5], so it will be a cost borne by the consumer if these proposals are enacted. Home builders in Virginia have provided cost estimates ranging from $450 to $1,000 for these devices.

Lastly, NFPA 13D systems require the review and approval by the Authority Having Jurisdiction (AHJ), which has the potential to extend construction time and place additional burden on localities, many of which are currently struggling to employ enough plan reviewers to keep up with current construction activity levels.

Building code requirements should not be rejected outright because of associated costs to the consumer, however, it is essential for policy makers to weigh the effects of a building code proposal on the supply and access to housing for households across the income spectrum; and furthermore, identify other code requirements that may accomplish an identical public safety benefit through means that are less costly for the consumer.

Data from the National Fire Protection Association (NFPA) demonstrates that states *have* been successful in adopting building codes which are cost-effective for the consumer and result in a significant decrease in residential fires, injuries, and deaths. This includes innovations in building science such as advanced heating and electrical systems, egress windows, and fire-resistant materials and features. The proliferation – and continued improvement – in smoke alarm technology has also played a considerable role in advancing home fire safety. In

[4] National Association of Home Builders – 2022"Priced Out" Report
[5] National Fire Protection Association: Common Questions on Home Fire Sprinkler Installations

fact, our analysis of a recent NFPA report indicates that educating homebuyers about the status and importance of their smoke alarm systems, as well as additional investments in free smoke alarm testing and replacement initiatives, would likely result in increased home fire safety and reduced home fire deaths[6].

Recognizing the ability to advance home fire safety in a manner that is cost-effective for consumers, states have overwhelmingly opted to *remove* the fire sprinkler mandates contained in the International Residential Code. Specifically, according to the National Fire Protection Association[7]:

- Only three states/regions require fire sprinklers in new, one- and two-family homes.
- The majority of states have enacted prohibitions on statewide and local adoption of fire sprinkler requirements for new one- and two-family homes.

Similarly, the vast majority of states have opted to not impose fire sprinkler mandates on townhomes[8]. This is due, in part, to the fact that many localities and housing advocates view townhome development as an important component of their strategy to increase the supply of affordable and "missing middle" housing[9], particularly as demand continues to rise among younger, first-time home buyers and seniors looking to downsize. This is validated by recent U.S. Census data, which shows that townhome construction jumped 28.1% in 2021 now make up nearly 13% of all single-family starts[10]. Several factors are contributing to this trend:

- **Construction Costs**: "In December, new residential construction input prices were up 15.1% over the year, a slightly more moderate pace compared to the month prior. Input prices for single-family construction were up 14.7%, while multifamily registered a 14.6% increase."
- **Lumber Costs**: "At the start of February, lumber futures contract prices fell below $1,000 per 1,000 board feet, which represents around a 25% decline from the $1,278 seen in January *but is still more than 100% above the lows registered at the end of August*." (Emphasis added)
- **Land Costs:** Developers, builders, and local government planners frequently cite increasing land costs as a significant factor impacting housing costs and supply. According to FHFA estimates, the median land value of a quarter-acre lot occupied by an existing single-family home was $163,500 in 2019, some 60 percent higher than in 2012. An analysis by the Harvard Joint Center for Housing Studies found significant increases in the price per acre land costs between 2012 and 2017 in many urban, suburban, and rural localities across Virginia, including Alexandria (21.4%), Lynchburg (15.5%), Fredericksburg (16.2%), King George County (42.7%), Rockingham County (37.5%), New Kent County (41.4%), Henrico

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[6] A 2021 report from the NFPA found that nearly 60% of home fire deaths were caused by fires in properties with no smoke alarms (41%) or in properties where the smoke alarms failed to operate (16%). In response, the Home Builders Association of Virginia (HBAV) worked to pass legislation (SB 607) during the 2022 General Assembly Session requiring "…a home inspection and the report on its findings include a determination of whether the home's smoke detectors are in "good working order," The HBAV also worked to introduce budget language to provide additional funding to the Virginia Department of Fire Programs to support local fire department's free smoke alarm testing and replacement programs. The budget language was ultimately not adopted, but the HBAV will continue pursuing that initiative

[7] National Fire Protection Association: Fire Sprinkler Requirements, State by State

[8] National Association of Home Builders – Fire Sprinkler Mandates, State By State

[9] "Missing Middle" is a term that refers to the range of housing types that fit between single-family detached homes and mid-to-high-rise apartment buildings. Used in this context, "middle" references the size and type of a home, and its relative location – in the middle – on a spectrum of housing types.

[10] National Association of Home Builders – Townhouse Construction Surged in 2021

County (13.6%), Prince William County (43.4%), Stafford County (26.8%), Spotsylvania County (14.2%), and others[11].

The higher density, reduced setbacks and buffers, and smaller building footprints typically associated with townhome development allows for a more efficient use of land and can significantly reduce construction costs, which ultimately benefits consumers through lower sales prices and rents. Imposing this mandate would significantly hinder the ability for townhomes to be an effective tool in combatting the persistent housing affordability crisis in the Commonwealth.

In conclusion, a growing share of Americans say that access to affordable housing is a major problem in their communities. Earlier this year, the Pew Research Center found that 49% of Americans say availability of affordable housing in their local community is a major problem, up 10 percentage points from early 2018. The survey also found that the issue is particularly acute for both younger and older Americans: 55% of adults under the age of 30 now say this is a major problem – a 16 percentage point rise from the 39% who said so in 2018. Additionally, the share of adults ages 30 to 49 who hold this view has risen from 42% in 2018 to 55% last year[12]. There is no question that home fire safety is an important issue, as well. However, decades of data and experience has proven that states have enacted building code requirements that keep individuals and families safe in their homes while not reducing the affordability and availability of housing.

We respectfully request that you oppose these three proposals. Thank you in advance for your consideration and please do not hesitate to contact our office if you have any questions.

Sincerely,

Andrew Clark
Vice President of Government Affairs
Home Builders Association of Virginia

[11] Harvard Joint Center for Housing Studies: https://www.jchs.harvard.edu/son-2019-land-prices-map
[12] Pew Research Center (January 18, 2022): A growing share of Americans say affordable housing is a major problem where they live

RB313.1(3)-21

Proponents: Jeffrey Shapiro (jeff.shapiro@intlcodeconsultants.com)

2018 Virgina Residential Code

Revise as follows:

R313.1 Townhouse automatic fire sprinkler systems. An automatic sprinkler system shall be installed in townhouses.~~Notwithstanding the requirements of Section 103.3, where installed, an automatic residential fire sprinkler system for *townhouses* shall be *townhouses* designed and installed in accordance with NFPA 13D or Section P2904.P2904.~~

~~**Exception**~~ **Exceptions :** 1. *Townhouses* containing no more than three *townhouse units.*

2. An automatic ~~residential fire~~ sprinkler system shall not be required when additions or alterations are made to existing *townhouses* that do not have an automatic ~~residential fire~~ sprinkler system installed.

R313.1.1 Design and installation. Automatic ~~residential fire~~ sprinkler systems for *townhouses* shall be designed and installed in accordance with Section P2904 or NFPA 13D~~, 13, or 13R~~.

Reason Statement: This proposal provides a reasonable approach to providing fire safety in newly constructed Virginia townhouses, by including an option for townhouses with less than four units to be built without fire sprinklers. This exception specifically responds to concerns that have previously been raised in Virginia about the feasibility and cost of providing sprinklers in smaller townhouse projects and projects built in rural areas that lack a public water supply. Although 12 of the 13 states/DC that currently adopt the IRC requirement for townhouse sprinklers do not amend in an un-sprinklered unit threshold, and all of these states include the same types of rural and remote area that have been cited as being of concern in Virginia, it is hoped that this Virginia exception will provide a path that building officials, industry, and the fire service will view as reasonable and worthy of support.

Below is a list of considerations that are commonly discussed when reviewing adoption of the IRC's townhouse sprinkler requirement.

1. **Precedence - Adopt the model code requirement:** This proposal will realign the Virginia Residential Code with the IRC by retaining the IRC requirement for fire sprinklers in new townhouses, as modified by an exclusion for less than 4 townhouse units. The IRC requirement was first published in the 2009 IRC and has been retained in the 2012, 2015, 2018, 2021, and 2024 editions of the code. Thirteen state-level code adoptions [California, District of Columbia, Hawaii, Maine, Maryland, Massachusetts, Minnesota, New Hampshire, New York (3+ stories above grade), Oklahoma, Pennsylvania, Washington (more than 4 units), Wisconsin] and numerous other jurisdictions, include the IRC townhouse sprinkler requirement. There is no evidence of negative impacts on home affordability or other detrimental issues associated with the adoption of townhouse sprinklers in any jurisdictions where the IRC requirement is in place.
2. **Parity with the Virginia Building Code:** Section 903.2.8 of the Virginia Building Code requires all townhouses, regardless of height or area, to be sprinklered. There is no technical basis for requiring fire sprinklers to be installed under the Virginia Building Code yet exempt the same requirement under the Residential Code. It is the intent of the IRC and this proposal to provide equal protection to residents of all townhouses with four or more units, regardless of which code they are built under.
3. **Increased fire risk associated with townhouses – They are multifamily occupancies:** Unlike detached homes, where an owner has direct control over personal safety, townhouses are multifamily structures that include many unrelated individuals and families living under a single roof. Clearly, there is no “owner’s choice” argument in the case of townhouses because the fire safety of at least two other families relies on the behavior of someone else who lives under the same roof, i.e. a neighbor’s accident, carelessness, or perhaps even unlawful activities such as a drug lab will impact your safety, your family’s safety, your pets’ safety (who may be home unattended when a fire occurs) and your property. There have been many incidents where a fire in one townhouse unit had catastrophic consequences on neighbors who had nothing to do with the cause of the fire. Residential fire sprinklers prevent such tragedies by keeping fires contained to the unit of origin, either controlling the fire or extinguishing it altogether. It is also worth noting that the National Fire Incident Reporting System codes townhouses as multifamily occupancies, separate from one- and two-family dwellings and recognizing that the risk associated with a townhouse fires is that of a multifamily occupancy.
4. **Increased danger of residential fire behavior:** Research conducted by the National Institute of Standards and Technology and Underwriters Laboratories on residential fire behavior and the value of residential fire sprinklers to firefighter and occupant safety provides a technical basis for this recommendation. Research shows that the rate of fire growth in modern residential structures has increased, partly attributed to an increased heat release rate and an increased heat of combustion associated with modern synthetic materials used in household goods and furnishings. Faster fire growth in a multifamily structure means that occupants of adjacent units will be endangered more quickly than was the case with legacy furnishings
5. **Increased risk to firefighters and demand on fire service resources from townhouses:** Townhouses place significantly increased demand on fire service resources as compared to detached dwellings. Townhouses increase the complexity of rescue operations, and firefighting is hampered because fire spread into adjacent units cannot be easily followed by firefighters from unit to unit. There are no access openings in party walls allowing firefighters to pass back and forth between opposite sides when fighting a fire. Furthermore, townhouses with four or more units, which are the focus of this proposal, tend to be large structures that create the potential for large fires. Wind-driven flames from an uncontrolled residential fire can bypass rated separations and result in fire extension to adjacent units and structures and are

challenging to emergency responders, particularly in rural areas served by diminishing volunteer and equipment resources.

6. **Sustainable housing and environmental impact:** In addition to life-safety and property protection attributes of fire sprinklers, research by FM Global has also verified the value of fire sprinklers in sustainable housing and protecting the environment from pollution associated with toxic smoke and contaminated runoff from manual firefighting. Of particular interest is the conclusion that a single fire event, in addition to destroying a townhouse, can offset the cumulative value of green construction and energy saving appliances, i.e. green efforts are negated if a fire occurs and sprinklers aren't installed as an insurance policy that remains ready to control it.
7. **Financial impact of townhouse sprinklers recognized by builders and cannot be equated to one- and two-family dwellings:** Arguments often conveyed by the building industry in opposition to residential sprinklers based on possible cost implications aren't relevant to townhouses because sprinklered townhouses can actually be less expensive to build than non-sprinklered townhouses. The difference is attributed to incentives that are offered by the IRC and the International Fire Code (IFC) for sprinklered properties. Unlike single family developments, where multiple builders might not be able to directly recoup the value of infrastructure incentives, townhouses are typically built in communities where the developer is the builder, so the cost reductions are directly realized. There's no better testament to this cost comparison than the fact that the IRC's townhouse sprinkler requirement was proposed (RB66-07/08) by a major national multifamily builder, Avalon Bay Communities, not the fire service or public safety interest group. Prior to the 2009 edition, the IRC didn't include an allowance to reduce the fire rating of townhouse separation walls from 2-hours to 1-hour, which had been permitted by the IBC. Avalon Bay Communities proposed adding the IBC wall reduction to the IRC with the quid pro quo of also adding the IBC's requirement to sprinkler all townhouses. Avalon Bay Communities knew that the cost savings associated with the reduced wall rating alone may equal or exceed the cost of installing sprinklers. When combined with other incentives offered by the IFC for access roads and water supply, the company knew that they could actually save money by sprinklering townhouses.
8. **Economic impact:** Installation costs for fire sprinklers in townhouses are offset by cost savings that can be realized in other aspects of construction. Cost incentives for townhouse development/buildings may include:
    1. Reduced material and labor costs associated with reductions in the required fire rating of townhouse separation walls from 2-hours to 1-hour. This incentive has an added benefit, particularly in the current market of tight material and labor supplies, of significantly reducing the amount of drywall that must be secured to construct a project and the associated challenge of securing labor resources to apply additional drywall layers needed to achieve a 2-hour assembly rating. In addition, Code Change RB67-19 resulted in a change to the 2021 IRC that permits sprinkler piping to penetrate and be routed in townhouse common walls. This can reduce sprinkler installation costs by allowing a single water supply for multiple sprinkler systems in a townhouse building, and by allowing sidewall sprinklers to be used as a means of improved coverage and avoid the need to install pipe in attic areas that might be subject to freezing.
    2. Reductions in minimum required water supply for firefighting, allowing for smaller water mains, and typically eliminating some fire hydrants.
    3. Somewhat unique to Virginia is an allowance in R310.1, Exception 1, which eliminates the IRC requirement to provide emergency escape and rescue openings for dwellings that are equipped with a fire sprinkler system. Accordingly, there is a significant design advantage with respect to allowing builders to used fixed glazing or windows that do not meet the minimum size and operability requirements of the IRC for escape openings. In addition, for townhouses, which typically have small fenced yards that may not easily connect to a public way, the elimination of escape and rescue openings can solve site layout issues by eliminating the need for accessways from yards to a public way. Additionally, eliminating escape window or door openings for basements deletes not only additional windows for sleeping rooms, but also the associated window well, escape ladder, fall protection for the window well opening and issues with sealing below-grade wall openings from water infiltration, and associated costs.
    4. Increased portion of roof area permitted to have solar panels (R324.6), which increases available solar generating capacity.
    5. Permissible area of a mezzanine increases from 1/3 of the floor area of the room with a mezzanine to 1/2 (R325.3). This permits increased design flexibility for a top-story mezzanine vs. having a 4th story in a townhouse, which falls out of the IRC scope and forces IBC compliance.
    6. Permissible enclosure of mezzanines in rooms not exceeding 2 stories above grade plane vs requiring openness to the room with walls not exceeding 36 inches in height (R325.5).

Many of these cost offsets relate to design options that are difficult to specifically quantify because they relate to unique architectural design features, such as the inclusion of mezzanines, or on local fire code requirements that are specific to individual jurisdictions. However, the cost offsets associated with permissible reductions in townhouse separations and unfinished basement floor-ceiling assemblies can be quantified.

To quantify these values, a calculation model was created using data from the Craftsman National Construction Estimator program. For the purpose of this submittal, four sample runs were performed on a sample townhouse using two wall types (back-to-back 1-hour walls in a non-sprinklered building vs. a staggered stud 1-hour wall in a sprinklered building) and two sprinkler installation costs ($1.50/sqft and $2.00/sqft). Although the NFPA published a report "Home Fire Sprinkler Cost Assessment – 2013" (attached) estimates a national average cost of $1.35/sqft installation costs, the Virginia model runs used costs of $1.50/sqft and $2.00/sqft in an effort to be reasonably conservative, even though townhouse sprinkler systems may cost less than NFPA's estimated costs because there is an economy of scale in townhouse communities.

The sample townhouse building contains five units that are three stories tall with a pitched roof and dimensions 20ft x 30ft x 10ft floor-to-floor. Summary sheets for each run with full documentation of the wall designs and costs are available. Cumulative results for the four runs provided below. Each run includes a national average cost and four additional data point multipliers for unique communities. The value modifiers are based on cumulative average cost adjustments for labor and materials recommended by the Craftsman estimator, intended to provide a reasonable representation of costs in different areas.

It should be noted that builders often claim that reductions in the fire resistance of wall assemblies are not realistic because the 2-hour assemblies are needed for control of sound transmission. However, research on Sound Transmission Classes (STCs) of various wall designs indicates that this is not accurate. STC ratings are a measure of the effectiveness of partitions in reducing airborne sound transmission, with higher numbers having better performance in resisting sound transmission. For reference, there is no minimum in the IRC, but optional IRC Appendix K recommends a minimum of 45. The IBC requires a minimum STC of 50 by design or 45 by field test.

For the purpose of this analysis, two different types of 1-hour rated wall assemblies were evaluated and compared to a back-to-back set of 1-hour wall assemblies, sometimes used as a permissible alternate to a listed 2-hour assembly. STCs for these walls are reported as follows:

· Base level staggered stud 1-hour wall (one layer of insulation, which could be increased to 50-52 with modifications) – STC 45-48

· Base level double stud 1-hour wall (insulation in each stud channel) – STC 57

· Back-to-back 1-hour walls sometimes used as a 2-hr substitute (STC can be increased by adding additional insulating material in the space between the inner wall membranes at additional cost. Empty air space between these inner membranes actually reduces sound performance, which is why the base wall STC is not at high-performance level) – STC 45

Other wall designs with higher STC ratings can be modeled upon request if wall construction details are provided. To put the cost results into perspective of a monthly mortgage payment, a calculation was performed to evaluate the net cost of a $2,000 price increase (the highest of costs in the four model runs) to a homeowner after reductions associated with homeowners insurance (assumed at 5% based on NAHB's insurance analysis for major carriers and which is a common reduction offered by insurers in many states for NFPA 13D protection) and income tax deductions (assumed at 24% Federal marginal rate and excluding Virginia income tax). Based on a review of online interest rates, properties and sample insurance rates, a mortgage value of $400,000 was selected at an interest rate of 4.25% and an annual homeowner's insurance cost of $1,500 for a property estimated at $500,000 value. Based on the highest-cost system from model runs and parameters described above, the net monthly payment for fire sprinklers is $1.23, or approximately $15/year. This is far less than even a minor fluctuation in interest rates that buyers may experience at any time.

Note that permit and plan review fees and time vary from jurisdiction to jurisdiction. Some jurisdictions do not require any plan review for residential fire sprinklers, which is consistent with the "developed pipe length" methodology prescribed in IRC Section P2904. Alternately, some jurisdictions use a flow test of the installed system in lieu of design plans and plan review, which requires a single onsite inspection that can be performed by a regular building or plumbing inspector when performing other on-site inspections.

With respect to maintenance, there is no mandatory maintenance required for typical residential sprinkler systems supplied by a public or private water service, other than not interfering with the system by closing valves, painting sprinklers, etc. Homeowners may choose to perform voluntary verification test for water flow alarms (which are not required by NFPA 13D or IRC P2904).

Specific cost model documentation will be provided separately since cdpVA would not support inclusion of tables in the reason statement.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
See reason statement. It is difficult to quantify net cost or savings because these are going to vary based on individual projects and the extent to which developers/builders take advantage of savings incentives to offset costs associated with sprinkler installation.

Resiliency Impact Statement: This proposal will increase Resiliency
See reason statement.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: RB313.1(3)-21

Discussion by Paul Messplay
Aug 18, 2022 12:07 UTC

Proponents: Robby Dawson, representing National Fire Protection Association (rdawson@nfpa.org) requests As Submitted

Commenter's Reason: The National Fire Protection Association has published the concept of the Fire and Life Safety Ecosystem, one of the components of this system is the adoption of the most current model building codes and safety standards. These national model consensus codes and standards are considered the least safe way to build any structure – residential or commercial. NFPA believes that anytime the model code is weakened, safety is compromised. To view more about the NFPA Fire and Life Safety Ecosystem, visit www.nfpa.org/ecosystem.
For this reason, NFPA is opposed to eliminating any provision of the IRC – specifically related to this proposal is residential sprinklers in one- and two-family dwellings – from the International Residential Code. While this provision has been removed from the IRC in Virginia since its inclusion in the model codes in 2006, safety advocates have continually tried to add this proven and affordable fire safety provision back into the Uniform Statewide Building Code. These efforts have been widely attended, however some of the challenges are new individuals entering the discussions and these groups having to re-hash time and time again many of the false and inaccurate impressions about these systems – all of which were dispelled at the national level when sprinklers were added to the IRC.

Additionally, the NFPA Fire and Life Safety Policy Institute has surveyed the home buying public. That research shows that, "86% of respondents reported that they felt confident that if they bought a newly construction home, it would meet the most up-to-date fire and electrical safety codes." (see attached NFPA Journal article for the details of the survey and results). Elimination of fire sprinklers from single family homes clearly does not meet the most up-to-date fire safety code.

While it is clear that smoke alarms have been a significant safety provision since their inclusion in the building codes, the fire environment has changed greatly over the years with the presence of synthetic and plastics. This has resulted much faster fire spread and faster flashover in homes, which means there I very little time to escape. The residents of homes are also changing. With an aging population, the challenge of hearing impairment, mobility challenges, and health issues only exacerbate the problem and make these basic life safety systems even more important.

The National Fire Protection Association believes the most appropriate proposal before ethe Board of Housing and Community Development is RB313.1(2)-21 submitted by Mr. Glenn Dean as this reverts the USBC to the national model code, which is also in place in Maryland, and should be approved As Submitted. However, in the spirit of compromise, and given the greater fire hazards present in townhomes, RB313.1-21 submitted by Mr. Andrew Milliken is a reasonable alternative given the cost savings associated with the trade offs of fire ratings, road widths, and required fire protection water required. Additionally, this (RB313.1(3)-21) proposal submitted by Mr. Jeff Shapiro has also been implemented in other states and would protect larger developments (those townhouse developments with more than 3 units per building) and would provide this basic fire protection to the occupants of these townhomes, and should be considered by the Board of Housing as a limited alternative to the model code.

The expressed opposition to any of these proposals seems to hinge on the affordability of homes. Given these provisions have been incorporated in the State of Maryland's building code, and without evidence from that state showing the negative impact to housing starts, growth, or affordability, this argument is without merit.

Bibliography: Resiliency will be increased for those units with sprinkler protection.

Cost Impact: The net effect of the public comment and code change proposal will not increase or decrease the cost of construction
Given the provided trade-offs in fire protection.

Discussion by Florin Moldovan
Jun 22, 2022 11:28 UTC

See attached floor modification discussed during the GSWG on June 14th.
Attachments: https://va.cdpaccess.com/proposal/1183/discuss/182/file/download/788/RB313.1%283%29-21%20Floor%20Modification.pdf
Discussion by Paul Messplay
Jun 6, 2022 12:44 UTC

Attached are public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.

Attachments:
https://va.cdpaccess.com/proposal/1183/discuss/146/file/download/734/HBAV%20Public%20Comment_Residential%20Fire%20Sprinklers%20%2805

RB313.1(3)-21 – Staff Summary

Proponent: Jeffrey Shapiro

Brief Description:

This proposal would require a P2904 or NFPA 13D compliant automatic sprinkler system for townhouses containing more than three townhouse units.

STUDY GROUP OR SUB-WORKGROUP INFORMATION.

The proposal was discussed during the May 17th meeting of the Residential Sprinklers Study Group. The discussions from this meeting lead to the proposal being amended to remove NFPA 13 and NFPA 13R systems as permissible design standards for automatic sprinkler systems. The proponent would prefer to strike the Virginia amendments to R313.1, R313.1.1, and R313.2 entirely to have Virginia's code align with the model code, but provided this proposal as a compromise and an incremental step to work toward that goal.

Residential Sprinklers Study Group members in attendance:

- Andrew Clark: Home Builders Association of Virginia (HBAV)
- Keith Johnson: Virginia Fire Chiefs Association; Virginia Fire Services Board
- Mike Nannery: Local Utility Department (Chesterfield County)
- Ron Clements: Virginia Building and Code Officials Association (VBCOA)
- Jason Laws (Alternate for Mike Eutsey): Virginia Building and Code Officials Association (VBCOA)
- Jimmy Csizmadia: Virginia Fire Prevention Association (VFPA)

Residential Sprinklers Study Group members not in attendance:

- Garrett Dyer: Virginia Department of Fire Programs (VDFP), State Fire Marshal's Office (SFMO)
- Mike Poole: American Institute of Architects – Virginia Chapter (AIA-VA)
- Mike Eutsey: VBCOA
- Reid Walters: Local Government – General (Town of Independence)
- Robbie McCraw: Local Government - Elected Official (Carroll County)
- Meredith Raetz: Private Water Company (Virginia American Water)
- Overton McGehee: Affordable Housing (Habitat for Humanity)
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Dan Willham, Fairfax County; Andrew Milliken, Virginia Fire Services Board

- Dan Willham, representing Fairfax County, expressed support for the proposal and indicated that they think this is a very measured approach.

- Andrew Milliken, VFSB, stated that the VFSB Codes and Standards Committee reviewed the proposal, they see it as a reasonable compromise and are definitely in support of it.

Opposition:

Names: Andrew Clark, HBAV; David Beahm, Warren County; Paula Eubank, representing self.

- Andrew Clark, representing HBAV, stated that land development incentives would make for good discussions in the future and might be what moves the needle, especially with road widths. He opposed the proposal given the lack of those incentives in the proposal.
- David Beahm, Warren County, wanted to get on the record as opposing the proposal, as well as the other two proposals requiring the installation of sprinkler systems in townhouses and one- and two-family dwellings.
- Paula Eubank, representing self, wanted to get on the record for opposing the proposal while giving some credit for its more moderate approach.

DHCD Staff Notes:

- Please see attached Residential Sprinklers Study Group Final Report for additional information surrounding townhouse sprinkler systems.
- Please also see staff summaries for RB313.1-21 and RB313.1(2)-21.

Meeting summaries and proposal related information: Tab 10 - Page 98; Tab 14: Residential Sprinklers Study Group Report; Tab 15 - Page 39.

May 31, 2022

Board of Housing and Community Development
1111 East Main Street
Suite 1400
Richmond, VA 23218

Subject: Opposition to Residential Fire Sprinkler Proposals: RB313.1-21, RB313.1(2)-21, and RB313.1(3)-21

Members of the Board of Housing and Community Development:

On behalf of the Home Builders Association of Virginia, I am writing to express our industry's opposition to the three code proposals to require residential fire sprinklers systems in new one- and two- family dwellings and townhomes.

Our industry shares the fire service professional's commitment to advancing building code requirements that ensure the health, safety, and welfare of all Virginians in their homes and apartments. That shared commitment has clearly yielded significant progress over the last 40 years: according to the National Fire Protection Association's most recent "Fire Loss in the United States" report, the 2020 estimates of the number of fires were 40% to 64% lower than in 1980 for most of the major incident type categories. Furthermore, the 2020 estimate of total fire deaths was 46% lower than in 1980, home fire deaths were 50% lower, deaths in one- or two-family home fires were 47% lower, and apartment fire deaths were 66% lower[1].

However, the Home Builders Association of Virginia and our members are equally as committed to addressing a crisis which has become *so* entrenched in our Commonwealth that it has remained unaddressed, but not unnoticed, for decades and could arguably have greater short-term and long-term impacts on public safety *and* our local, regional, state and national economies, if left alone: housing affordability. While the objective of the fire sprinkler proposals is certainly laudable, the Home Builders Association of Virginia believes that further advancements in residential fire safety could be accomplished through code requirements – and other initiatives – that are less burdensome on homebuyer's and renter's budgets.

As you know, communities across the country are grappling with the effects of a housing affordability crisis. Over the past three decades, the proliferation of local and state regulatory barriers to new residential development has limited the industry's ability to deliver new units to the market, resulting in a supply-demand imbalance which is widely viewed as a primary driver of rapidly escalating home prices and rents[2].

Unfortunately, Virginia has not been immune to these challenges. Our members often hear from local government officials and community organizations about the growing need for housing that is attainable for households at the lower to middle end of the income spectrum – which is validated by virtually every home

[1] National Fire Protection Association: Fire Loss in the United States During 2020
[2] White House Housing Development Toolkit (2016)

builder's and developer's internal analysis of local and regional housing markets. In partnership with local government officials, our members work to identify and remove locally-enacted impediments to new residential development and propose policy changes to alleviate some of the primary drivers of cost during the land development and construction process.

Although modest progress has been made, a comprehensive report released by the Joint Legislative Audit and Review Commission (JLARC) in 2021 confirms that there is much more work to be done.

JLARC's analysis found that housing costs have been rising in every region of the Commonwealth, "…leading to increased housing instability for Virginians."[3] The report also found nearly 30% of Virginia households (905,000) were "housing cost burdened" in 2019, meaning they spend more than 30% of the income on housing costs, which is the widely accepted threshold where housing costs begin negatively impacting the household's ability to make other necessary expenditures. Furthermore, in just one-year, median home sales prices in Virginia rose between 10% and 41% (see figure below).

	Median home sales prices			Percentage change	
	2016	2020	2021	2016 to 2021	2020 to 2021
Northern Virginia	$508,000	$582,000	$650,000	28%	12%
Charlottesville	290,000	319,000	350,000	21	10
Hampton Roads	254,000	234,000	330,000	30	41
Northern Neck	267,000	270,000	325,000	22	20
Central Virginia	210,000	257,000	299,000	42	16
Valley	233,000	241,000	285,000	22	18
Southwest/New River Valley	192,000	196,000	217,000	13	11
Southside	125,000	134,000	177,000	42	32
Far Southwest	98,000	117,000	160,000	63	37
Statewide	$204,000	$234,000	$270,000	32%	15%

SOURCE: JLARC analysis of Monthly Median Sales Prices by County/Independent City, 2016 – present. Virginia REALTORS, updated July 15, 2021.

NOTE: Median cost home sales prices reflect the median prices in July of each year. Adjusted to 2021 dollars.

In short, Virginians are struggling to find affordable homes to purchase or rent – and the three residential fire sprinkler proposals before the Board will add substantially to the cost of housing ***for consumers***, further exacerbating a concern raised in the JLARC report: "Low- and middle-income households may have incomes that could support mortgage payments but lack the savings to cover the upfront costs of purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes."

Residential sprinkler advocates often cite data from the Fire Protection Research Foundation, which shows an average cost of roughly $6,000 to install fire sprinklers. While many home builders in Virginia believe that to be an extremely conservative estimate, if it were assumed to be accurate, it ignores the reality that many Virginians cannot bear thousands of dollars in additional cost. Nationally, a $1,000 increase in the cost of a median-priced new home pushes 117,932 households out of the market. Based on their incomes and standard underwriting criteria, these households would be able to qualify for a mortgage to purchase the home before the price

[3] Joint Legislative Audit and Review Commission Report: Affordable Housing in Virginia

increase, but not afterward. In Virginia, a $1,000 increase in the cost of a home pushes 3,871 households out of the market[4].

Furthermore, the cost estimates from the Fire Protection Research Foundation do not include the cost of increasing the size of a structure's water meter from ¾" or 5/8" to 1" to accommodate the residential fire sprinkler system. Increasing the water meter size, in many localities, results in a significantly higher per-unit water connection or availability fee. The Home Builders Association of Virginia surveyed localities across the Commonwealth to determine to magnitude of the fee increase and found increases ranging from several hundred dollars to over $13,000 per unit.

Although residential sprinkler advocates in Virginia dispute this claim, the issue of water connection fees has garnered the attention of legislators in California after fire marshals across the state reported very broad and disproportionate fee schedules for residential fire sprinklers from jurisdictions. Data collected by the California Residential Water Purveyor and Fire Sprinkler Task Force in 2021 showed that localities were requiring 1" water meters for residential structures and that residential fire sprinkler hook-ups could range in cost from $3,000 per house up to over $60,000 per house.

Additionally, cost estimates from residential sprinkler advocates often overlook two additional "tangible" costs, and one "intangible" cost.

First, in some communities where the static pressure of surrounding waterlines is insufficient, it will be necessary to install a booster pump to provide enough pressure for an effective fire suppression system. Home builders in several regions of the Commonwealth provided cost estimates of $1,260 to $2,600 for these systems.

Second, although NFPA 13D does not itself require the installation of a backflow prevention device, the National Fire Protection Association agrees that many municipal water authorities in Virginia and across the country ***require*** the devices to prevent contaminants from reaching drinking water[5], so it will be a cost borne by the consumer if these proposals are enacted. Home builders in Virginia have provided cost estimates ranging from $450 to $1,000 for these devices.

Lastly, NFPA 13D systems require the review and approval by the Authority Having Jurisdiction (AHJ), which has the potential to extend construction time and place additional burden on localities, many of which are currently struggling to employ enough plan reviewers to keep up with current construction activity levels.

Building code requirements should not be rejected outright because of associated costs to the consumer, however, it is essential for policy makers to weigh the effects of a building code proposal on the supply and access to housing for households across the income spectrum; and furthermore, identify other code requirements that may accomplish an identical public safety benefit through means that are less costly for the consumer.

Data from the National Fire Protection Association (NFPA) demonstrates that states *have* been successful in adopting building codes which are cost-effective for the consumer and result in a significant decrease in residential fires, injuries, and deaths. This includes innovations in building science such as advanced heating and electrical systems, egress windows, and fire-resistant materials and features. The proliferation – and continued improvement – in smoke alarm technology has also played a considerable role in advancing home fire safety. In

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[4] National Association of Home Builders – 2022"Priced Out" Report

[5] National Fire Protection Association: Common Questions on Home Fire Sprinkler Installations

fact, our analysis of a recent NFPA report indicates that educating homebuyers about the status and importance of their smoke alarm systems, as well as additional investments in free smoke alarm testing and replacement initiatives, would likely result in increased home fire safety and reduced home fire deaths[6].

Recognizing the ability to advance home fire safety in a manner that is cost-effective for consumers, states have overwhelmingly opted to *remove* the fire sprinkler mandates contained in the International Residential Code. Specifically, according to the National Fire Protection Association[7]:

- Only three states/regions require fire sprinklers in new, one- and two-family homes.
- The majority of states have enacted prohibitions on statewide and local adoption of fire sprinkler requirements for new one- and two-family homes.

Similarly, the vast majority of states have opted to not impose fire sprinkler mandates on townhomes[8]. This is due, in part, to the fact that many localities and housing advocates view townhome development as an important component of their strategy to increase the supply of affordable and "missing middle" housing[9], particularly as demand continues to rise among younger, first-time home buyers and seniors looking to downsize. This is validated by recent U.S. Census data, which shows that townhome construction jumped 28.1% in 2021 now make up nearly 13% of all single-family starts[10]. Several factors are contributing to this trend:

- **Construction Costs**: "In December, new residential construction input prices were up 15.1% over the year, a slightly more moderate pace compared to the month prior. Input prices for single-family construction were up 14.7%, while multifamily registered a 14.6% increase."
- **Lumber Costs**: "At the start of February, lumber futures contract prices fell below $1,000 per 1,000 board feet, which represents around a 25% decline from the $1,278 seen in January *but is still more than 100% above the lows registered at the end of August*." (Emphasis added)
- **Land Costs:** Developers, builders, and local government planners frequently cite increasing land costs as a significant factor impacting housing costs and supply. According to FHFA estimates, the median land value of a quarter-acre lot occupied by an existing single-family home was $163,500 in 2019, some 60 percent higher than in 2012. An analysis by the Harvard Joint Center for Housing Studies found significant increases in the price per acre land costs between 2012 and 2017 in many urban, suburban, and rural localities across Virginia, including Alexandria (21.4%), Lynchburg (15.5%), Fredericksburg (16.2%), King George County (42.7%), Rockingham County (37.5%), New Kent County (41.4%), Henrico

[6] A 2021 report from the NFPA found that nearly 60% of home fire deaths were caused by fires in properties with no smoke alarms (41%) or in properties where the smoke alarms failed to operate (16%). In response, the Home Builders Association of Virginia (HBAV) worked to pass legislation (SB 607) during the 2022 General Assembly Session requiring "…a home inspection and the report on its findings include a determination of whether the home's smoke detectors are in "good working order," The HBAV also worked to introduce budget language to provide additional funding to the Virginia Department of Fire Programs to support local fire department's free smoke alarm testing and replacement programs. The budget language was ultimately not adopted, but the HBAV will continue pursuing that initiative

[7] National Fire Protection Association: Fire Sprinkler Requirements, State by State

[8] National Association of Home Builders – Fire Sprinkler Mandates, State By State

[9] "Missing Middle" is a term that refers to the range of housing types that fit between single-family detached homes and mid-to-high-rise apartment buildings. Used in this context, "middle" references the size and type of a home, and its relative location – in the middle – on a spectrum of housing types.

[10] National Association of Home Builders – Townhouse Construction Surged in 2021

County (13.6%), Prince William County (43.4%), Stafford County (26.8%), Spotsylvania County (14.2%), and others[11].

The higher density, reduced setbacks and buffers, and smaller building footprints typically associated with townhome development allows for a more efficient use of land and can significantly reduce construction costs, which ultimately benefits consumers through lower sales prices and rents. Imposing this mandate would significantly hinder the ability for townhomes to be an effective tool in combatting the persistent housing affordability crisis in the Commonwealth.

In conclusion, a growing share of Americans say that access to affordable housing is a major problem in their communities. Earlier this year, the Pew Research Center found that 49% of Americans say availability of affordable housing in their local community is a major problem, up 10 percentage points from early 2018. The survey also found that the issue is particularly acute for both younger and older Americans: 55% of adults under the age of 30 now say this is a major problem – a 16 percentage point rise from the 39% who said so in 2018. Additionally, the share of adults ages 30 to 49 who hold this view has risen from 42% in 2018 to 55% last year[12]. There is no question that home fire safety is an important issue, as well. However, decades of data and experience has proven that states have enacted building code requirements that keep individuals and families safe in their homes while not reducing the affordability and availability of housing.

We respectfully request that you oppose these three proposals. Thank you in advance for your consideration and please do not hesitate to contact our office if you have any questions.

Sincerely,

Andrew Clark
Vice President of Government Affairs
Home Builders Association of Virginia

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[11] Harvard Joint Center for Housing Studies: https://www.jchs.harvard.edu/son-2019-land-prices-map

[12] Pew Research Center (January 18, 2022): A growing share of Americans say affordable housing is a major problem where they live

RB313.1(3)-21 Floor Modification

VRC: R313.1, R313.1.1

Proponents:

Jeffrey Shapiro (jeff.shapiro@intlcodeconsultants.com)

2018 Virgina Residential Code

Revise as follows:

R313.1 Townhouse automatic fire sprinkler systems.
An automatic sprinkler system shall be installed in townhouses.

Exceptions:

1. *Townhouses* containing no more than three *townhouse units.*
2. An automatic sprinkler system shall not be required when additions or alterations are made to existing *townhouses* that do not have an automatic sprinkler system installed.

R313.1.1 Design and installation.
Automatic sprinkler systems for *townhouses* shall be designed and installed in accordance with Section P2904 or ~~NFPA 13D, 13, or 13R.~~ NFPA 13D.

NOTE: the underlined and strikethrough text identifies changes to the cdpVA proposal.

REC-R402.1.2 (1)-21

Proponents: Laura Baker (laura@reca-codes.com); Eric Lacey (eric@reca-codes.com)

2018 Virginia Energy Conservation Code

Revise as follows:

TABLE R402.1.2 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT [a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR [b]	SKYLIGHT [b] *U*-FACTOR	GLAZED FENESTRATION SHGC [b, e]	CEILING R-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE [i]	FLOOR *R*-VALUE	BASEMENT [c] WALL *R*-VALUE	SLAB [d] *R*-VALUE & DEPTH	CRAWL SPACE [c] WALL *R* VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.30	0.55	0.25	38	20 or 13 + 5 ci or 0 + 15ci [h]	8/13	19	5/13 [f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	30 or 20 + 5ci or 13 + 10ci or 0 + 20ci ~~15 or 13+1~~ [h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	30 or 20 + 5ci or 13 + 5 ci or 0 + 20ci [h]	13/17	30 [g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20+5 [h] or 13+10 [h]	15/20	30 [g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20+5 [h] or 13+10 [h]	19/21	38 [g]	15/19	10, 4 ft	15/19

NR = Not Required.

For SI: 1 foot = 304.8 mm.

a. R-values are minimums. U-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed R-value of the insulation shall be not less than the R-value specified in the table.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.

Exception: In Climate Zones 1 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.

c. “10/13” means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation on the interior of the basement wall.

“15/19” means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. Alternatively, compliance with “15/19” shall be R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home.

d. R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation *R*-value for slabs. as indicated in the table. The slab edge insulation for heated slabs shall not be required to extend below the slab.

e. There are no SHGC requirements in the Marine Zone.

f. Basement wall insulation is not required in warm-humid locations as defined by Figure R301.1 and Table R301.1.

g. Alternatively, insulation sufficient to fill the framing cavity and providing not less than an *R*-value of R-19.

h. The first value is cavity insulation, the second value is continuous insulation. Therefore, as an example, “13+5” means R-13 cavity insulation plus R-5 continuous insulation.

i. Mass walls shall be in accordance with Section R402.2.5. The second R-value applies where more than half of the insulation is on the interior of the mass wall.

TABLE R402.1.4 EQUIVALENT U-FACTORS [a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR [b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
1	0.50	0.75	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.084	0.165	0.064	0.360	0.477
3	0.32	0.55	0.030	0.060	0.098	0.047	0.091 [c]	0.136
4 except Marine	0.32	0.55	0.026	0.0~~79~~ 45	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.026	0.0~~60~~ 45	0.082	0.033	0.050	0.055
6	0.30	0.55	0.026	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	0.026	0.045	0.057	0.028	0.050	0.055

2018 Virgina Residential Code

Revise as follows:

TABLE N1102.1.2 (R402.1.2) INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
1	NR	0.75	0.25	30	13	¾	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13 + 5ci[h] or 0 + 15ci	8/13	19	5/13[f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	30 or 20 + 5ci or 13 + 10ci or 0 + 20ci ~~15 or 13 + 1~~[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	30 or 20 + 5ci or 13 + 10ci or 0 + 20ci~~5~~[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20 + 5[h] or 13 + 10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20 + 5[h] or 13 + 10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

For SI: 1 foot = 304.8 mm.

NR = Not Required.

a. *R*-values are minimums. *U*-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall be not less than the *R*-value specified in the table.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.

Exception: In Climate Zones 1 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.

c. “10/13” means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation on the interior of the basement wall. “15/19” means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation on the interior of the basement wall. Alternatively, compliance with “15/19” shall be R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home.

d. R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation *R*-value for slabs. as indicated in the table. The slab edge insulation for heated slabs shall not be required to extend below the slab.

e. There are no SHGC requirements in the Marine Zone.

f. Basement wall insulation shall not be required in warm-humid locations as defined by Figure N1101.7 and Table N1101.7.

g. Alternatively, insulation sufficient to fill the framing cavity providing not less than an *R*-value of R-19.

h. The first value is cavity insulation, the second value is continuous insulation. Therefore, as an example, “13+5” means R-13 cavity insulation plus R-5 continuous insulation.

i. Mass walls shall be in accordance with Section N1102.2.5. The second *R*-value applies where more than half of the insulation is on the interior of the mass wall.

TABLE N1102.1.4 (R402.1.4) EQUIVALENT U-FACTORS[a]

CLIMATE ZONE	FENESTRATION *U*- FACTOR	SKYLIGHT *U*- FACTOR	CEILING *U*- FACTOR	FRAME WALL *U*- FACTOR	MASS WALL *U*- FACTOR[b]	FLOOR *U*- FACTOR	BASEMENT WALL *U*- FACTOR	CRAWL SPACE WALL *U*- FACTOR
1	0.50	0.75	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.084	0.165	0.064	0.360	0.477
3	0.32	0.55	0.030	0.060	0.098	0.047	0.091[c]	0.136
4 except Marine	0.32	0.55	0.026	~~0.079~~ 0.045	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.026	~~0.060~~ 0.045	0.082	0.033	0.050	0.055
6	0.30	0.55	0.026	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	0.026	0.045	0.057	0.028	0.050	0.055

a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.

b. Mass walls shall be in accordance with Section N1102.2.5. Where more than half the insulation is on the interior, the mass wall *U*-factors shall not exceed 0.17 in Climate Zone 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.

c. In warm-humid locations as defined by Figure N1101.7 and Table N1101.7, the basement wall *U*-factor shall not exceed 0.360.

2018 Virginia Construction Code

Revise as follows:

1301.1.1.1 Changes to the International Energy Conservation Code (IECC). The following changes shall be made to the IECC:

~~18. Change the wood frame wall *R*-value categories for Climate Zone 4 (Except Marine) in Table R402.1.2 to read:~~

~~19. Change the frame wall *U*-factor categories for Climate Zone 4 (Except Marine) in Table R402.1.4 to read:~~

~~TABLE R402.1.2 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]~~

~~CLIMATE ZONE~~	~~WOOD FRAME WALL *R*-VALUE~~
~~4 except Marine~~	~~15 or 13 + 1[h]~~

~~TABLE R402.1.4 EQUIVALENT U-FACTORS[a]~~

~~CLIMATE ZONE~~	~~FRAME WALL *U*-FACTOR~~
~~4 except Marine~~	~~0.079~~

Reason Statement: This proposal improves the comfort, efficiency, and resiliency of Virginia homes by improving the wall insulation requirements. It will also make Virginia's energy code consistent with the 2021 IECC requirements for wall insulation. The U.S. DOE found the 2021 IECC to be cost-effective for Virginia (*see* https://www.energycodes.gov/sites/default/files/2021-07/VirginiaResidentialCostEffectiveness_2021.pdf), and improvements to the thermal building envelope are important to the long-term efficiency and cost-effectiveness of new buildings. Using the U.S. Department of Energy methodology for reviewing code change proposals, and using BEopt modeling software, our analysis found that an improvement from R-15 to R-20+5 in wall insulation will result in a 13.1% improvement in efficiency, and a simple payback period of less than 5 years. Wall insulation is easiest (and most cost-effective) to install during construction. Given that there may only be limited opportunities to upgrade the walls in the future, it is important to construct well-insulated walls from the very beginning. Better-insulated buildings are clearly an investment in Virginia's energy future. We recommend maintaining consistency with the 2021 IECC requirements.
The wall insulation R-values in the 2021 IECC do not require the use of any specific product and can be achieved with either 2X4 or 2X6 wall construction. The values in the prescriptive R-value table are only a few of many different options. For additional wall insulation options, builders can use one of several compliance paths, each of which provides multiple options and combinations for meeting the code requirements:

- The U-factor alternative table (R402.1.2)
- The Total UA Alternative (R402.1.5)
- U.S. DOE's REScheck software (www.energycodes.gov)
- The Simulated Performance Alternative (R405)
- The Energy Rating Index (R406)

This proposal also updates the equivalent U-factors to be consistent with the 2021 IRC/IECC, which is important for builders and design professionals who intend to use DOE's free REScheck compliance software or other energy rating programs. We recommend that Virginia adopt equivalent U-factor values that will be consistent with the latest version of the IECC, both to maximize cost-effective energy efficiency and to improve the resiliency of every new home built in the Commonwealth.

Cost Impact: The code change proposal will increase the cost of construction
The improvement in wall insulation will increase initial construction cost, but is clearly cost-effective to the homeowner. Using the U.S. Department of Energy methodology for evaluating code change proposals, and using BEopt modeling software, we estimated that the average incremental increase in cost for climate zone 4 is $735.00. The average improvement in energy cost savings is 13.1%, which means simple payback is achieved within 4.4 years, on average. Obviously, results will vary based on which compliance option is selected by the builder, unique characteristics of each building, and so on. But given that walls are unlikely to be altered over the expected 70-100 year useful lifetime of the building, wall insulation is a vitally important measure to incorporate at the time of construction.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal will increase resiliency in Virginia's residential buildings. The International Code Council published a white paper titled *The Important Role of Energy Codes in Achieving Resilience* regarding the role of energy efficiency in resiliency. *See* https://www.iccsafe.org/wp-content/uploads/19-18078_GR_ANCR_IECC_Resilience_White_Paper_BRO_Final_midres.pdf. Specifically, the ICC found that increased insulation requirements support passive survivability and reduce energy burdens on low-income families, grid impacts by reducing energy demand, ice-dams, and condensation, limiting mold and mildew.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐Approved
☐Approved with Modifications
☐Carryover
☐Disapproved
☐None

Public Comments for: REC-R402.1.2 (1)-21

Discussion by Richard Potts
Jun 3, 2022 23:34 UTC

Attached are two public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.
Attachments:
https://va.cdpaccess.com/proposal/926/discuss/139/file/download/722/HBAV_DoE%20Data%20on%20New%20Construction%20EE%20Improvement
https://va.cdpaccess.com/proposal/926/discuss/139/file/download/721/HBAV_Clarifying%20ACEEE%20Report%20on%20Virginia%27s%20Residentia

Discussion by Ross Shearer
Feb 9, 2022 20:31 UTC

Virginia is now two iterations behind the IECC residential model for wall R values. Walls comprise a majority share of the above grade exposed surface of residential buildings.

Comment by Ross Shearer
Feb 9, 2022 22:31 UTC

Virginia is currently at the 2009 code for walls: R-13 insulation in the cavities of a 3 by 5 stud wall structure. This framing and insulating approach has been the custom since the 70s with the R-13 rating since 1990. (A change in the process of manufacturing fiberglass increased from R-11 to R-13 the resistance to heat movement in 3.5 inches of fiberglass.) Builders did not have to change their wall structures or insulation practices in 1990 or in 2009 when Virginia adopted the 2009 IECC model. It appears they have not had to change their practices since the mid 70s. After nearly one-half century's passage, change is way overdue, and Virginians deserve full adoption of the 2021 IECC residential wall model.

Laura Baker and Eric Lacey have provided information from a study showing that adoption of the IECC model wall provisions will yield at least 13% in energy savings, capable of recouping the added construction costs of meeting this requirement within less than 5 years, a return on investment rate that is significantly better than the long term average of securities markets. Denying these savings to future homeowners (and tenants) over the period of homeownership (and the 70 to 100 year life of houses) should be unacceptable to all. In addition to these material benefits, full adoption of this efficiency standard offers other less tangible, but valuable benefits including increased resiliency during lengthy utility outages and lower mortgage default rates. All these factors contribute to stabilization of families and neighborhoods during utility outages and economic recessions.

For those who have reservations about the results of a study obtained by those advocating for responsible energy codes, the DHCD should request a similar analysis from the Pacific Northwest National Lab. If requested by DHCD, **PNNL will run its data to compare Virginia's current residential code to Virginia adopting only the 2021 requirements for above grade walls as proposed.** PNNL indicated to me that "We would be able to analyze the codes in any form as they are adopted/modified. We typically analyze the entire code and not just portions of the code. So we would compare any stock code year to a modified code, wall changes only, or any change."

I urge all stakeholders to support this highly cost effective code change. For any stakeholders harboring reservations about the effectiveness claimed, I ask those stakeholders support a request by DHCD for a specific wall insulation analysis by PNNL, as I state above in bold.

REC-R402.1.2 (1)-21 & REC-R402.1.2 (2)-21 – Staff Summary

Proponent:

- REC-R402.1.2 (1)-21**:** Laura Baker, Responsible Energy Codes Alliance; Eric Lacey, Responsible Energy Codes Alliance
- REC-R402.1.2 (2)-21: William Penniman, Sierra Club – Virginia Chapter

Brief Description:

The proposals increase the insulation R-values (and reduce U-factors) to be consistent with the 2021 International Energy Conservation Code (IECC).

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposals were on the Agenda for the Energy Sub-Workgroup meeting on May 12, 2022, but the proponents requested for the proposals to be carried over to the next Energy SWG so that stakeholders can meet offline and explore potential areas of agreement.

The proposals were discussed by the Energy Sub-Workgroup at their May 19, 2022 meeting, but with obvious opposition, an official vote to determine the Sub-Workgroup's position on the proposals was not taken.

Supporting comments from Energy Sub-Workgroup members:

- William Penniman, Sierra Club, expressed support for the proposal and agreed with the proponent in that Virginia is behind and this would catch up to the 2021 IECC.

Opposing comments from Energy Sub-Workgroup members:

- Andrew Clark, HBAV, shared that this is one of the energy proposals that garnered the most concern from the home builders industry. There's a cost increase estimate in the proposal of about $735, but builders think it's more like $10-15k. The need to redesign existing home designs is a secondary concern. Department of Energy data shows that homes built after 2000 are affordable for people and the energy cost burden is not on them. This proposal would be costly.

Statements from other stakeholders in support of the proposal:

- Ben Rabe (New Buildings Institute) opined that homes would be energy efficient for lower-income people to purchase down the road.

Energy Sub-Workgroup members in attendance:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
- K.C. Bleile: Viridiant

- William (Bill) Penniman: Sierra Club – Virginia chapter

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club; Dan Willham, Fairfax County; Chelsea Harnish, Virginia Energy Efficiency Council (VAEEC).

- William Penniman, Sierra Club, expressed support for the proposal and noted that there has been an attempt to bring this change for many cycles, and the home builders consistently oppose. He likes the idea of phasing things in, which is what the IECC has done, but Virginia has fallen behind. In response to some of the opposing comments below, he noted that the proposal does not require the use of 2X6 lumber and it is related to wall insulation requirements only and not to the HVAC systems. Maryland has been doing this and they build affordable housing. He argued that the proposal would save money and reduce pollution. Prices go up and down all the time, the price of gas and electricity has also gone up and energy efficiency would save on energy bills.
- Dan Willham, Fairfax County, expressed support for the proposal and opined that it is long overdue in Virginia as we've been debating this issue for several code development cycles. In response to some of the opposing comments below, he agreed with William Penniman that 2x6 wall studs are not required by this proposal as 2x4 studs with continuous insulation could be used instead. Also, if 2x6 studs are used, the stud spacing can be reduced, thus using less studs. He disagreed with the HVAC cost increase mentioned by the opposition, and argued that the improved energy efficiency resulting from complying with this proposal could actually reduce the size and cost of the HVAC system.
- Chelsea Harnish, VAEEC, recorded their support for the proposal in the Adobe Platform Chat box.

Opposition:

Names: Andrew Clark, HBAV; Christopher Fox, Van Metre; John Olivieri, HBAV – Virginia Beach.

- Andrew Clark, HBAV, indicated that his comments to the proposal discussed immediately prior [EC-C1301.1.1.1(2)-21], are applicable for this proposal as well. Said comments highlighted that the proposal would add a significant cost to housing for the consumer. Virginia has an almost perfect score on residential and commercial energy efficiency in the ACEEE report. When the ACEEE report is broken down, utility programs and transportation policy brings the Virginia score down. The score is better for building and energy codes. The DOE data shows that most cost burden is found under 30% AMI. Adding up-front costs are not going to help anyone over the next few decades, when they can't afford to purchase the home.
- Christopher Fox, Van Metre, identified several changes that the proposal would cause. There would be over 48 lumber products that would need to be changed, which would require a master file design change and that is a considerable amount of work. Having to use 2x6 exterior studs would either add 3 inches to the footprint of the house, or it would remove 3 inches from the interior, habitable space of the house. Changing from 2x4 to 2x6 lumber would be difficult because the lumber is not readily available, and is more costly. It would cost about $10k more per house to comply with this proposal.
- John Olivieri, HBAV – Virginia Beach, shared that he has been building affordable housing for many years, but this proposal would basically kill affordable housing. He estimated the costs of complying with these provisions to be between $10-18k. It does not matter how much money could be saved on energy bills if people cannot afford to buy the house to begin with. Some of the upgrades needed would never allow for recuperating the costs. He gave the example of an HVAC upgraded unit, which has a lifespan of maybe twelve years. If it costs $5k for the upgraded unit, the money would never be recuperated. There are diminishing returns. Also, some of the products required are extremely difficult to get today. He gave the example of sprayed foam insulation – a petroleum base product, which was on allocation at the time of the meeting. He opined that Virginia has done a great job of phasing in these energy improvements over the years, without doing it all at ones.

DHCD Staff Notes: REC-R402.1.2(1)-21 & REC-R402.1.2(2)-21 are almost identical proposals but with different proponents and reason statements. The summary included above reflects discussions around REC-R402.1.2(1)-21 but applies to both proposals as supporters and opponents of REC-R402.1.2 (2)-21 rested on the statements made during REC-R402.1.2(1)-21 discussions.

Meeting summaries and proposal related information: Tab 10 - Page 42; Tab 10 - Page 80; Tab 11 - Page 6; Tab 11 - Page 29; Tab 11 - Page 33; Tab 11 - Page 40.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

Clarifying the *American Council for an Energy-Efficient Economy's* Report on Virginia's Energy Policy and Building Codes

The American Council for an Energy-Efficient Economy (ACEEE) periodically releases a report ranking each state's energy efficiency policies and programs. This report is *widely* cited by energy efficiency stakeholders as justification for additional advancements in Virginia's energy codes – particularly, the report's ranking of Virginia as 25th in the country for energy efficiency[1].

Although the Home Builders Association of Virginia has partnered with these stakeholders during the 2015 and 2018 code cycles (which resulted in several significant advancements) and has continued to do so during the 2021 cycle, we felt it important to clarify the ACEEE's findings on Virginia's energy codes.

While the ACEEE report is a helpful resource for policymakers and regulatory boards, a state's ***overall ranking*** in the report is not particularly informative when evaluating the "strength" or "weakness" of a state's residential and commercial energy codes or specific energy code proposals. A deeper analysis of the ACEEE report shows that Virginia's ***overall ranking*** distorts the fact that Virginia receives extremely high scores for residential and commercial energy codes.

Virginia loses nearly half (24.5 points) of its points in categories *unrelated* to building codes

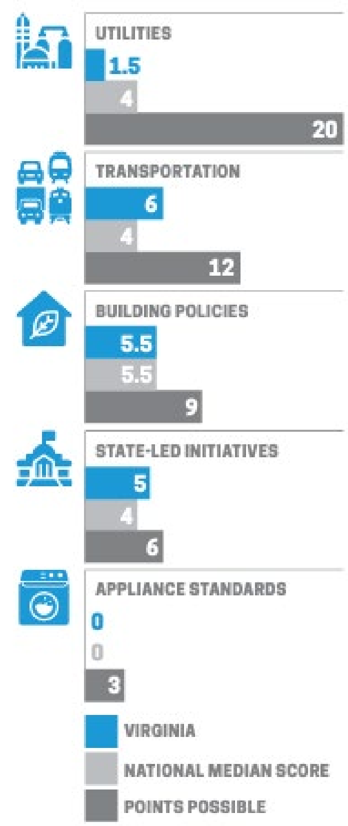
The ACEEE report ranks states based on five categories: (i) utility and public benefits programs and policies; (ii) transportation policies; (iii) building energy efficiency policies; (iv) state government initiatives; (v) appliance efficiency standards.

A state can only earn a certain number of points in each category:

- Utility and public benefits programs and policies (20 pts)
- Transportation policies (12 pts)
- Building energy efficiency policies (9 pts)
- State government initiatives (6 pts)
- Appliance efficiency standards (3 pts)

In the ACEEE's most recent report (2020), Virginia earned 18 out of 50 points – which is 25th in the nation.

However, a deeper analysis of the ACEEE's findings shows that Virginia lost nearly 50% of its points (24.5) in categories that are *unrelated* to energy efficiency building codes. Specifically, Virginia only earned 1.5 out of 20 pts for "Utility and Public Benefits Programs and Policies" and only received 6 out of 12 points for "Transportation Policies". *(See figure to the right)*



Due to the report's scoring system, it is inaccurate to claim that Virginia's 25th-in-the-Nation ranking in this report is the result of the Commonwealth's "weak energy code".

[1] American Council for an Energy-Efficient Economy – 2020 State Energy Efficiency Scorecard

Virginia receives a near-perfect score for residential code stringency and perfect score for commercial code stringency.

In the "Building Energy Efficiency Policy" category, Virginia receives 5.5 out of 9 points – by comparison, Virginia is only .5 points behind Maryland and 2 points behind California, which are the two states most frequently described by energy efficiency stakeholders as "leaders" in energy efficiency.

The "Building Energy Efficiency Policy" category consists of 8 sub-categories, including "residential code stringency" and "commercial code stringency". Contrary to statements made during several sub-workgroup and workgroup meetings, Virginia receives a near perfect score for "residential energy efficiency" (1.5 points out of 2) and a perfect score for "commercial energy efficiency" (2 points out of 2).

It is HBAV's understanding that these rankings were determined while Virginia was in the middle of the last code development cycle. While Virginia received exemplary scores for residential and commercial energy code stringency in ACEEE's report, the rankings only reflect a *portion* of the progress which was made in Virginia's energy codes during the last code cycle. During the last code cycle, the Home Builders Association of Virginia and other organizations reached consensus with energy efficiency stakeholders on several proposals, including:

1. Removed visual option for verifying building envelope air tightness and required blower door testing for all new residential buildings. Also added requirement that all new homes pass the blower door test with 5 air changes per hour;
2. Require an "energy certificate" in all new residential buildings to inform current and future homeowners about the key energy characteristics of their home;
3. Increase minimum ceiling insulation requirements (R-38 to R-49) for all new residential buildings;
4. ResCheck compliance updated to 2018 IECC, without Virginia amendments. Previously, a work around had been created for VA amendments that weakened the current IECC;
5. Increased fenestration requirements.

While the ACEEE has yet to release an updated report, it is highly likely that Virginia will receive further recognition for the full scope of energy efficiency code proposals that were adopted during the last code cycle – and possibly for the energy efficiency code proposals which are likely to be forwarded to the Board as "consensus" during the current code development cycle.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

U.S. Department of Energy Data Shows Significant Advancements in Residential Energy Efficiency and Reduction in Energy Cost Burdens in New Construction

"The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs."

Building code regulations were first established – and are continually revised – to ensure a *baseline standard* of quality, safety, and efficiency in new residential structures. For example, they provide assurance for consumers that they are residing in safe structures, guidelines for builders/design professionals as to what constitutes a safe and durable structure, and certainty for lenders of the value and quality of structure.

Similarly, energy efficiency standards were first adopted by the U.S. Housing and Home Finance Agency in the 1950's to address a concerning *public health and welfare* issue at the time: the rising number of mortgage defaults on federally insured loans on homes with high utility bills.

While increasing the efficiency of new residential structures is a laudable objective, it is critically important for policymakers to balance that objective with the growing concerns over the cost of housing in Virginia and the dramatic undersupply of housing that is attainable for households across the income spectrum. Furthermore, it is important for policymakers to distinguish between building code requirements that are essential to providing that baseline standard of quality, safety, and efficiency, and code requirements that are "aspirational".

Consumers can make a personal financial decision to purchase or build a home that is constructed to a higher energy efficiency standard, if that is an amenity that they are willing and able to afford. While energy efficiency requirements can reduce negative environmental externalities, promote high-quality housing stock, and protect consumers from soaring energy costs over time, the ability to afford the **upfront costs** of additional energy efficiency code requirements will vary widely by income.

The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs.

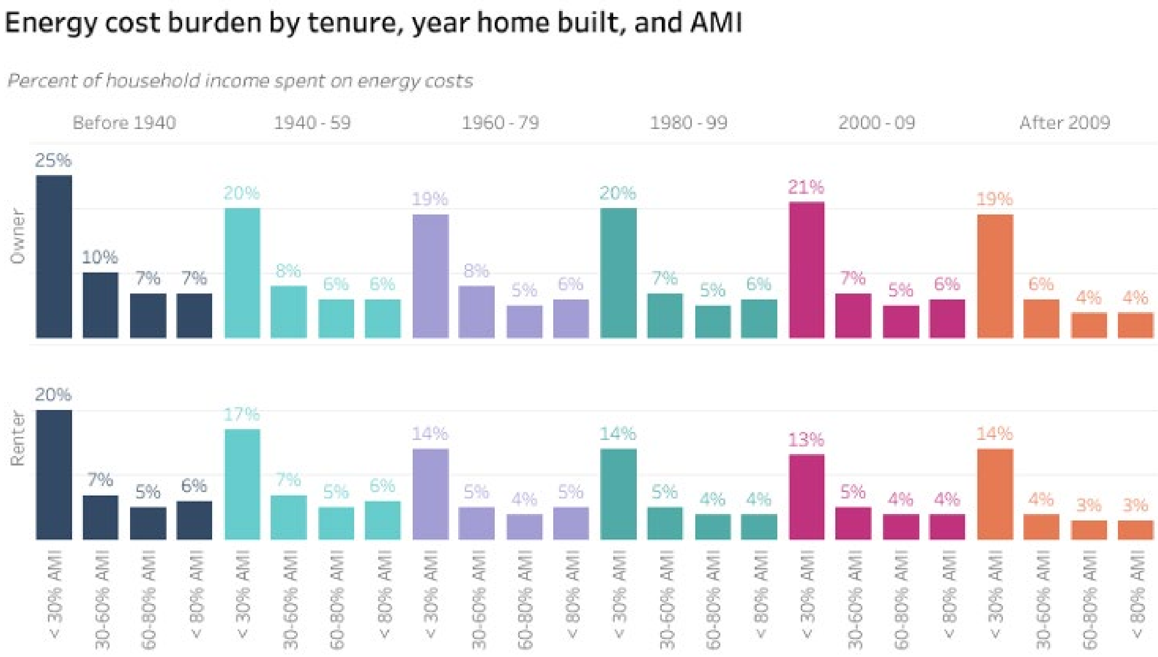
U.S. Department of Energy Data

Data from the U.S. Department of Energy's *Low-Income Energy Affordability Data (LEAD) Tool* validates the claim that Virginia *has* made vast improvements in residential energy efficiency over the last 80 years and has significantly reduced household energy costs to a level considered sustainable for individuals and families across the income spectrum.

A household is considered "energy cost burdened" when over 6% of the household income is dedicated to covering energy bills – this calculation includes all costs associated with energy used by the house (e.g., electricity and natural gas). When a household is "energy cost burdened", it impacts their ability to use electricity and heat or cool their home – and forces households to choose between paying utility bills, paying a mortgage or rent, or other essential expenses. In short, high energy cost burdens results in higher levels of housing instability, including evictions and foreclosures.

The chart below was compiled using data from the U.S. Department of Energy and included in a recent report released by Virginia Housing (formerly, Virginia Housing Development Authority) and the Department of Housing and Community Development[1].

[1] HB 854 Statewide Housing Study Report (January 2022)



Source: National Renewable Energy Laboratory, Low-Income Energy Affordability Data (LEAD) Tool, 2018.

The data from the U.S. Department of Energy (chart above) provides several important insights:

First, renters and owners residing in residential structures built since 2000 are below the 6% "energy cost burdened" threshold, with two exceptions: (i) Owner households in structures built between 2000 and 2009 are slightly over the 6% energy cost burdened threshold; (ii) Owners and renters with incomes below 30% of AMI residing in structures built between 2000 and 2019 are experiencing extremely high energy cost burdens. More analysis is needed to understand the latter - there are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Second, the highest "energy cost burdened" households (owner and renter) are residing in structures built prior to 1980's/1990's. The most "energy cost burdened" demographic – regardless of age of structure – are households earning under 30% AMI. Again, more analysis is needed to understand this dynamic. There are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Conclusion:

Data from the U.S. Department of Energy shows that residential structures constructed in the last 20 years are significantly more energy efficient than older homes, which has reduced household energy costs to levels considered sustainable for individuals and families across the income spectrum. The data also reflects the reality that efforts to reduce household energy cost burdens would be best focused on older, existing structures occupied by individuals and families at the lower end of the income spectrum.

Several energy proposals submitted during the 2021 code cycle seek to impose stricter energy efficiency requirements on all new homes, thus increasing the upfront cost of all new homes and exacerbating an issue raised by the Virginia Joint Legislative Audit and Review Commission's recent report on housing affordability: "Rising prices make it more difficult for low- and middle-income households to afford to purchase homes because of the increased monthly mortgage costs, as well as the increased upfront costs associated with purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes.[2]"

[2] Joint Legislative Audit and Review Commission: Affordable Housing in Virginia (2021)

REC-R402.1.2 (2)-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Energy Conservation Code

Revise as follows:

TABLE R402.1.2 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT [a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR [b]	SKYLIGHT [b] *U*-FACTOR	GLAZED FENESTRATION SHGC [b, e]	CEILING R-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE [i]	FLOOR *R*-VALUE	BASEMENT [c] WALL *R*-VALUE	SLAB [d] *R*-VALUE & DEPTH	CRAWL SPACE [c] WALL *R* VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13+5 or 0+15ci [h]	8/13	19	5/13 [f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	~~15 or 13+1~~ 30 or 20+5ci or 13+10ci or 20ci [h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	~~20 or 13+5~~30 or 20+5ci 13+10ci or 20ci [h]	13/17	30 [g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20+5 [h] or 13+10 [h]	15/20	30 [g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20+5 [h] or 13+10 [h]	19/21	38 [g]	15/19	10, 4 ft	15/19

NR = Not Required.

For SI: 1 foot = 304.8 mm.

a. R-values are minimums. U-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed R-value of the insulation shall be not less than the R-value specified in the table.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.

Exception: In Climate Zones 1 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.

c. “10/13” means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation on the interior of the basement wall.

“15/19” means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. Alternatively, compliance with “15/19” shall be R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home.

d. R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation *R*-value for slabs. as indicated in the table. The slab edge insulation for heated slabs shall not be required to extend below the slab.

e. There are no SHGC requirements in the Marine Zone.

f. Basement wall insulation is not required in warm-humid locations as defined by Figure R301.1 and Table R301.1.

g. Alternatively, insulation sufficient to fill the framing cavity and providing not less than an *R*-value of R-19.

h. The first value is cavity insulation, the second value is continuous insulation. Therefore, as an example, “13+5” means R-13 cavity insulation plus R-5 continuous insulation.

i. Mass walls shall be in accordance with Section R402.2.5. The second R-value applies where more than half of the insulation is on the interior of the mass wall.

TABLE R402.1.4 EQUIVALENT U-FACTORS [a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR [b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
1	0.50	0.75	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.084	0.165	0.064	0.360	0.477
3	0.32	0.55	0.030	0.060	0.098	0.047	0.091 [c]	0.136
4 except Marine	0.32	0.55	0.026	~~0.079~~ 0.045	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.026	~~0.060~~ 0.045	0.082	0.033	0.050	0.055
6	0.30	0.55	0.026	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	0.026	0.045	0.057	0.028	0.050	0.055

Reason Statement: The purpose of this proposal is to have Virginia adopt the full wall insulation efficiency requirements of the 2021 IECC. These updates are critical since Virginia is still implementing the 2009 wall insulation standards, making it a *more than a decade* behind the IECC. Continuing to lag years behind the IECC is inconsistent with Virginia law governing building codes. Sections 36-99A and 36-99B of the Virginia Code require the USBC to protect the public, to adhere to recognized standards of energy conservation and water conservation, and to reduce construction and rehabilitation costs only to the extent the results are consistent with the recognized code standards. ("The provisions of the Building Code and modifications thereof shall be such as to protect the health, safety and welfare of the residents of the Commonwealth, provided that buildings and structures should be permitted to be constructed, rehabilitated and maintained at the least possible cost consistent with recognized standards of health, safety, energy conservation and water conservation….") H2227, which was enacted in 2021, specifically calls for efficiency standards Virginia's code to be "at least as stringent" as the most current IECC.
Residents' welfare is plainly harmed by failing to adopt the 2021 IECC building efficiency standards. The incremental costs of construction are more than outweighed by the energy cost savings and other benefits to residents from tighter, more energy-efficient construction. The 2021 IECC incorporates wall insulation changes in addition to those made in the 2012 IECC. DOE/PNNL found, years ago, that the 2012 IECC would save residents money every year compared to the 2009 standards even considering the impacts of construction costs on residents' full occupancy costs.[1] In 2021, it found that updating to the 2021 IECC would save residents money compared to the 2012 IECC standards. Its findings support 2021 IECC compliance both nationally and for Virginia.[2] DOE/PNNL's lifecycle cost-benefit analysis considered all the costs of ownership, including the mortgage and tax impacts attributable to incremental construction costs and the savings from reduced energy usage.

Structural energy efficiency measures, including wall insulation, are extremely important in dwellings that have an expected life of 70 years or more.[3] They will benefit all residents whether owners or tenants. The ongoing burden of inefficient construction harms everyone, but it particularly harms low-income and moderate-income residents.[4]
Other benefits to residents from implementing the 2021 IECC envelope insulation (and leakage) standards include (a) health benefits, (b) added comfort, (c) greater resilience, and (d) avoidance of future need for more costly wall retrofits. The general public would also benefit from implementing the 2021 IECC envelope standards by (i) reducing climate harms from carbon pollution, (ii) reducing other health impacts from fossil fuel pollution, (iii) reducing overall utility bills by avoiding peak and annual fuel costs and minimizing facility construction costs.

It is vital to implement the IECC's envelope insulation standards during initial construction. The cost of *retrofitting* insulation in walls is much higher because it would require removing, replacing and refinishing walls. As a result, retrofitting to achieve the 2021 requirements for new construction is less likely to be undertaken. Indeed, the Base Document would continue a practice of not requiring any insulation upgrades unless walls are opened for some other purpose. Thus, residents and the public would suffer long-term harm from continuing to permit builders to under-insulate walls.
To make matters worse, the public and utility customers are paying for efficiency upgrades of some dwellings in order to offset poor efficiency in existing buildings. Virginia is on-course to spend over $1 billion, this decade, on improving energy efficiency primarily in existing dwellings--vastly more than it would have cost to build the housing well in the first place. There is no basis for assuming that utilities will continue to spend ratepayer money to make up for construction practices that are not "at least as stringent" as those in the latest IECC.
In sum, it would harm both residents and the public to continue implementing outdated building code standards that results from construction standards that are not at least as stringent as the 2021 IECC.
[1] DOE/PNNL, *National Energy Cost Savings for New Single and Multifamily Homes, A Comparison of the 2006, 2009, and 2012 Editions of the IECC*, https://www.energycodes.gov/sites/default/files/documents/NationalResidentialCostEffectiveness.pdf
[2] https://www.energycodes.gov/national-and-state-analysis
[3] Alliance to Save Energy, https://www.ase.org/buildings
[4] The VA Poverty Law Center reports that "On average Virginia households experience an already higher than average electricity burden of 3.1%, compared to a national average of 2.7%. 'Electricity burden' is the percentage amount of your household income that is spent on electricity costs. Financial advisors agree that an average of 6% for your entire energy burden is 'affordable.' Virginian's higher than average electricity burden is unaffordable for over 75% of Virginia's households." https://vplc.org/electricity-burden-and-the-myth-of-virginias-rate-utopia/

Cost Impact: The code change proposal will increase the cost of construction
Adopting these long-overdue energy saving measures will add marginally to construction costs, but will provide greater long-term savings to residents and mitigate costs to the public generally, as outlined in the Reason and Resliency Statements. DOE/PNNL calculate that implementing the 2021 IECC will save Virginia residents $8,376 on a lifecycle basis, with positive cash flow to residents annually. DOE/PNNL, *Cost-Effectiveness of the 2021 IECC for Residential Buildings in Virginia* (July 2021), https://www.energycodes.gov/national-and-state-analysis DOE/PNNL analysis showed that the 2012-2018 IECC standards, including for wall insulation, also would save residents thousands of dollars -- if Virginia had adopted them on a timely basis. DOE/PNNL, *National Energy Cost Savings for New Single and Multifamily Homes, A Comparison of the 2006, 2009, and 2012 Editions of the IECC*, https://www.energycodes.gov/sites/default/files/documents/NationalResidentialCostEffectiveness.pdf

In other words, residents will experience net annual and monthly costs savings for many years compared to living in dwellings built based on pre-2012 IECC standards. Since the benefits to residents from full compliance with the 2021 IECC clearly outweigh the incremental construction costs, the statutory standards to adopt standards "at least as stringent" as the 2021 IECC have been more than satisfied. (Although the data published by DOE/PNNL amply demonstrates that full compliance satisfies the statutory standards, more detailed data and analysis can be requested by DHCD from PNNL, if desired.)

Resiliency Impact Statement: This proposal will increase Resiliency
The proposed measures will help to enhance resiliency by protecting residents, reducing energy demand, helping to mitigate climate impacts and preparing Virginia's buildings and economy for a future that requires the least energy usage and energy-driven pollution possible.
Improving envelope efficiency will help residents and communities to withstand power outages from storms or other causes. During power outages, buildings with tighter, better insulated envelopes remain comfortable much longer because more efficient envelopes better maintain indoor heat in cold periods and indoor coolness in warm periods. Reducing demand through greater building efficiency will reduce burdens on utilities. That will help utilities to hold down operating and capital costs, in addition to helping them better cope with storms and other difficulties. All rate payers and the entire community benefits from this greater resilience and lower costs.

Reduced demand for energy will also mitigate climate change impacts. Climate change is already harming Virginia, and the harms will get much worse if we do not sharply reduce GHG emissions (particularly CO2 and methane). Growing climate dangers include harms to communities, infrastructure, people, property and the economy from rising seas, worsening storms and more severe rainfall events. These harms extend well beyond coastal communities. Growing dangers also include rising atmospheric and water temperatures that threaten worsening heat-related illnesses, limits on economic activity, agriculture, fisheries, and our natural heritage. The likelihood of mitigating and of recovering from those harms declines the longer we delay maximizing energy savings and minimizing GHG pollution. Sensible investments now in energy conserving measures will reduce future rehabilitation and adaptation costs, as well as future harms.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved

☐None

Public Comments for: REC-R402.1.2 (2)-21

Discussion by William Penniman
Jun 15, 2022 17:13 UTC

Wall Insulation Should be Brought up to the 2021 IECC – Wall insulation is critical to saving energy, reducing energy costs, and reducing air and climate pollution that results from excess energy consumption. Wall insulation covers much more area of a dwelling than attic insulation. Wall insulation is also extremely difficult to retrofit because retrofitting requires opening walls and then repairing them. Installing wall insulation is critically important when dwellings are constructed. Planning for and installing wall insulation that meets the latest IECC standards is feasible, economical and beneficial to initial and future residents and to the public.

Virginia is a decade behind the 2012 IECC with respect to wall insulation. That is unfortunate for residents and the public because wall insulation applies to most of a building's envelope and is critical to saving energy and energy costs.

- **The 2012 IECC** significantly raised the requirements for wall insulation and DOE/PNNL determined that the 2012 IECC improvements would save residents money during each year of occupancy and that the savings would exceed the increased costs of construction. DOE/PNNL's findings applied nationally and specifically for Virginia. **The 2021 IECC** again strengthened the requirements for wall insulation, and DOE/PNNL again determined that the 2021 IECC improvements will save residents money during each year of occupancy and that the savings would exceed the increased costs of construction. Again, DOE/PNNL's findings applied nationally and specifically for Virginia. It also found that there would be large public benefits from implementing the 2021 IECC, including from reducing energy-driven pollution that harms health and the climate.

- **The following table compares Virginia's existing code tied to the 2009 to the IECC standards for 2012-2018 and 2021 IECC with respect to the "prescriptive" wall insulation standards applicable to Climate Zone 4, which applied to the entire State prior to the 2021, and to Climate Zones 4, 5 and 3 which apply to different parts of Virginia in the 2021 IECC**. For the sake of illustration, it focuses on R-values for wood framed walls for the "prescriptive" implementation option in residential construction. (Under the IECC, builders can choose to achieve equivalent energy efficiency results under performance based options provided by the IECC.) It shows Virginia's R-value for CZ4 wall insulation is **far behind** 2021 IECC.

Code /Prescriptive R-Value:	CZ4	CZ5	CZ3
2021 IECC	R30 or 20&5ci or 13& 10ci or 0& 20ci	Same as CZ4	R20 or 13& 5ci or 0& 15ci
2012 - 2018 IECC	R.20 or R.15+5.	N/A	N/A
Virginia 2009-to date	R15 or 13+1 [h]	N/A	N/A

-The first value is cavity insulation; the second value is continuous insulation. Therefore, as an example, "13&5" means R-13 cavity insulation plus R-5 continuous insulation.
-"ci" means continuous insulation

Builders have made several arguments, in work groups, in opposition to efficiency improvements. None justifies failing to adopt standards "at least as stringent" as the latest IECC.

- As in the past, builders have opposed action saying Virginia should proceed "gradually" on wall insulation. However, they have blocked even gradual progress since 2009. In contrast, ***the IECC has proceeded gradually on wall insulation***: updating those standards in 2012 and, again, 3 cycles later, in 2021. It is time to catch up.

- Builders have incorrectly asserted that they would be forced to install 6-inch studs instead of the 4-inch studs. In fact, the 2021 and 2012 IECC "prescriptive standards" provide for compliance with either 4-inch or 6-inch studs, and the "performance" standards (e.g., ERI standards, RESCHECK, U-Factor standards) provide greater flexibility.

- Builders complain about having to redesign aspects of their products. However, builders have to undertake design adjustments every code cycle (and out of cycle) for many other reasons, few of which relate to the IECC. They have had a decade to adapt plans to the IECC standards called for by law and will have until 2024 to adapt if the Board acts.

- While there will be some construction cost increases (as there are with almost all code changes), they are outweighed by the energy cost savings and health benefits from using less energy, by the greater comfort that comes from a tighter house, and by the long-term benefits of reducing pollution and climate harms which are increasingly threatening Virginians. The cost increases will be partially offset by other construction savings, such as spacing 6-inch studs farther apart and potentially installing a smaller HVAC system.

- They warn against potential sales price increases, which have gone up for both existing and new homes, while ignoring the benefits to residents (both initial and future) from the efficiency improvements. The benefits of greater insulation begin in the first year of occupancy and continue to accrue over "over time" as the purchase costs are spread out by mortgages. They ignore that utility costs are the second largest cost of operating dwellings. The lifetime *net benefits* to residents have been documented by DOE/PNNL at over $5300 for the 2012 IECC (for Climate Zone 4 compared to 2009 IECC) and lifecyle savings averaging over $2000 for Climate Zones 3, 4 and 5 comparing the 2021 and 2018 IECC (which Virginia is behind). These benefits "over time" substantially exceed the incremental cost of construction.

- Contrary to builder advocates, adopting the IECC wall standards for new housing will not harm low-income people. With lower utility expenses, buyers may be able to buy "more" home, not less. Reducing occupancy costs through energy efficiency will make it easier to stay in dwellings while also paying rents and mortgages, even when energy prices spike. The annual savings from structural efficiency measures, like wall insulation, will continue for decades, extending to all future occupants, not just the first buyer.

- Efficiency standards for new construction are not going to leave anyone unhoused or leave builders unable to sell the homes they build. The incremental costs of better insulation are small compared to the cost of a new home, and they actually save money for residents. Rising home prices in Virginia are due to many factors (including builders' choices), not better insulation the standards for which have not changed in a decade in Virginia. In any event, new buyers have other housing choices; only a small fraction of new homes are built for the low-income market; and low-income buyers often have the benefit of financial supports, low-cost loans and other subsidies to buy those.

- NAHB reports that roughly 80% of home buyers want more efficient homes. Unfortunately, they depend on building codes to get it. Few are in the market for custom homes and fewer still understand the intricacies of what's hidden behind the wall. Reassurances that a building "meets code" should mean the IECC's national code, which is what most buyers assume.

- Retrofits of wall insulation are vastly more expensive than installing during initial construction. Failure to enhance wall insulation during initial construction means that the dwellings will probably consume excess energy and cause higher occupancy costs for the 70+ year life of the dwelling. The public often has to subsidize energy retrofits that are undertaken.

Opponents of efficiency improvements consistently ignore the public harms from energy-driven pollution and accelerating climate damage to Virginia and the U.S.

- Climate change is driving a growing number of crises, including flooding, fires, severe storms, heat-deaths and heat-illnesses, crop and forest damage, harm to wildlife, arrivals of new pests, disruption of supplies (e.g., lumber) and supply chains, national security threats (wars and rebellions over resources), mass migrations and immigration, etc.

- Virginia's coast is seeing extraordinary rates of sea level rise (potentially 2 feet by 2050), and the entire state is seeing higher temperatures, heavier precipitation events, and increasingly severe storms. These threaten people's health, outdoor employment, school schedules, supply chains (including lumber), agriculture, natural resources and the economy.

- Making matters worse, the heat trapping gases released today and during the lives of new buildings will harm the climate and the public for centuries. Energy efficiency is the first line of defense against climate change, energy pollution and energy costs.

Meeting the full IECC complies with Virginia's legal standards. Implementation of the IECC's standards for wall insulation and air leakage are long overdue. Virginia's homebuilders blocked compliance with the 2012 IECC in the 2012, 2015 and 2018 cycles. They should not be permitted to do so again. Failure to comply with the latest standards will harm Virginians for decades. The harms from failing to maximize energy efficiency are high and are growing. Efficiency-driven reductions in energy use are the first line of defense against high utility bills and pollution that harms health and drives climate change

For years, Virginia's law has required that the building code protect the health, safety and welfare of residents of the Commonwealth and that construction costs be minimized only to the extent "consistent' with national codes for energy conservation. It was updated in 2021 to require that the code be "at least as stringent" as the IECC so long as the long-term savings and benefits to residents and the public exceed the incremental construction costs. Nothing in the law authorizes builders to have a work-group veto by withholding consent from changes that would eliminate previously-made exceptions.

Now, updating the wall insulation to the 2021 IECC for residential construction is cost effective and beneficial to residents and the public -- taking into account costs and benefits to residents and the public over time. That will protect the health, safety and welfare of the residents of Virginia and is required by Virginia law.

Discussion by Richard Potts
Jun 3, 2022 23:35 UTC

Attached are two public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.
Attachments:
https://va.cdpaccess.com/proposal/995/discuss/140/file/download/724/HBAV_Clarifying%20ACEEE%20Report%20on%20Virginia%27s%20Residentia
https://va.cdpaccess.com/proposal/995/discuss/140/file/download/723/HBAV_DoE%20Data%20on%20New%20Construction%20EE%20Improvement
Discussion by Andrew Clark
Mar 18, 2022 15:16 UTC

Contrary to the proponent's reason statement, HB 2227 does not "specifically endorse" the adoption of the latest International Energy Conservation Code. The legislation, as enacted by the General Assembly and signed by the Governor, simply states that the Board of Housing and Community Development "…*consider* adopting amendments to the Uniform Statewide Building Code (Building Code) to address changes in the IECC relating to energy efficiency and conservation" (emphasis added). If the proponent's logic were to be accepted – and the provisions of HB 2227 be interpreted as a mandate to adopt the latest IECC – they would effectively be endorsing the provisions of HB 1289, which was passed by the General Assembly during the 2022 Session and contained nearly identical provisions directing the Board "…to consider…" exempting several use and occupancy classifications from any energy efficiency standards in the Virginia Uniform Statewide Building Code/2018 Virginia Energy Conservation Code. As originally introduced, both HB 1289 and HB 2227 were mandates to the Board to adopt certain code provisions – however, the General Assembly made it clear, through their public comments and amendments to both bills, that they did not want to "legislate the building code" or mandate that the Board to adopt certain building code provisions.

Comment by William Penniman
Mar 23, 2022 15:09 UTC

Unlike HR1298 (2022) referenced by Mr. Clark, the 2021 amendment to the code (H2227) requires consideration of standards "at least as stringent" as those in the IECC *and provides a clear standard for adopting the IECC or more stringent standards,* which overlays the pre-existing statutory guidance for keeping Virginia's building codes consistent with national codes. That is, in addition to directing the BHCD to *consider* code proposals "at least as stringent" as the latest IECC, H2227 states: "*In conducting its review, the Board shall assess the public health, safety, and welfare benefits of adopting standards that are at least as stringent as those contained in the IECC, including potential energy savings and air quality benefits over time compared to the cost of initial construction."* Taken as a whole, the law calls for adoption of energy standards "at least as stringent as" the latest IECC when the long-term savings and other benefits to residents and the public exceed the incremental costs of construction.

Thus, as spelled out more fully in the reason statement to EC1301.1.1.1-21:

> The BHCD's NOIRA published November 22, 2021, https://townhall.virginia.gov/L/viewstage.cfm?stageid=9475 states:
>
> > "The 2021 editions of the International Codes are now completed and available from ICC. *The use of the newest available model codes and standards in the USBC assures that the statutory mandate is met to base the regulation on the latest editions of nationally recognized model codes to assure the protection of the health, safety and welfare of the residents of Virginia and that buildings and structures are constructed and maintained at the least possible cost.*"
>
> The BHCD's NOIRA also states: "As the basis for Virginia's building code it is important to stay in sync with the national model codes." These statements are consistent with Section 36-99A of the Virginia Code has long prescribed that the purposes of the USBC are to protect the public and implement recognized standards of energy conservation and water conservation:
>
> > "The provisions of the Building Code and modifications thereof shall be such as *to protect the health, safety and welfare of the residents of the Commonwealth*, provided that buildings and structures should be permitted to be constructed, rehabilitated and maintained at the least possible cost *consistent with recognized standards of health, safety, energy conservation and water conservation*…."
>
> Legislation (H2227), enacted by the General Assembly and signed by the Governor in 2021, supplements the pre-existing law's commitment to protecting residents and the public "consistent with recognized standards of … energy conservation" by specifically endorsing adoption of energy standards "at least as stringent as" the latest IECC when the benefits "over time" to residents and the public exceed the incremental costs of construction.

We believe that our proposals meet the applicable tests under Virginia law. We will work with builders who identify ways to meet or exceed the IECC's efficiency standards at lower construction costs where possible.

REC-R402.1.2 (1)-21 & REC-R402.1.2 (2)-21 – Staff Summary

Proponent:

- REC-R402.1.2 (1)-21**:** Laura Baker, Responsible Energy Codes Alliance; Eric Lacey, Responsible Energy Codes Alliance
- REC-R402.1.2 (2)-21: William Penniman, Sierra Club – Virginia Chapter

Brief Description:

The proposals increase the insulation R-values (and reduce U-factors) to be consistent with the 2021 International Energy Conservation Code (IECC).

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposals were on the Agenda for the Energy Sub-Workgroup meeting on May 12, 2022, but the proponents requested for the proposals to be carried over to the next Energy SWG so that stakeholders can meet offline and explore potential areas of agreement.

The proposals were discussed by the Energy Sub-Workgroup at their May 19, 2022 meeting, but with obvious opposition, an official vote to determine the Sub-Workgroup's position on the proposals was not taken.

Supporting comments from Energy Sub-Workgroup members:

- William Penniman, Sierra Club, expressed support for the proposal and agreed with the proponent in that Virginia is behind and this would catch up to the 2021 IECC.

Opposing comments from Energy Sub-Workgroup members:

- Andrew Clark, HBAV, shared that this is one of the energy proposals that garnered the most concern from the home builders industry. There's a cost increase estimate in the proposal of about $735, but builders think it's more like $10-15k. The need to redesign existing home designs is a secondary concern. Department of Energy data shows that homes built after 2000 are affordable for people and the energy cost burden is not on them. This proposal would be costly.

Statements from other stakeholders in support of the proposal:

- Ben Rabe (New Buildings Institute) opined that homes would be energy efficient for lower-income people to purchase down the road.

Energy Sub-Workgroup members in attendance:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
- K.C. Bleile: Viridiant

- William (Bill) Penniman: Sierra Club – Virginia chapter

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club; Dan Willham, Fairfax County; Chelsea Harnish, Virginia Energy Efficiency Council (VAEEC).

- William Penniman, Sierra Club, expressed support for the proposal and noted that there has been an attempt to bring this change for many cycles, and the home builders consistently oppose. He likes the idea of phasing things in, which is what the IECC has done, but Virginia has fallen behind. In response to some of the opposing comments below, he noted that the proposal does not require the use of 2X6 lumber and it is related to wall insulation requirements only and not to the HVAC systems. Maryland has been doing this and they build affordable housing. He argued that the proposal would save money and reduce pollution. Prices go up and down all the time, the price of gas and electricity has also gone up and energy efficiency would save on energy bills.
- Dan Willham, Fairfax County, expressed support for the proposal and opined that it is long overdue in Virginia as we've been debating this issue for several code development cycles. In response to some of the opposing comments below, he agreed with William Penniman that 2x6 wall studs are not required by this proposal as 2x4 studs with continuous insulation could be used instead. Also, if 2x6 studs are used, the stud spacing can be reduced, thus using less studs. He disagreed with the HVAC cost increase mentioned by the opposition, and argued that the improved energy efficiency resulting from complying with this proposal could actually reduce the size and cost of the HVAC system.
- Chelsea Harnish, VAEEC, recorded their support for the proposal in the Adobe Platform Chat box.

Opposition:

Names: Andrew Clark, HBAV; Christopher Fox, Van Metre; John Olivieri, HBAV – Virginia Beach.

- Andrew Clark, HBAV, indicated that his comments to the proposal discussed immediately prior [EC-C1301.1.1.1(2)-21], are applicable for this proposal as well. Said comments highlighted that the proposal would add a significant cost to housing for the consumer. Virginia has an almost perfect score on residential and commercial energy efficiency in the ACEEE report. When the ACEEE report is broken down, utility programs and transportation policy brings the Virginia score down. The score is better for building and energy codes. The DOE data shows that most cost burden is found under 30% AMI. Adding up-front costs are not going to help anyone over the next few decades, when they can't afford to purchase the home.
- Christopher Fox, Van Metre, identified several changes that the proposal would cause. There would be over 48 lumber products that would need to be changed, which would require a master file design change and that is a considerable amount of work. Having to use 2x6 exterior studs would either add 3 inches to the footprint of the house, or it would remove 3 inches from the interior, habitable space of the house. Changing from 2x4 to 2x6 lumber would be difficult because the lumber is not readily available, and is more costly. It would cost about $10k more per house to comply with this proposal.
- John Olivieri, HBAV – Virginia Beach, shared that he has been building affordable housing for many years, but this proposal would basically kill affordable housing. He estimated the costs of complying with these provisions to be between $10-18k. It does not matter how much money could be saved on energy bills if people cannot afford to buy the house to begin with. Some of the upgrades needed would never allow for recuperating the costs. He gave the example of an HVAC upgraded unit, which has a lifespan of maybe twelve years. If it costs $5k for the upgraded unit, the money would never be recuperated. There are diminishing returns. Also, some of the products required are extremely difficult to get today. He gave the example of sprayed foam insulation – a petroleum base product, which was on allocation at the time of the meeting. He opined that Virginia has done a great job of phasing in these energy improvements over the years, without doing it all at ones.

DHCD Staff Notes: REC-R402.1.2(1)-21 & REC-R402.1.2(2)-21 are almost identical proposals but with different proponents and reason statements. The summary included above reflects discussions around REC-R402.1.2(1)-21 but applies to both proposals as supporters and opponents of REC-R402.1.2 (2)-21 rested on the statements made during REC-R402.1.2(1)-21 discussions.

Meeting summaries and proposal related information: Tab 10 - Page 42; Tab 10 - Page 81; Tab 11 - Page 7; Tab 11 - Page 29; Tab 11 - Page 33; Tab 11 - Page 40.

REC-R402.4-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Construction Code

Revise as follows:

1301.1.1.1 Changes to the International Energy Conservation Code (IECC).

21. ~~Change Sections R402.4 and R402.4.1.1 to read:~~

~~**R402.4 Air leakage.** The *building* thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.5.~~

~~**R402.4.1.1 Installation (Mandatory).** The components of the *building* thermal envelope as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in Table R402.4.1.1, as applicable to the method of *construction.* Where required by the code official, an *approved* third party shall inspect all components and verify compliance.~~

22. ~~Change the title of the "Insulation Installation Criteria" category of Table R402.4.1.1; change the "Shower/tub on exterior wall" category of Table R402.4.1.1, and add footnotes "b" and "c" to Table R402.4.1.1 to read:~~

23. ~~Change Section R402.4.1.2 to read:~~

~~**R402.4.1.2 Testing.** The *building* or *dwelling unit* shall be tested and verified as having an air leakage rate not exceeding five air changes per hour in Climate Zone 4. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). A written report of the results of the test shall be signed by the party conducting the test and provided to the *building official.* Testing shall be conducted by a Virginia licensed general contractor, a Virginia licensed HVAC contractor, a Virginia licensed home inspector, a Virginia *registered design professional*, a certified BPI Envelope Professional, a certified HERS rater, or a certified duct and envelope tightness rater. The party conducting the test shall have been trained on the *equipment* used to perform the test. Testing shall be performed at any time after creation of all penetrations of the *building* thermal envelope.~~

~~**Note:** Should additional sealing be required as a result of the test, consideration may be given to the issuance of a temporary certificate of occupancy in accordance with Section 116.1.1.~~

~~During testing:~~

1. ~~Exterior windows and doors and *fireplace* and stove doors shall be closed, but not sealed beyond the intended weatherstripping or other infiltration control measures;~~
2. ~~Dampers, including exhaust, intake, makeup air, backdraft, and flue dampers, shall be closed, but not sealed beyond intended infiltration control measures;~~
3. ~~Interior doors, if installed at the time of the test, shall be open;~~
4. ~~Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;~~
5. ~~Heating and cooling systems, if installed at the time of the test, shall be turned off; and~~
6. ~~Supply and return registers, if installed at the time of the test, shall be fully open.~~

24. ~~Change Section R403.3.3 to read:~~

> ~~**R403.3.3 Duct testing (Mandatory).** Ducts shall be pressure tested to determine air leakage by one of the following methods:~~
>
> 1. ~~Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.~~
> 2. ~~Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.~~
>
> ~~**Exception:** A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.~~

~~A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. The licensed mechanical contractor installing the mechanical system shall be permitted to perform the duct testing. The contractor shall have been trained on the equipment used to perform the test.~~

Reason Statement: The purpose of this proposal is to bring Virginia's standards for air leakage testing and air leakage rates into full compliance with the 2021 IECC from which the new language is drawn.

The air leakage level permitted by Virginia's 2018 Energy Conservation Code predates the 2012 IECC, which required air leakage to not exceed 3.0 air changes per hour in Virginia's climate zones. Retaining the 5.0 ACH level would make Virginia's USBC more than a decade behind the IECC, and plainly out of compliance with statutory standards. Sections 36-99A and 36-99B of the Virginia Code make clear that building codes are required to "protect the health, safety and welfare of the residents of the Commonwealth" and that deviations to reduce construction costs must nevertheless be "consistent with recognized standards of health, safety, energy efficiency and water efficiency." H2227, which was enacted in 2021, calls for adoption of energy efficiency standards that are "at least as stringent" as the latest IECC.

Reducing the maximum air infiltration to 3 air changes per hour was established as technically and economically viable when the 2012 IECC was promulgated. Following promulgation of the 2012 IECC, DOE found that the changes from 2009 improved efficiency and was cost effective for occupants in that they saved money every year and quickly recouped the cost of construction. DOE/PNNL, *National Energy Cost Savings for New Single and Multifamily Homes, A Comparison of the 2006, 2009, and 2012 Editions of the IECC*, https://www.energycodes.gov/sites/default/files/documents/NationalResidentialCostEffectiveness.pdf

The IECC requirement has remained at 3 air changes per hour in the 2015, 2018 and 2021 IECCs. If there were any technical or economic reason to adopt 5 ACH in Virginia's climate zones, the ICC has had three cycles to make the adjustments, but it has not done so. There is no valid reason for Virginia to continue to permit leaky houses that require additional heating and cooling in order to offset the infiltration of outside air.

Tightening building air sealing to test at 3 (versus 5) air changes per hour (a.k.a. "3 ACH" or "3 ACH50") is important to residents who will save money, experience greater comfort and a healthier home. Every additional air change requires additional heating and conditioning of air in the dwelling, and reflects poor sealing which leaves gaps for pests to enter the dwelling. While indoor humidity can be an issue in buildings (regardless of the tightness of construction) during periods in which spaces are not being heated or cooled, it is not a valid reason for refusing to implement the IECC's long-established standards for 3 ACH since greater air to flow through walls and ceilings increases the risks that moisture will be captured inside walls and insulation increasing the risks of mold and deterioration.

There is a broad consensus among recognized standards that tighter sealing of walls protects the health, safety and welfare of residents. To address indoor air issues, the IECC has long required whole-house mechanical ventilation for buildings that test at less than 5 ACH and has modified the envelope barrier standards. DOE has even tighter standards (2.5 ACH50 for Climate Zone 4) for its Zero-Energy program, and Passive House standards call for 0.6 ACH50. https://basc.pnnl.gov/information/infiltration-meets-ach50-requirements ; http://passivehousebuildings.com/books/phc-2019/five-principles-of-passive-house-design-and-construction/ The National Association of Home Builders has also recognized many benefits from minimizing air leakage.[1] And, EPA encourages tighter sealing of walls to reduce air infiltration (including infiltration of humid air), reduce energy waste, reduce the risks of indoor air pollution, reduce humidity and mold in walls, and reduce risks of infiltration by insects and rodents—another specific concern in Virginia's building code, which we cited. As EPA has stated, in *EnergyStar: A complete Thermal Enclosure System* (2017):

> The energy savings from comprehensive air sealing can quickly add up when you consider all the places hot or cool air can enter or escape from your home. Having a well-sealed home also means better air quality because dirt, pollen, pests, and moisture can't get in as easily. In addition, good sealing practices help protect your home against mold and moisture damage that can be caused by condensation.

[1] See NAHB, et al., "TechNote – Building Tightness Code Compliance & Air Sealing Overview", which (a) states "Air leakage in a building should be minimized;" (b) identifies benefits to residents including ""Heating & cooling energy savings; Reduced potential for moisture movement through the building thermal enclosure; Improved insulation effectiveness and reduced risk of ice dams; Reduced peak heating and cooling loads resulting in smaller HVAC equipment; Improved comfort (reduces drafts and noise); Improved indoor air quality (limits contaminants from garages, crawl spaces, attics, and adjacent units)" and (c) suggests a possible construction strategy with a goal of 2.5 ACH – stricter than the IECC.

Cost Impact: The code change proposal will increase the cost of construction
The code change proposal will increase the cost of construction in some, but not all projects, *i.e.,* primarily when blower door tests reveal an excess of air leakage between 3 and 5 ACH. A well planned and built house should meet the 3 ACH standard, and the additional costs of caulking and other sealing techniques are limited. To the extent a blower door test reveals leaks between 3 and 5 ACH, the additional cost will typically involve filling envelope gaps with caulk and other materials which are not costly. It may take some looking to find the gaps, but it shouldn't be hard to block the leaks. Greater care by builders during the framing, insulating and sealing processes will avoid having to go back and fix leaks.
On the other hand, residents will save money and experience other benefits by reducing the volume of air changes that have to be reheated, re-cooled or dehumidified. Retrofitting to achieve the same level of tightness after walls have been closed up could require going behind walls and would be much more difficult and costly to building owners than doing the job well during the construction phase. As noted in the Reason Statement, DOE/PNNL found that the 2012 IECC changes, including the air tightness standards, would save residents money year in and year out, on a life-cycle basis. DOE/PNNL, *National Energy Cost Savings for New Single and Multifamily Homes, A Comparison of the 2006, 2009, and 2012 Editions of the IECC*, https://www.energycodes.gov/sites/default/files/documents/NationalResidentialCostEffectiveness.pdf If the costs had outweighed the benefits of the 3.0 ACH leakage standard, the ICC could have raised the permissible leakage rate any time in the four cycles 2012-2021. It did not, and Virginia should no longer deny the benefits to occupants of newly constructed dwellings. (Although the data published by DOE/PNNL amply demonstrates that full compliance satisfies the statutory standards, more detailed data and analysis can be requested by DHCD from PNNL, if desired.)

Resiliency Impact Statement: This proposal will increase Resiliency
Improving building energy efficiency with the 3 ACH standard will increase resiliency compared to Virginia's outdated 5 ACH standard. By reducing the volume of air that needs to be reheated or cooled every day, the proposal will reduce energy usage and cost burdens. By better preserving indoor conditioned temperatures, it will help residents and communities withstand periods of power outages from storms or other causes. Improving envelope efficiency will also reduce burdens on utilities which will help them better cope with storms and other difficulties.

By reducing demands for energy generation, tightening construction will also help mitigate climate impacts and prepare Virginia's buildings and economy for a future that requires the least energy usage and related pollution possible. Climate change is already harming Virginia and the harms will get much worse if we do not sharply reduce GHG emissions (particularly CO2 and methane). Growing climate dangers include harms to communities, infrastructure, people, property and the economy from rising seas, worsening storms and more severe rainfall events. Growing dangers also include rising atmospheric and water temperatures that threaten worsening heat-related illnesses, limits on economic activity, agriculture, fisheries, and our natural heritage. The likelihood of mitigating and recovering from those harms declines the longer we delay maximizing energy savings and minimizing GHG pollution.

Furthermore, saving energy will reduce occupants' utility bills while increasing their comfort. Reducing energy cost burdens will improve the *economic resiliency* of all residents, but particularly low and moderate income customers most harmed by high bills. It will also the *economic resiliency* of lenders, landlords and communities by reducing loan defaults and residents' choices between paying energy bills and rent, mortgages and other basic family needs. With buildings lasting 70 or more years, there is no excuse for not meeting standards established 10 years ago.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- ☐ Approved
- ☐ Approved with Modifications
- ☐ Carryover
- ☐ Disapproved
- ☐ None

Public Comments for: REC-R402.4-21

Discussion by William Penniman
Jun 15, 2022 0:00 UTC

As outlined in the original Reason Statement, the IECC's 3ACH50 standard for air leakage (also called air infiltration) would benefit residents and the public and should be adopted. The 2012 IECC code update was found by DOE/PNNL to be cost effective, saving residents money year in and year out from the first year of occupancy. Nothing has changed to alter that finding and 3.0ACH50 remains the 2021 IECC's prescriptive standard for air leakage.

As found by DOE and acknowledged by NAHB (see below), air leakage requires constant heating and cooling to maintain a stable indoor temperature. Leakage accounts for a significant share of energy usage for space conditioning. That increases costs and pollution. Air flow through walls also contributes to moisture and mold problems harmful to residents' health. The benefits to residents and the public (including energy cost savings, cleaner and healthier indoor air, reduced entry of pests, and reduced air pollution) from implementing the IECC's tighter air leakage standards outweigh builders' complaints.

Materials for retarding air leakage are not expensive. They include caulk, tape, foam, gaskets, vapor barriers, wall board, continuous board insulation, foam and other materials that builders routinely use. Many of these materials serve multiple needed functions and provide multiple benefits.

The principal objections expressed by builders have been that they would have to exercise greater care during construction to minimize leaks and they might have to go back to locate and fix problem locations if they fail a blower door test (which only seems fair to residents). However, as quoted below, the NAHB has identified the benefits and practical implementation measures exist.

As explained in an EnergyStar publication **"Air Sealing",** air leakage is an energy problem and creates other problems as well. "Air will leak through a building envelope that is not well sealed. This leakage of air decreases the comfort of a residence by allowing moisture, cold drafts, and unwanted noise to enter and may lower indoor air quality by allowing in dust and airborne pollutants." It continues (emphasis added):

> **"Air sealing the building envelope is one of the most critical features of an energy efficient home.** To prevent air leakage, it is best to seal the building envelope during construction prior to installation of the drywall. Once covered, many air leakage paths will be more difficult and costly to access and properly seal. A "blower door" test (typically included with a Home Energy Rating) is a good way to identify air leakage paths so that they can be sealed using an appropriate material. **There are many products available for air sealing including caulks, foams, weatherstripping, gaskets, and door sweeps**."

Allowing air leak through walls can trap moisture in the insulation and bring into the house molds, bacteria that build up inside walls. Tight sealing can also reduce the hazard of pests and outdoor odors from entering through gaps in the envelope.
https://www.energy.gov/energysaver/blower-door-tests

In 2017, NAHB published "**TechNotes - Building Air Tightness: Code Compliance & Air Sealing Overview**" which explaines the benefits and feasibility of air sealing and practical strategies for IECC compliance. It states (footnotes omitted, emphasis added):

> "Building air tightness describes the degree of air leakage into and out of the building's thermal enclosure which separates conditioned space from the outdoors. Air leakage is the uncontrolled flow through the thermal enclosure due to pressure imbalances caused by wind, stack effect, and mechanical equipment. **Air leakage in a building should be minimized; this goal can be effectively and consistently achieved using an air sealing strategy** (page 4).
>
> **"Tighter buildings are intended to increase energy efficiency, durability, occupant comfort and indoor air quality.** Houses have become considerably tighter over the past couple decades; however, the most recent energy codes mandate even more stringent air sealing and tightness testing requirements."

The NAHB publication summarizes the benefits of tighter houses:

> **"Benefits of Tight Houses (Reduced Air Leakage)**
>
> Heating & cooling energy savings

Reduced potential for moisture movement through the building thermal enclosure

Improved insulation effectiveness and reduced risk of ice dams

Reduced peak heating and cooling loads resulting in smaller HVAC equipment

Improved comfort (reduces drafts and noise)

Improved indoor air quality (limits contaminants from garages, crawl spaces"

This NAHB TechNotes publication (p.4) also describes practical, reasonable strategies for meeting the higher standards and minimizing the risks of having to go back in search of leaks. Some of the strategies include establishing a clear plan, outlining contractors' responsibilities, inspecting regularly during construction and testing before walls and ceilings are finally enclosed:

"Air Sealing Strategy

"Develop a whole-house air sealing plan

Establish a specific house leakage goal to meet or exceed code (**e.g., 2.5 ACH50**).

Establish the continuous air boundary for the entire house. Avoid installing systems through the air boundary (e.g., HVAC systems not in conditioned space).

Prioritize the air sealing locations and efforts. Include all code requirements (See also ENERGY STAR air sealing resources [6].)

Conduct design review meetings with all affected trades and vendors. Include the testing partner if applicable (some may also be air sealing professionals). Evaluate available products, and select methods that are practical to install, cost-effective, and easily inspected for quality assurance. Establish trade partner scopes of work based on mutually agreed upon responsibilities and expectations.

Implement the plan – a thorough air sealing effort is critical for success. Quality inspections should allow for additional "touch-up" air sealing as required. Seal all large holes and focus on high priority areas.

Refine the plan as needed for optimum performance and cost.

"Suggested techniques to achieve code compliance

It is easier to air seal while the house is under construction rather than trying to seal after failing a tightness test. Testing prior to completion may identify leakage points that can be easily fixed.

Perform blower door test prior to insulating the ceiling - this will allow easier access to air leakage points in the attic if the building does not meet the tightness requirement.

When designing the house, avoid complex architectural designs that may be difficult to seal.

Reduce the number of penetrations to the air barrier (e.g., recessed lights, speakers).

Maintain continuity between air barrier materials."

Thus, even the NAHB has recognized the practicality and benefit of tighter air sealing in compliance with updated building codes.

In sum, the 2021 IECC is a reasonable standard, and it is long overdue in Virginia. The 3.0ACH50 prescriptive standard has been deemed reasonable and beneficial by the IECC for a decade. (Indeed, there are other standards, such as Passive House, with an ACH level that is only one fifth of the IECC's 3.0 ACH.)

Virginia builders operating next door in Maryland and other Maryland builders meet the standard there. There is no reason why all Virginia builders should not meet the standards here.

Discussion by Richard Potts
Jun 3, 2022 23:37 UTC

Attached are two public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.
Attachments:
https://va.cdpaccess.com/proposal/994/discuss/141/file/download/726/HBAV_Clarifying%20ACEEE%20Report%20on%20Virginia%27s%20Residentia
https://va.cdpaccess.com/proposal/994/discuss/141/file/download/725/HBAV_DoE%20Data%20on%20New%20Construction%20EE%20Improvement
Discussion by Andrew Clark
Mar 18, 2022 15:17 UTC

Contrary to the proponent's reason statement, HB 2227 does not "specifically endorse" the adoption of the latest International Energy Conservation Code. The legislation, as enacted by the General Assembly and signed by the Governor, simply states that the Board of Housing and Community Development "…*consider* adopting amendments to the Uniform Statewide Building Code (Building Code) to address changes in the IECC relating to energy efficiency and conservation" (emphasis added). If the proponent's logic were to be accepted – and the provisions of HB 2227 be interpreted as a mandate to adopt the latest IECC – they would effectively be endorsing the provisions of HB 1289, which was passed by the General Assembly during the 2022 Session and contained nearly identical provisions directing the Board "…to consider…" exempting several use and occupancy classifications from any energy efficiency standards in the Virginia Uniform Statewide Building Code/2018 Virginia Energy Conservation Code. As originally introduced, both HB 1289 and HB 2227 were mandates to the Board to adopt certain code provisions – however, the General Assembly made it clear, through their public comments and amendments to both bills, that they did not want to "legislate the building code" or mandate that the Board to adopt certain building code provisions.

Comment by William Penniman
Mar 23, 2022 15:12 UTC

Unlike HR1298 (2022) referenced by Mr. Clark, the 2021 amendment to the code (H2227) requires consideration of standards "at least as stringent" as those in the IECC *and provides a clear standard for adopting the IECC or more stringent standards,* which overlays the pre-existing statutory guidance for keeping Virginia's building codes consistent with national codes. That is, in addition to directing the BHCD to *consider* code proposals "at least as stringent" as the latest IECC, H2227 states: "*In conducting its review, the Board shall assess the public health, safety, and welfare benefits of adopting standards that are at least as stringent as those contained in the IECC, including potential energy savings and air quality benefits over time compared to the cost of initial construction."* Taken as a whole, the law calls for adoption of energy standards "at least as stringent as" the latest IECC when the long-term savings and other benefits to residents and the public exceed the incremental costs of construction.

Thus, as spelled out more fully in the reason statement to EC1301.1.1.1-21:

> The BHCD's NOIRA published November 22, 2021, https://townhall.virginia.gov/L/viewstage.cfm?stageid=9475 states:
>
> > "The 2021 editions of the International Codes are now completed and available from ICC. *The use of the newest available model codes and standards in the USBC assures that the statutory mandate is met to base the regulation on the latest editions of nationally recognized model codes to assure the protection of the health, safety and welfare of the residents of Virginia and that buildings and structures are constructed and maintained at the least possible cost.*"
>
> The BHCD's NOIRA also states: "As the basis for Virginia's building code it is important to stay in sync with the national model codes." These statements are consistent with Section 36-99A of the Virginia Code has long prescribed that the purposes of the USBC are to protect the public and implement recognized standards of energy conservation and water conservation:
>
> > "The provisions of the Building Code and modifications thereof shall be such as *to protect the health, safety and welfare of the residents of the Commonwealth*, provided that buildings and structures should be permitted to be constructed, rehabilitated and maintained at the least possible cost *consistent with recognized standards of health, safety, energy conservation and water conservation*…."
>
> Legislation (H2227), enacted by the General Assembly and signed by the Governor in 2021, supplements the pre-existing law's commitment to protecting residents and the public "consistent with recognized standards of … energy conservation" by specifically endorsing adoption of energy standards "at least as stringent as" the latest IECC when the benefits "over time" to residents and the public exceed the incremental costs of construction.

We believe that our proposals meet the applicable tests under Virginia law. We will work with builders who identify ways to meet or exceed the IECC's efficiency standards at lower construction costs where possible.

REC-R402.4-21 & REC-R402.4.1.2-21 – Staff Summary

Proponents:

- REC-R402.4-21: William Penniman, Sierra Club – Virginia Chapter
- REC-R402.4.1.2-21: Laura Baker, Responsible Energy Codes Alliance; Eric Lacey, Responsible Energy Codes Alliance

Brief Description:

The proposals delete the Virginia amendments to the thermal envelope air leakage provisions.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposals were heard by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on May 19, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman: Sierra Club - Virginia Chapter
    - The proposal brings the air leakage level down to 3 air changes per hour (ACH). The air leakage level of 3 ACH has been around for many years, but not yet adopted by Virginia. There was some discussion since the last group meeting with Andrew Clark and his constituents, and while consensus was not reached, he hopes there will be more discussion before the General Workgroup meets in June.
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey (Laura Baker alternate): Responsible Energy Codes Alliance (RECA)
    - Laura Baker: her proposal (R402.4.1.2) does essentially the same thing. She does support this proposal to bring Virginia up to the 2021 IECC standards.

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- K.C. Bleile: Viridiant

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter
- Jim Canter: Virginia Building and Code Officials Association
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)
- Bettina Bergoo: Virginia Department of Energy
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association

- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter
- Brian Clark: Habitat for Humanity

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Laura Baker, RECA; Ben Rabe; New Buildings Institute (NBI); Dan Willham, Fairfax County.

- Laura Baker, RECA, expressed support for the proposal which is similar to her proposal REC-R402.4.1.2 and noted that the 2021 International Energy Conservation Code sets the prescriptive requirement to 3 ACH, but the backstop requirement to 5 ACH. This allows builders to trade-off air tightness and have improved performance. There's also an alternate ACH calculation for small and attached homes, which eases some compliance concerns. The changes would tighten up the prescriptive requirements, and it would also create exceptions to help with compliance.
- Ben Rabe, NBI, expressed support for the proposal and pointed out that 3 ACH has been the norm in lower temperature areas for a while and the builders can easily achieve that. In response to some of the opposing comments below, he stated that the 3 ACH can be achieved using traditional building methods, and sprayed foam insulation is not required.
- Dan Willham, Fairfax County, wanted to get on the record for supporting the proposal and not endorsing rollbacks.

Note: KC Bleile, Viridiant, did not speak in support nor opposition, but provided some additional perspective in response to the issue of having to use sprayed foam, identified by the opposing parties. She shared that Viridiant is working with hundreds of projects currently that are able to achieve the 3 ACH without the use of sprayed foam.

Opposition:

Names: Christopher Fox, Van Metre; Andrew Clark, HBAV; David Beahm, representing self.

- Christopher Fox, Van Metre, opposed the proposal and indicated that the 2018 VRC, which takes effect on July 1, 2022, is when the blower door test was required for the first time in Virginia to verify compliance with the 5 ACH leakage requirements. As such, the builders have not had time to be practicing that, as it was implied. ACH between 2 and 5 is considered good, he is unsure as to why we now have to immediately drop to 3 ACH. There are costs associated with tightening up the house. Also, if the envelope is too tight, it could be unhealthy and mechanical ventilation would be needed, which draws more electricity. Foam insulation helps get to 5 ACH, but it is more expensive to use.
- Andrew Clark, HBAV, opposed the proposal and agreed with Christopher Fox's statements. He disagreed with the proponent in that tighter homes are healthier. Carbon monoxide poisoning is associated with houses that are too tight.
- David Beahm, representing self, opposed the proposal and disagreed with the proponent's statements related to contaminated air coming through walls and floors. He shared that the

windows in his house are probably open 70 percent of the time during the year, doors open all the time, etc. As such, the majority of outside air does not come through wall or floor cavities.

DHCD Staff Notes: Proposal REC-R402.4.1.2-21 is substantially similar to proposal REC-R402.4-21. Given that the proposals were discussed immediately one after another, the comments around proposal REC-R402.4.1.2-21 were very limited, or the commenters stood on their previous statements. The summary included above reflects discussions around REC-R402.4-21 but it also applies to REC-R402.4.1.2-21, with one difference: William Penniman (REC-R402.4-21 proponent) supported proposal REC-R402.4.1.2-21 (proponents: Laura Baker and Eric Lacey).

Meeting summaries and proposal related information: Tab 10 - Page 42; Tab 10 - Page 81; Tab 11 - Page 11; Tab 11 - Page 30; Tab 11 - Page 32; Tab 11 - Page 40.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

Clarifying the *American Council for an Energy-Efficient Economy's* Report on Virginia's Energy Policy and Building Codes

The American Council for an Energy-Efficient Economy (ACEEE) periodically releases a report ranking each state's energy efficiency policies and programs. This report is *widely* cited by energy efficiency stakeholders as justification for additional advancements in Virginia's energy codes – particularly, the report's ranking of Virginia as 25th in the country for energy efficiency[1].

Although the Home Builders Association of Virginia has partnered with these stakeholders during the 2015 and 2018 code cycles (which resulted in several significant advancements) and has continued to do so during the 2021 cycle, we felt it important to clarify the ACEEE's findings on Virginia's energy codes.

While the ACEEE report is a helpful resource for policymakers and regulatory boards, a state's ***overall ranking*** in the report is not particularly informative when evaluating the "strength" or "weakness" of a state's residential and commercial energy codes or specific energy code proposals. A deeper analysis of the ACEEE report shows that Virginia's ***overall ranking*** distorts the fact that Virginia receives extremely high scores for residential and commercial energy codes.

Virginia loses nearly half (24.5 points) of its points in categories *unrelated* to building codes

The ACEEE report ranks states based on five categories: (i) utility and public benefits programs and policies; (ii) transportation policies; (iii) building energy efficiency policies; (iv) state government initiatives; (v) appliance efficiency standards.

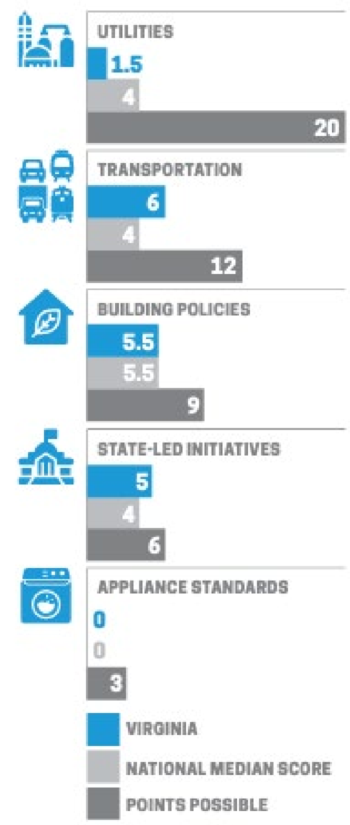
A state can only earn a certain number of points in each category:

- Utility and public benefits programs and policies (20 pts)
- Transportation policies (12 pts)
- Building energy efficiency policies (9 pts)
- State government initiatives (6 pts)
- Appliance efficiency standards (3 pts)

In the ACEEE's most recent report (2020), Virginia earned 18 out of 50 points – which is 25th in the nation.

However, a deeper analysis of the ACEEE's findings shows that Virginia lost nearly 50% of its points (24.5) in categories that are *unrelated* to energy efficiency building codes. Specifically, Virginia only earned 1.5 out of 20 pts for "Utility and Public Benefits Programs and Policies" and only received 6 out of 12 points for "Transportation Policies". *(See figure to the right)*

Due to the report's scoring system, it is inaccurate to claim that Virginia's 25th-in-the-Nation ranking in this report is the result of the Commonwealth's "weak energy code".



[1] American Council for an Energy-Efficient Economy – 2020 State Energy Efficiency Scorecard

Virginia receives a near-perfect score for residential code stringency and perfect score for commercial code stringency.

In the "Building Energy Efficiency Policy" category, Virginia receives 5.5 out of 9 points – by comparison, Virginia is only .5 points behind Maryland and 2 points behind California, which are the two states most frequently described by energy efficiency stakeholders as "leaders" in energy efficiency.

The "Building Energy Efficiency Policy" category consists of 8 sub-categories, including "residential code stringency" and "commercial code stringency". Contrary to statements made during several sub-workgroup and workgroup meetings, Virginia receives a near perfect score for "residential energy efficiency" (1.5 points out of 2) and a perfect score for "commercial energy efficiency" (2 points out of 2).

It is HBAV's understanding that these rankings were determined while Virginia was in the middle of the last code development cycle. While Virginia received exemplary scores for residential and commercial energy code stringency in ACEEE's report, the rankings only reflect a *portion* of the progress which was made in Virginia's energy codes during the last code cycle. During the last code cycle, the Home Builders Association of Virginia and other organizations reached consensus with energy efficiency stakeholders on several proposals, including:

1. Removed visual option for verifying building envelope air tightness and required blower door testing for all new residential buildings. Also added requirement that all new homes pass the blower door test with 5 air changes per hour;
2. Require an "energy certificate" in all new residential buildings to inform current and future homeowners about the key energy characteristics of their home;
3. Increase minimum ceiling insulation requirements (R-38 to R-49) for all new residential buildings;
4. ResCheck compliance updated to 2018 IECC, without Virginia amendments. Previously, a work around had been created for VA amendments that weakened the current IECC;
5. Increased fenestration requirements.

While the ACEEE has yet to release an updated report, it is highly likely that Virginia will receive further recognition for the full scope of energy efficiency code proposals that were adopted during the last code cycle – and possibly for the energy efficiency code proposals which are likely to be forwarded to the Board as "consensus" during the current code development cycle.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

U.S. Department of Energy Data Shows Significant Advancements in Residential Energy Efficiency and Reduction in Energy Cost Burdens in New Construction

"The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs."

Building code regulations were first established – and are continually revised – to ensure a *baseline standard* of quality, safety, and efficiency in new residential structures. For example, they provide assurance for consumers that they are residing in safe structures, guidelines for builders/design professionals as to what constitutes a safe and durable structure, and certainty for lenders of the value and quality of structure.

Similarly, energy efficiency standards were first adopted by the U.S. Housing and Home Finance Agency in the 1950's to address a concerning *public health and welfare* issue at the time: the rising number of mortgage defaults on federally insured loans on homes with high utility bills.

While increasing the efficiency of new residential structures is a laudable objective, it is critically important for policymakers to balance that objective with the growing concerns over the cost of housing in Virginia and the dramatic undersupply of housing that is attainable for households across the income spectrum. Furthermore, it is important for policymakers to distinguish between building code requirements that are essential to providing that baseline standard of quality, safety, and efficiency, and code requirements that are "aspirational".

Consumers can make a personal financial decision to purchase or build a home that is constructed to a higher energy efficiency standard, if that is an amenity that they are willing and able to afford. While energy efficiency requirements can reduce negative environmental externalities, promote high-quality housing stock, and protect consumers from soaring energy costs over time, the ability to afford the **upfront costs** of additional energy efficiency code requirements will vary widely by income.

The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs.

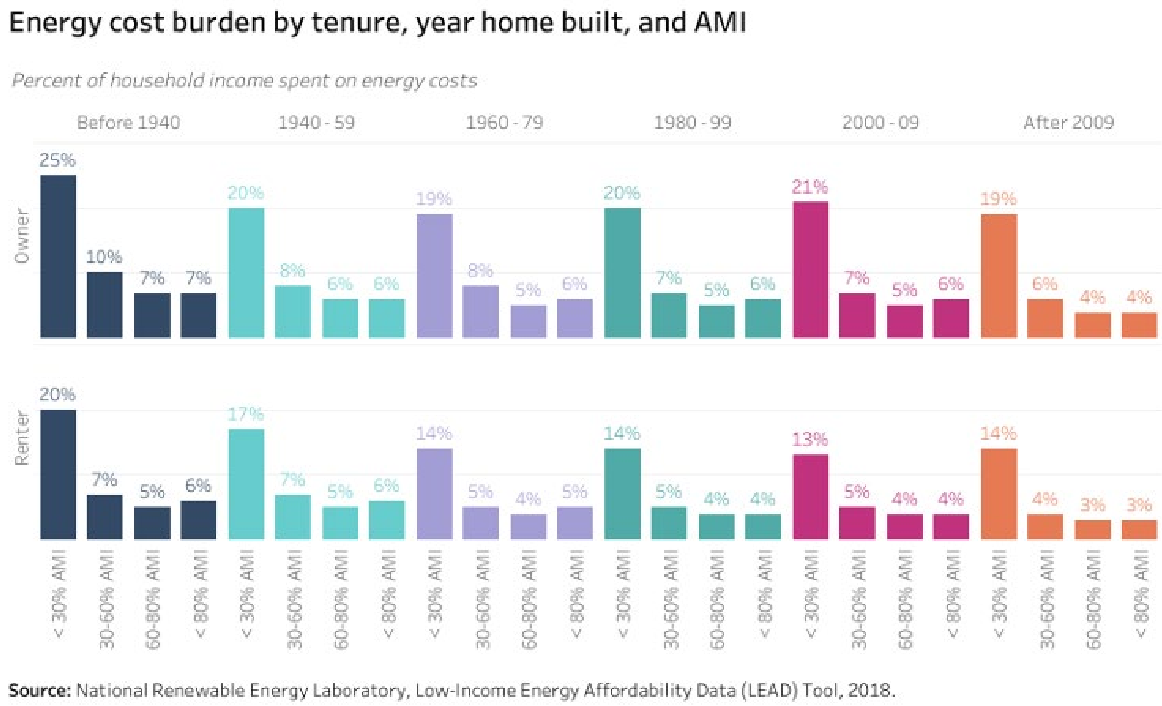
U.S. Department of Energy Data

Data from the U.S. Department of Energy's *Low-Income Energy Affordability Data (LEAD) Tool* validates the claim that Virginia *has* made vast improvements in residential energy efficiency over the last 80 years and has significantly reduced household energy costs to a level considered sustainable for individuals and families across the income spectrum.

A household is considered "energy cost burdened" when over 6% of the household income is dedicated to covering energy bills – this calculation includes all costs associated with energy used by the house (e.g., electricity and natural gas). When a household is "energy cost burdened", it impacts their ability to use electricity and heat or cool their home – and forces households to choose between paying utility bills, paying a mortgage or rent, or other essential expenses. In short, high energy cost burdens results in higher levels of housing instability, including evictions and foreclosures.

The chart below was compiled using data from the U.S. Department of Energy and included in a recent report released by Virginia Housing (formerly, Virginia Housing Development Authority) and the Department of Housing and Community Development[1].

[1] HB 854 Statewide Housing Study Report (January 2022)



The data from the U.S. Department of Energy (chart above) provides several important insights:

First, renters and owners residing in residential structures built since 2000 are below the 6% "energy cost burdened" threshold, with two exceptions: (i) Owner households in structures built between 2000 and 2009 are slightly over the 6% energy cost burdened threshold; (ii) Owners and renters with incomes below 30% of AMI residing in structures built between 2000 and 2019 are experiencing extremely high energy cost burdens. More analysis is needed to understand the latter - there are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Second, the highest "energy cost burdened" households (owner and renter) are residing in structures built prior to 1980's/1990's. The most "energy cost burdened" demographic – regardless of age of structure – are households earning under 30% AMI. Again, more analysis is needed to understand this dynamic. There are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Conclusion:

Data from the U.S. Department of Energy shows that residential structures constructed in the last 20 years are significantly more energy efficient than older homes, which has reduced household energy costs to levels considered sustainable for individuals and families across the income spectrum. The data also reflects the reality that efforts to reduce household energy cost burdens would be best focused on older, existing structures occupied by individuals and families at the lower end of the income spectrum.

Several energy proposals submitted during the 2021 code cycle seek to impose stricter energy efficiency requirements on all new homes, thus increasing the upfront cost of all new homes and exacerbating an issue raised by the Virginia Joint Legislative Audit and Review Commission's recent report on housing affordability: "Rising prices make it more difficult for low- and middle-income households to afford to purchase homes because of the increased monthly mortgage costs, as well as the increased upfront costs associated with purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes.[2]"

[2] Joint Legislative Audit and Review Commission: Affordable Housing in Virginia (2021)

REC-R402.4.1.2-21

Proponents: Laura Baker (laura@reca-codes.com); Eric Lacey (eric@reca-codes.com)

2018 Virginia Energy Conservation Code

Revise as follows:

R402.4.1.2 Testing. The building or *dwelling unit* shall be tested ~~and verified as having an~~ for air leakage . ~~rate not exceeding five air changes per hour in *Climate Zone* 4.~~ The maximum air leakage rate for any *building* or *dwelling unit* under any compliance path shall not exceed 5.0 air changes per hour or 0.28 cubic feet per minute (CFM) per square foot [0.0079 m^3/(s x m^2)] of the dwelling unit enclosure area. Testing shall be conducted in accordance with ANSI/RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the *code official* , testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the building official. ~~Testing shall be conducted by a Virginia licensed general contractor, a Virginia licensed HVAC contractor, a Virginia licensed home inspector, a Virginia registered design professional, a certified BPI Envelope Professional, a certified HERS rater, or a certified duct and envelope tightness rater. The party conducting the test shall have been trained on the equipment used to perform the test.~~ Testing shall be performed at any time after creation of all penetrations of the building thermal ~~envelope.~~ envelope have been sealed .

~~**Note:** Should additional sealing be required as a result of the test, consideration may be given to the issuance of a temporary certificate of occupancy in accordance with Section 116.1.1.~~

Exception: For heated, attached private garages and heated, detached private garages accessory to one- and two-family dwellings and townhouses not more than three stories above *grade plane* in height, building envelope tightness and insulation installation shall be considered acceptable where the items in Table R402.4.1.1, applicable to the method of construction, are field verified. Where required by the code official, an *approved* third party independent from the installer shall inspect both air barrier and insulation installation criteria. Heated, attached private garage space and heated, detached private garage space shall be thermally isolated from all other habitable, conditioned spaces in accordance with Sections R402.2.12 and R402.3.5, as applicable.

During testing:

1. Exterior windows and doors and fireplace and stove doors shall be closed, but not sealed beyond the intended weatherstripping or other infiltration control measures;
2. Dampers, including exhaust, intake, makeup air, backdraft, and flue dampers, shall be closed, but not sealed beyond intended infiltration control measures;
3. Interior doors, if installed at the time of the test, shall be open;
4. Exterior doors for continuous *ventilation* systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling systems, if installed at the time of the test, shall be turned off; and
6. Supply and return registers, if installed at the time of the test, shall be fully open.

Exception: When testing individual *dwelling units* , an air leakage rate not exceeding 0.30 cubic feet per minute per square foot [0.008 m^3/(s x m^2)] of the dwelling unit enclosure area, tested in accordance with ANSI/RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pa), shall be permitted in all climate zones for:

1. Attached single and multiple-family building dwelling units.

2. Buildings or dwelling units that are 1,500 square feet (139.4 m^2) or smaller.

Mechanical ventilation shall be provided in accordance with Section M1505 of the *International Residential Code* or Section 403.3.2 of the *International Mechanical Code* , as applicable, or with other *approved* means of ventilation.

Add new text as follows:

R402.4.1.3 Leakage rate.. When complying with Section R401.2.1, the building or dwelling unit shall have an air leakage rate not exceeding 5.0 air changes per house in Climate Zones 0, 1 and 2, and 3.0 air changes per hour in Climate Zones 3 through 8, when tested in accordance with Section R402.4.1.2.

2018 Virgina Residential Code

Revise as follows:

N1102.4.1.2 (R402412) Testing. The *building* or dwelling unit shall be tested ~~and verified as having an~~ for air leakage ~~rate not exceeding five air changes per hour in Climate Zone 4 4.~~ . The maximum air leakage rate for any *building* or *dwelling unit* under any compliance path shall not exceed 5.0 air changes per hour or 0.28 cubic feet per minute (CFM) per square foot [0.0079 m^3/(s x m^2)] of the dwelling unit enclosure area. Testing shall be conducted in accordance with ANSI/RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inches w.g. (50 Pa). Where required by the *code official* , testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the ~~building building~~ code official. ~~Testing shall be conducted by a Virginia licensed general contractor, a Virginia licensed HVAC contractor, a Virginia licensed home inspector, a Virginia registered design professional, a certified BPI Envelope Professional, a certified HERS rater, or a certified duct and envelope tightness rater. The party conducting the test shall have been trained on the *equipment* used to perform the test.~~ Testing shall be performed at any time after creation of all penetrations of the *building thermal envelope* have been sealed.

~~**Note:** Should additional sealing be required as a result of the test, consideration may be given to the issuance of temporary certificate of occupancy in accordance with Section 116.1.1.~~

Exception: For heated, attached private garages and heated, detached private garages accessory to one- and two-family dwellings and townhouses not more than three stories above *grade plane* in height, building envelope tightness and insulation installation shall be considered acceptable where the items in Table R402.4.1.1, applicable to the method of construction, are field verified. Where required by the code official, an *approved* third party independent from the installer shall inspect both air barrier and insulation installation criteria. Heated, attached private garage space and heated, detached private garage space shall be thermally isolated from all other habitable, conditioned spaces in accordance with Sections R402.2.12 and R402.3.5, as applicable.

During testing:

1. Exterior windows and doors and fireplace and stove doors shall be closed, but not sealed beyond the intended weatherstripping or other infiltration control measures;
2. Dampers, including exhaust, intake, makeup air, backdraft, and flue dampers shall be closed, but not sealed beyond intended infiltration control measures;
3. Interior doors, if installed at the time of the test, shall be open;
4. Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling systems, if installed at the time of the test, shall be turned off; and
6. Supply and return registers, if installed at the time of the test, shall be fully open.

Exception: When testing individual *dwelling units* , an air leakage rate not exceeding 0.30 cubic feet per minute per square foot [0.008 $m^3/(s \times m^2)$] of the dwelling unit enclosure area, tested in accordance with ANSI/RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pa), shall be permitted in all climate zones for:

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Mechanical ventilation shall be provided in accordance with Section M1505 of the *International Residential Code* or Section 403.3.2 of the *International Mechanical Code* , as applicable, or with other *approved* means of ventilation.

Add new text as follows:

N1102.4.1.3 (R402.4.1.3) Leakage rate.. When complying with Section N1101.2.1 (R401.2.1), the building or dwelling unit shall have an air leakage rate not exceeding 5.0 air changes per hour in Climate Zones 0, 1, and 2, and 3.0 air changes per hour in Climate Zones 3 through 8, when tested in accordance with Section N1102.4.1.2 (R402.4.1.2).

2018 Virginia Construction Code

Revise as follows:

1301.1.1.1 Changes to the International Energy Conservation Code (IECC). The following changes shall be made to the IECC:

~~23. Change Section R402.4.1.2 to read:~~

~~**R402.4.1.2 Testing.** The *building* or *dwelling unit* shall be tested and verified as having an air leakage rate not exceeding five air changes per hour in Climate Zone 4. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). A written report of the results of the test shall be signed by the party conducting the test and provided to the *building official.* Testing shall be conducted by a Virginia licensed general contractor, a Virginia licensed HVAC contractor, a Virginia licensed home inspector, a Virginia *registered design professional*, a certified BPI Envelope Professional, a certified HERS rater, or a certified duct and envelope tightness rater. The party conducting the test shall have been trained on the *equipment* used to perform the test. Testing shall be performed at any time after creation of all penetrations of the *building* thermal envelope.~~

~~**Note:** Should additional sealing be required as a result of the test, consideration may be given to the issuance of a temporary certificate of occupancy in accordance with Section 116.1.1.~~

~~During testing:~~

1. ~~Exterior windows and doors and *fireplace* and stove doors shall be closed, but not sealed beyond the intended weatherstripping or other infiltration control measures;~~
2. ~~Dampers, including exhaust, intake, makeup air, backdraft, and flue dampers, shall be closed, but not sealed beyond intended infiltration control measures;~~
3. ~~Interior doors, if installed at the time of the test, shall be open;~~
4. ~~Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;~~
5. ~~Heating and cooling systems, if installed at the time of the test, shall be turned off; and~~
6. ~~Supply and return registers, if installed at the time of the test, shall be fully open.~~

Reason Statement: The purpose of this code change proposal is to improve efficiency and maintain compliance flexibility for code users by modifying the air leakage testing requirements to be consistent with the 2021 IECC. Specifically, the proposal improves the baseline envelope tightness requirement from 5.0 ACH50 to 3.0 ACH50, but adds a performance path trade-off option for air tightness up to 5.0 ACH50, as long as the efficiency losses are accounted for. The proposal also adds a cfm/sq.ft. compliance option for attached dwelling units and small single-family dwelling units in order to provide more options for builders.
This proposal includes a cost-effective incremental improvement from Virginia's 2018 USBC by tightening the air leakage rate from 5.0 ACH50 to 3.0 ACH50. Based on an analysis of this code change using the U.S. Department of Energy's methodology and using BEopt modeling software, we estimate that this improvement will achieve 9.2% lower energy costs, with a simple payback period of less than 2 years. Results will obviously vary based on the characteristics and size of the home, as well as how much additional work is necessary to achieve the lower leakage rates, but given the long-term benefits of a tighter envelope -- lower energy costs, more efficient system operation, better indoor air quality, etc. -- this improvement is well-justified.

The prescriptive air leakage rate of 3.0 ACH50 has been in the code since the 2012 edition of the IECC. In the 2018 USBC update, Virginia implemented mandatory blower door testing at a rate of 5.0 ACH50, which was short of the full requirement in the 2018 IECC. Now that builders have had some additional experience with mandatory blower door testing and sealing techniques, we believe it is reasonable to further improve the requirements. At the same time, for projects that are not yet able to achieve envelope air tightness of 3.0, there is an alternative to comply via the performance path or Energy Rating Index, which will allow leakage rates up to 5.0 ACH50. This proposal also clarifies the maximum air leakage rates as 3.0 and 5.0 air changes per hour. While most code users understand the maximum air leakage rates as already being at 3.0 and 5.0 changes per hour, the addition of another digit will pre-empt any "round up" vs. "round-down" arguments from code users, providing additional support for building code officials who are simply trying to enforce the code. This part of the proposal does not change any actual requirements, but rather provides clarification and reduces inconsistency and confusion.

Cost Impact: The code change proposal will increase the cost of construction
For buildings not already achieving 3 ACH50 or less, this code change will likely increase construction costs. Based on an analysis using the U.S. DOE methodology for reviewing code changes, and using BEopt modeling software, we estimate that the average marginal cost increase of this proposal is $144. However, our analysis also showed a 9.2% improvement in overall efficiency, which would result in a simple payback of less than 2 years. We also note that for any project for which the prescriptive requirement may be infeasible, builders will have the flexibility to meet the current air leakage requirement from the 2018 USBC using tradeoffs under another compliance path.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal will increase the resiliency of homes. A properly sealed home will help maintain better indoor air quality and improve the long-term

durability of the home. It will also reduce the volatility of indoor temperature swings and maintain more livable conditions during power outages due to natural emergencies.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- ☐ Approved
- ☐ Approved with Modifications
- ☐ Carryover
- ☐ Disapproved
- ☐ None

Public Comments for: REC-R402.4.1.2-21

Discussion by Richard Potts
Jun 3, 2022 23:39 UTC

Attached are two public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.
Attachments:
https://va.cdpaccess.com/proposal/953/discuss/142/file/download/728/HBAV_Clarifying%20ACEEE%20Report%20on%20Virginia%27s%20Residentia
https://va.cdpaccess.com/proposal/953/discuss/142/file/download/727/HBAV_DoE%20Data%20on%20New%20Construction%20EE%20Improvement

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Proposal # 953

REC-R402.4-21 & REC-R402.4.1.2-21 – Staff Summary

Proponents:

- REC-R402.4-21: William Penniman, Sierra Club – Virginia Chapter
- REC-R402.4.1.2-21: Laura Baker, Responsible Energy Codes Alliance; Eric Lacey, Responsible Energy Codes Alliance

Brief Description:

The proposals delete the Virginia amendments to the thermal envelope air leakage provisions.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposals were heard by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on May 19, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman: Sierra Club - Virginia Chapter
    - The proposal brings the air leakage level down to 3 air changes per hour (ACH). The air leakage level of 3 ACH has been around for many years, but not yet adopted by Virginia. There was some discussion since the last group meeting with Andrew Clark and his constituents, and while consensus was not reached, he hopes there will be more discussion before the General Workgroup meets in June.
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey (Laura Baker alternate): Responsible Energy Codes Alliance (RECA)
    - Laura Baker: her proposal (R402.4.1.2) does essentially the same thing. She does support this proposal to bring Virginia up to the 2021 IECC standards.

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia (HBAV)

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- K.C. Bleile: Viridiant

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter
- Jim Canter: Virginia Building and Code Officials Association
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)
- Bettina Bergoo: Virginia Department of Energy
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association

- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter
- Brian Clark: Habitat for Humanity

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Laura Baker, RECA; Ben Rabe; New Buildings Institute (NBI); Dan Willham, Fairfax County.

- Laura Baker, RECA, expressed support for the proposal which is similar to her proposal REC-R402.4.1.2 and noted that the 2021 International Energy Conservation Code sets the prescriptive requirement to 3 ACH, but the backstop requirement to 5 ACH. This allows builders to trade-off air tightness and have improved performance. There's also an alternate ACH calculation for small and attached homes, which eases some compliance concerns. The changes would tighten up the prescriptive requirements, and it would also create exceptions to help with compliance.
- Ben Rabe, NBI, expressed support for the proposal and pointed out that 3 ACH has been the norm in lower temperature areas for a while and the builders can easily achieve that. In response to some of the opposing comments below, he stated that the 3 ACH can be achieved using traditional building methods, and sprayed foam insulation is not required.
- Dan Willham, Fairfax County, wanted to get on the record for supporting the proposal and not endorsing rollbacks.

Note: KC Bleile, Viridiant, did not speak in support nor opposition, but provided some additional perspective in response to the issue of having to use sprayed foam, identified by the opposing parties. She shared that Viridiant is working with hundreds of projects currently that are able to achieve the 3 ACH without the use of sprayed foam.

Opposition:

Names: Christopher Fox, Van Metre; Andrew Clark, HBAV; David Beahm, representing self.

- Christopher Fox, Van Metre, opposed the proposal and indicated that the 2018 VRC, which takes effect on July 1, 2022, is when the blower door test was required for the first time in Virginia to verify compliance with the 5 ACH leakage requirements. As such, the builders have not had time to be practicing that, as it was implied. ACH between 2 and 5 is considered good, he is unsure as to why we now have to immediately drop to 3 ACH. There are costs associated with tightening up the house. Also, if the envelope is too tight, it could be unhealthy and mechanical ventilation would be needed, which draws more electricity. Foam insulation helps get to 5 ACH, but it is more expensive to use.
- Andrew Clark, HBAV, opposed the proposal and agreed with Christopher Fox's statements. He disagreed with the proponent in that tighter homes are healthier. Carbon monoxide poisoning is associated with houses that are too tight.
- David Beahm, representing self, opposed the proposal and disagreed with the proponent's statements related to contaminated air coming through walls and floors. He shared that the

windows in his house are probably open 70 percent of the time during the year, doors open all the time, etc. As such, the majority of outside air does not come through wall or floor cavities.

DHCD Staff Notes: Proposal REC-R402.4.1.2-21 is substantially similar to proposal REC-R402.4-21. Given that the proposals were discussed immediately one after another, the comments around proposal REC-R402.4.1.2-21 were very limited, or the commenters stood on their previous statements. The summary included above reflects discussions around REC-R402.4-21 but it also applies to REC-R402.4.1.2-21, with one difference: William Penniman (REC-R402.4-21 proponent) supported proposal REC-R402.4.1.2-21 (proponents: Laura Baker and Eric Lacey).

Meeting summaries and proposal related information: Tab 10 - Page 42; Tab 10 - Page 81; Tab 11 - Page 12; Tab 11 - Page 30; Tab 11 - Page 33; Tab 11 - Page 40.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

Clarifying the *American Council for an Energy-Efficient Economy's* Report on Virginia's Energy Policy and Building Codes

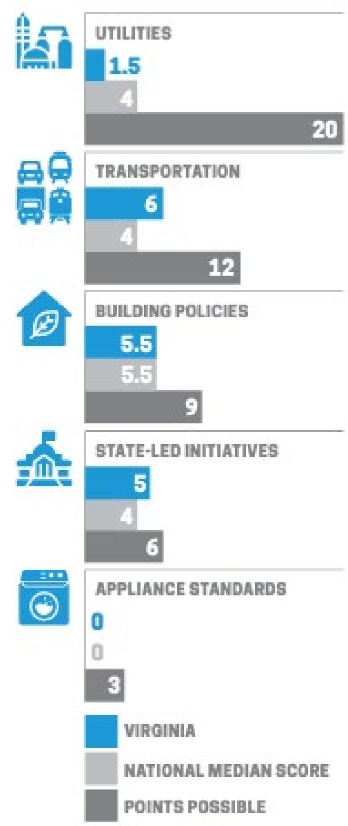
The American Council for an Energy-Efficient Economy (ACEEE) periodically releases a report ranking each state's energy efficiency policies and programs. This report is *widely* cited by energy efficiency stakeholders as justification for additional advancements in Virginia's energy codes – particularly, the report's ranking of Virginia as 25th in the country for energy efficiency[1].

Although the Home Builders Association of Virginia has partnered with these stakeholders during the 2015 and 2018 code cycles (which resulted in several significant advancements) and has continued to do so during the 2021 cycle, we felt it important to clarify the ACEEE's findings on Virginia's energy codes.

While the ACEEE report is a helpful resource for policymakers and regulatory boards, a state's ***overall ranking*** in the report is not particularly informative when evaluating the "strength" or "weakness" of a state's residential and commercial energy codes or specific energy code proposals. A deeper analysis of the ACEEE report shows that Virginia's ***overall ranking*** distorts the fact that Virginia receives extremely high scores for residential and commercial energy codes.

Virginia loses nearly half (24.5 points) of its points in categories *unrelated* to building codes

The ACEEE report ranks states based on five categories: (i) utility and public benefits programs and policies; (ii) transportation policies; (iii) building energy efficiency policies; (iv) state government initiatives; (v) appliance efficiency standards.



A state can only earn a certain number of points in each category:

- Utility and public benefits programs and policies (20 pts)
- Transportation policies (12 pts)
- Building energy efficiency policies (9 pts)
- State government initiatives (6 pts)
- Appliance efficiency standards (3 pts)

In the ACEEE's most recent report (2020), Virginia earned 18 out of 50 points – which is 25th in the nation.

However, a deeper analysis of the ACEEE's findings shows that Virginia lost nearly 50% of its points (24.5) in categories that are *unrelated* to energy efficiency building codes. Specifically, Virginia only earned 1.5 out of 20 pts for "Utility and Public Benefits Programs and Policies" and only received 6 out of 12 points for "Transportation Policies". *(See figure to the right)*

Due to the report's scoring system, it is inaccurate to claim that Virginia's 25th-in-the-Nation ranking in this report is the result of the Commonwealth's "weak energy code".

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The "Building Energy Efficiency Policy" category consists of 8 sub-categories, including "residential code stringency" and "commercial code stringency". Contrary to statements made during several sub-workgroup and workgroup meetings, Virginia receives a near perfect score for "residential energy efficiency" (1.5 points out of 2) and a perfect score for "commercial energy efficiency" (2 points out of 2).

It is HBAV's understanding that these rankings were determined while Virginia was in the middle of the last code development cycle. While Virginia received exemplary scores for residential and commercial energy code stringency in ACEEE's report, the rankings only reflect a *portion* of the progress which was made in Virginia's energy codes during the last code cycle. During the last code cycle, the Home Builders Association of Virginia and other organizations reached consensus with energy efficiency stakeholders on several proposals, including:

1. Removed visual option for verifying building envelope air tightness and required blower door testing for all new residential buildings. Also added requirement that all new homes pass the blower door test with 5 air changes per hour;
2. Require an "energy certificate" in all new residential buildings to inform current and future homeowners about the key energy characteristics of their home;
3. Increase minimum ceiling insulation requirements (R-38 to R-49) for all new residential buildings;
4. ResCheck compliance updated to 2018 IECC, without Virginia amendments. Previously, a work around had been created for VA amendments that weakened the current IECC;
5. Increased fenestration requirements.

While the ACEEE has yet to release an updated report, it is highly likely that Virginia will receive further recognition for the full scope of energy efficiency code proposals that were adopted during the last code cycle – and possibly for the energy efficiency code proposals which are likely to be forwarded to the Board as "consensus" during the current code development cycle.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

U.S. Department of Energy Data Shows Significant Advancements in Residential Energy Efficiency and Reduction in Energy Cost Burdens in New Construction

"The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs."

Building code regulations were first established – and are continually revised – to ensure a *baseline standard* of quality, safety, and efficiency in new residential structures. For example, they provide assurance for consumers that they are residing in safe structures, guidelines for builders/design professionals as to what constitutes a safe and durable structure, and certainty for lenders of the value and quality of structure.

Similarly, energy efficiency standards were first adopted by the U.S. Housing and Home Finance Agency in the 1950's to address a concerning *public health and welfare* issue at the time: the rising number of mortgage defaults on federally insured loans on homes with high utility bills.

While increasing the efficiency of new residential structures is a laudable objective, it is critically important for policymakers to balance that objective with the growing concerns over the cost of housing in Virginia and the dramatic undersupply of housing that is attainable for households across the income spectrum. Furthermore, it is important for policymakers to distinguish between building code requirements that are essential to providing that baseline standard of quality, safety, and efficiency, and code requirements that are "aspirational".

Consumers can make a personal financial decision to purchase or build a home that is constructed to a higher energy efficiency standard, if that is an amenity that they are willing and able to afford. While energy efficiency requirements can reduce negative environmental externalities, promote high-quality housing stock, and protect consumers from soaring energy costs over time, the ability to afford the **upfront costs** of additional energy efficiency code requirements will vary widely by income.

The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs.

U.S. Department of Energy Data

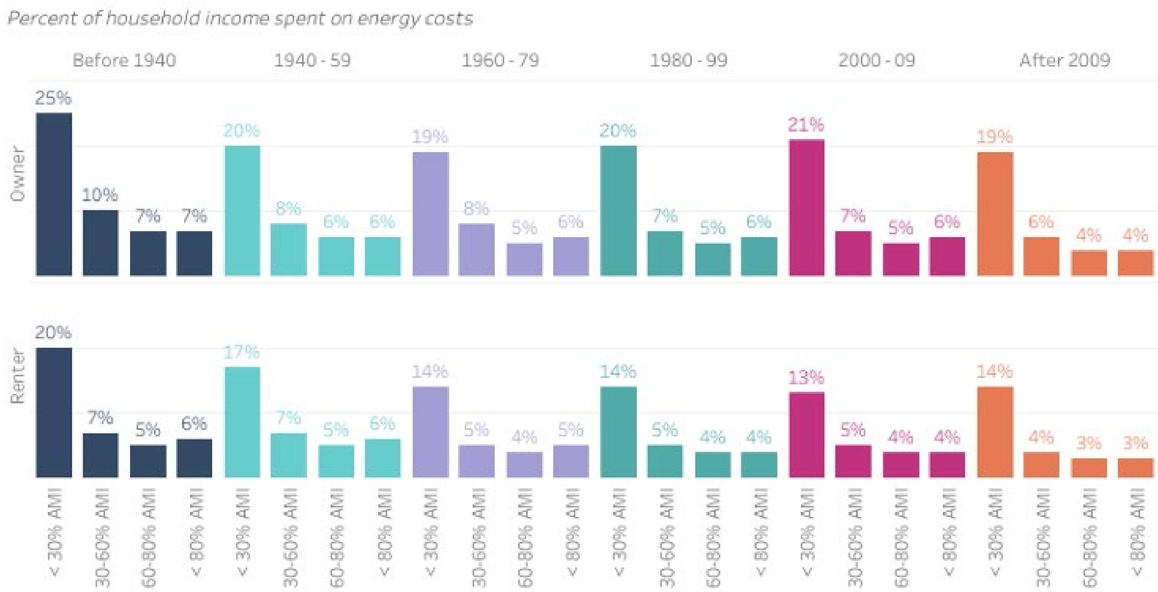
Data from the U.S. Department of Energy's *Low-Income Energy Affordability Data (LEAD) Tool* validates the claim that Virginia *has* made vast improvements in residential energy efficiency over the last 80 years and has significantly reduced household energy costs to a level considered sustainable for individuals and families across the income spectrum.

A household is considered "energy cost burdened" when over 6% of the household income is dedicated to covering energy bills – this calculation includes all costs associated with energy used by the house (e.g., electricity and natural gas). When a household is "energy cost burdened", it impacts their ability to use electricity and heat or cool their home – and forces households to choose between paying utility bills, paying a mortgage or rent, or other essential expenses. In short, high energy cost burdens results in higher levels of housing instability, including evictions and foreclosures.

The chart below was compiled using data from the U.S. Department of Energy and included in a recent report released by Virginia Housing (formerly, Virginia Housing Development Authority) and the Department of Housing and Community Development[1].

[1] HB 854 Statewide Housing Study Report (January 2022)

Energy cost burden by tenure, year home built, and AMI



Source: National Renewable Energy Laboratory, Low-Income Energy Affordability Data (LEAD) Tool, 2018.

The data from the U.S. Department of Energy (chart above) provides several important insights:

First, renters and owners residing in residential structures built since 2000 are below the 6% "energy cost burdened" threshold, with two exceptions: (i) Owner households in structures built between 2000 and 2009 are slightly over the 6% energy cost burdened threshold; (ii) Owners and renters with incomes below 30% of AMI residing in structures built between 2000 and 2019 are experiencing extremely high energy cost burdens. More analysis is needed to understand the latter - there are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Second, the highest "energy cost burdened" households (owner and renter) are residing in structures built prior to 1980's/1990's. The most "energy cost burdened" demographic – regardless of age of structure – are households earning under 30% AMI. Again, more analysis is needed to understand this dynamic. There are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Conclusion:

Data from the U.S. Department of Energy shows that residential structures constructed in the last 20 years are significantly more energy efficient than older homes, which has reduced household energy costs to levels considered sustainable for individuals and families across the income spectrum. The data also reflects the reality that efforts to reduce household energy cost burdens would be best focused on older, existing structures occupied by individuals and families at the lower end of the income spectrum.

Several energy proposals submitted during the 2021 code cycle seek to impose stricter energy efficiency requirements on all new homes, thus increasing the upfront cost of all new homes and exacerbating an issue raised by the Virginia Joint Legislative Audit and Review Commission's recent report on housing affordability: "Rising prices make it more difficult for low- and middle-income households to afford to purchase homes because of the increased monthly mortgage costs, as well as the increased upfront costs associated with purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes.[2]"

[2] Joint Legislative Audit and Review Commission: Affordable Housing in Virginia (2021)

B105.1.1-21

Proponents: Resiliency Sub-Workgroup

2018 Virginia Construction Code

Revise as follows:

105.1.1 Qualifications of building official. The *building official* shall have at least 5 years of *building* experience as a licensed professional engineer or architect, *building*, fire or trade inspector, contractor, housing inspector or superintendent of *building*, fire or trade *construction* or at least 5 years of *building* experience after obtaining a degree in architecture or engineering, with at least 3 years in responsible charge of work. Any combination of education and experience that would confer equivalent knowledge and ability shall be deemed to satisfy this requirement. The *building official* shall have general knowledge of sound engineering practice in respect to the design and *construction* of *structures*, the basic principles of fire prevention, the accepted requirements for means of egress and the installation of elevators and other service equipment necessary for the health, safety and general welfare of the occupants and the public. The building official shall have general knowledge of the principles and requirements of floodplain and high-velocity wind *construction*. The *local governing body* may establish additional qualification requirements.

105.2.1 Qualifications of technical assistants. A *technical assistant* shall have at least 3 years of experience and general knowledge in at least one of the following areas: *building construction*; *building construction* conceptual and administrative processes; *building*, fire or housing inspections; plumbing, electrical or mechanical trades; or fire protection, elevator or property maintenance work. Any combination of education and experience that would confer equivalent knowledge and ability, including high school technical training programs or college engineering, architecture, or construction degree programs, shall be deemed to satisfy this requirement. Technical assistants shall have general knowledge of the principles and requirements of floodplain and high-velocity wind *construction*. The *locality* may establish additional qualification requirements.

Reason Statement: This proposal comes from the Resiliency Sub-workgroup and seeks to increase the knowledge base of building officials and technical assistants by requiring people in these positions to have general knowledge of the principles and requirements of floodplain and high-velocity wind construction.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
None

Resiliency Impact Statement: This proposal will increase Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- ☐ Approved
- ☐ Approved with Modifications
- ☐ Carryover
- ☐ Disapproved
- ☐ None

Public Comments for: B105.1.1-21

Discussion by Paul Messplay

Aug 18, 2022 11:46 UTC

Proponents: Michael Redifer, representing self requests Disapprove

Commenter's Reason: The USBC and referenced model codes and standards contain specific criteria regarding design of structures to resist flood and wind damage where such hazards exist. This proposal suggests that building officials and permit technicians are not aware of minimum code requirements. General knowledge of the USBC includes these any many more hazards which must be considered when review for code compliance is conducted. Additionally, the term "high-velosity wind construction" is not defined and even if it were, it is doubtful such loads exist in all jurisdictions. This proposal could be interpreted in such a way as to negatively impact individuals seeking related employment within the Commonwealth.

Bibliography: Disapproval of this proposal will have no effect on the resiliency of buildings and structures because the provisions of the code which contribute to resiliency remain in the code.

Proposal # 1160

B105.1.1-21 – Staff Summary

Proponent: Resiliency Sub-Workgroup

Brief Description:

The proposal adds general knowledge of the principles and requirements of floodplain and high-velocity wind construction to the required minimum qualifications for building officials and technical assistants.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was drafted and submitted by DHCD staff on behalf of the Resiliency Sub-Workgroup based on language agreed to by the Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on 04/27/2022.
The first iteration of the proposal, drafted by George Homewood, applied only to building officials in Coastal Virginia localities.

- Steve Sunderman wondered why would this apply only to building officials and technical assistants in Coastal Virginia localities; and suggested that it should apply universally, to all building officials and technical assistants throughout the Commonwealth.
- George Homewood clarified that he is not opposed to the idea but he had limited the scope to Coastal Virginia so that it would be more acceptable.
- The Sub-Workgroup members in attendance decided to revise the proposal to include all the building officials and technical assistants.

Resiliency Sub-Workgroup members in attendance:

- Andrew Grigsby: Viridiant
- Angela Davis: Virginia Department of Conservation and Recreation (DCR)
- George Homewood: City of Norfolk, Planning Director
- John Harbin: Hampton Roads Planning District Commission (HRPDC)
- Raka Goyal: Virginia Department of General Services (DGS), Division of Engineering and Buildings (DEB)
- Richard Gordon: Virginia Building & Code Officials Association (VBCOA)
- Steve Shapiro: Apartment and Office Building Association (AOBA); Virginia Apartment and Management Association (VAMA)
- Steve Sunderman: Resilient Virginia
- Traci Munyan: DHCD, Resiliency
- Rebecca Quinn: Federal Emergency Management Agency (FEMA) *alternate voting member standing in for Charles Baker

Note: Debbie Messmer: Virginia Department of Emergency Management (VDEM), abstained.

Resiliency Sub-Workgroup members not in attendance:

- Joel Andre: American Institute of Architects (AIA) – Virginia Chapter

- Kenneth Somerset: Virginia Floodplain Management Association (VFMA)
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Casey Littlefield: International Association of Electrical Inspectors (IAEI) – Virginia Chapter
- Andrew Clark: Home Builders Association of Virginia (HBAV)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Steve Shapiro, AOBA and VAMA

- Steve Shapiro, AOBA and VAMA, speaking as a Resiliency Sub-Workgroup member, testified that the Sub-Workgroup thought it was necessary to highlight flood plain and high-velocity wind construction, as they are important to resiliency. The proposal intentionally uses "general knowledge" as those terms are already found in the code.

Opposition:

Names: David Beahm, representing self; Jason Laws, Chesterfield County; Andrew Clark, HBAV; Andrew Milliken, representing self; Shahriar Amiri, Arlington County; Allison Cook, Arlington County.

- David Beahm, representing self, expressed concerns about the proposal in that it creates an extensive list of required qualifications which are already covered under the "sound engineering practice" provisions already stipulated by the existing code requirements.
- Jason Laws, Chesterfield County, indicated that the proposed requirement is acceptable for building officials but not for technical assistants.
- Several other stakeholders, including Andrew Clark - HBAV; Andrew Milliken, representing self; Shahriar Amiri, Arlington County; and Allison Cook, Arlington County, agreed with Jason Laws' testimony.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 56; Tab 11 - Page 69.

B113.3-21

Proponents: Resiliency Sub-Workgroup

2018 Virginia Construction Code

Revise as follows:

113.3 Minimum inspections. The following minimum inspections shall be conducted by the *building official* when applicable to the *construction* or permit:

1. Inspection of footing excavations and reinforcement material for concrete footings prior to the placement of concrete.
2. Inspection of foundation systems during phases of *construction* necessary to assure compliance with this code.
3. Inspection of preparatory work prior to the placement of concrete.
4. Inspection of the elevation of the *lowest floor* in accordance with Section 113.3.2 prior to further vertical construction located in any *flood hazard area* or *special flood hazard area*.

~~4.~~ 5. Inspection of structural members and fasteners prior to concealment.

~~5.~~ 6. Inspection of electrical, mechanical and plumbing materials, *equipment* and systems prior to concealment.

~~6.~~ 7. Inspection of energy conservation material prior to concealment.

8. Inspection in accordance with Section 113.3.3 prior to final inspection located in any *flood hazard area* or *special flood hazard area*.

~~7.~~ 9. Final inspection.

Reason Statement: This proposal comes from the Resiliency Sub-workgroup and seeks to delineate specific inspection requirements for buildings and structures in flood hazard areas and special flood hazard areas.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
None.

Resiliency Impact Statement: This proposal will increase Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: B113.3-21

Discussion by Paula Eubank
Aug 18, 2022 11:43 UTC

In support of the code proposal, although the technical language must be accurate and the term definitions must be consistent prior to codification.

The inspection and measurement requirements to establish the structure elevation are stipulated in the FEMA NFIP and may be applied or measured differently dependent upon the structure location in Coastal High Hazard Area Zone V or Zone A. The FEMA and NFIP Glossary (59.1) defines the three terms Lowest Floor, Lowest Floor Elevation, and Lowest Horizontal Structural Member separately and uniquely.

Further references to VCC Sections 1612.4 and 1612.5 in Sections 113.3.2 and 113.3.3, respectively, identify those inspection and measurement requirements relative to certain conditions and the structure location, including the mandated elevation certification or documentation requirements.

FEMA NFIP Substantiating Documentation:

Glossary –

· Lowest Horizontal Structural Member:

In V Zones, new construction must have the elevation of the lowest horizontal structural member at or above the Base Flood Elevation (BFE). Horizontal structural members are obstructions and can transmit the force of wave impacts to rest of the structure. This elevation is used as the reference level to determine insurance rates. This contrasts with construction and insurance rating in A Zones, which uses the elevation of the lowest floor including basement as the reference level This requirement is to keep the entire building in a V Zone above the anticipated breaking wave height of a base flood storm surge.

In an elevated building, the lowest beam, joist, or other horizontal member that supports the building is the lowest horizontal structural member. Grade beams installed to support vertical foundation members where they enter the ground are not considered lowest horizontal members.

National Flood Insurance Program Requirements:

60.3 – Floodplain management criteria for floodprone areas

(e)(4) – V Zone Elevation Requirement

· Lowest Floor:

The lowest floor of the lowest enclosed area (including basement). An unfinished or flood resistant enclosure, usable solely for parking of vehicles, building access or storage in an area other than a basement area is not considered a building's lowest floor, provided, that such enclosure is not built so as to render the structure in violation of the applicable non-elevation design requirements of Section 60.3.

Communities are required to obtain the elevation of the lowest floor (including basement) of all new and substantially improved structures.

All new and substantially improved structures must have the lowest floor elevated to or above the Base Flood Elevation (BFE). Non-residential buildings may be floodproofed below the BFE.

National Flood Insurance Program Requirements:

59.1 – Definitions

60.3 (b) (5) i – Floodplain management criteria for floodprone areas

· Lowest Floor Elevation (LFE)

The measured distance of a building's lowest floor above the National Geodetic Vertical Datum (NGVD) or other datum specified on the FIRM for that location.

NFIP – National Flood Insurance Program:

Glossary Section

Proposal # 1161

B113.3-21 – Staff Summary

Proponent: Resiliency Sub-Workgroup

Brief Description:

The proposal requires the building official to perform an inspection of the lowest floor elevation, prior to vertical construction and prior to final inspection, on projects located in flood hazard area or special flood hazard area.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

Proposal drafted and submitted by DHCD staff on behalf of the Resiliency Sub-Workgroup based on language agreed to by the Sub-Workgroup members in attendance at the Sub-workgroup's meeting on 04/27/2022.

Resiliency Sub-Workgroup members in attendance:

- Andrew Grigsby: Viridiant
- Angela Davis: Virginia Department of Conservation and Recreation (DCR)
- George Homewood: City of Norfolk, Planning Director
- Debbie Messmer: Virginia Department of Emergency Management (VDEM)
- Raka Goyal: Virginia Department of General Services (DGS), Division of Engineering and Buildings (DEB)
- Richard Gordon: Virginia Building and Code Officials Association (VBCOA)
- Steve Shapiro: Apartment and Office Building Association (AOBA); Virginia Apartment and Management Association (VAMA)
- Steve Sunderman: Resilient Virginia
- Traci Munyan: DHCD, Resiliency
- Rebecca Quinn: Federal Emergency Management Agency (FEMA) *alternate voting member standing in for Charles Baker

Note: John Harbin: Hampton Roads Planning District Commission (HRPDC) was away from the room at the moment and did not vote on the proposed language.

The following Resiliency Sub-Workgroup members were not in attendance at the 04/27/2022 meeting:

- Joel Andre: American Institute of Architects (AIA), Virginia
- Kenneth Somerset: Virginia Floodplain Management Association (VFMA)
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Casey Littlefield: International Association of Electrical Inspectors (IAEI), Virginia
- Andrew Clark: Home Builders Association of Virginia (HBAV)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support: Rebecca Quinn, FEMA; Paula Eubanks, FEMA.

Names:

- Rebecca Quinn, FEMA, pointed out that the same inspections are in the I-Codes. She also suggested that the proposal should say "*as part of the foundation inspection, submission of elevation documentation is required*" so that there's no judgement needed by the inspector, just submission of documents. Documentation gets reviewed back in the office. Also, submission of elevation documents are needed prior to final inspection.
- Paula Eubank, in response to one of the opposing comments, stated that the field inspection is a verification of the elevation certificate and the floor elevation by use of documentation submitted.

Opposition:

Names: David Beahm; Shahriar Amiri, Arlington County.

- David Beahm indicated that building officials may not be qualified to do elevation inspections, so he is concerned about not having provisions for a third-party inspector approval process. He objects to this proposal as it is written, as well as where it is located.
- Shahriar Amiri, Arlington County, agreed with David Beahm.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 58; Tab 11 - Page 70.

RB302.13-21

Proponents: Andrew Milliken (amilliken@staffordcountyva.gov)

2018 Virgina Residential Code

Revise as follows:

R302.13 Fire protection of floors. ~~(Section deleted.)~~

Floor assemblies that are not required elsewhere in this code to be fire-resistance rated, shall be provided with a 1/2-inch (12.7 mm) gypsum wallboard membrane, 5/8-inch (16 mm) *wood structural panel* membrane, or equivalent on the underside of the floor framing member. Penetrations or openings for ducts, vents, electrical outlets, lighting, devices, luminaires, wires, speakers, drainage, piping and similar openings or penetrations shall be permitted.

Exceptions:

1. Floor assemblies located directly over a space protected by an automatic sprinkler system in accordance with Section P2904, NFPA 13D, or other *approved* equivalent sprinkler system.
2. Floor assemblies located directly over a *crawl space* not intended for storage or for the installation of fuel-fired or electric-powered heating *appliances* .
3. Portions of floor assemblies shall be permitted to be unprotected where complying with the following:
   3.1. The aggregate area of the unprotected portions does not exceed 80 square feet (7.4 m^2) per story.
   3.2. Fireblocking in accordance with Section R302.11.1 is installed along the perimeter of the unprotected portion to separate the unprotected portion from the remainder of the floor assembly.
4. Wood floor assemblies using dimension lumber or *structural composite lumber* equal to or greater than 2-inch by 10-inch (50.8 mm by 254 mm) nominal dimension, or other *approved* floor assemblies demonstrating equivalent fire performance.

Reason Statement: This proposal simply seeks to restore the 2021 International Residential Code regarding the protection of floor assemblies which was deleted from the VRC when initially introduced in the 2012 IRC. The code compliance solutions for section R302.13, have come a long way since the original requirement in R501.3 of the 2012 International Residential Code. New equivalency paths, and even a new ASTM E119 standard have been developed to support the implementation of this section. None of these new developments have been considered in Virginia since it was originally deleted from the 2012 VRC. This section was found to be a common ground for a number of partner agencies on the national level and is paramount to ensuring the safety of occupants and first responders. It should be reconsidered once again in Virginia, particularly where homes are not required to be equipped with a fire sprinkler system. This proposal is to simply follow the 2021 IRC regarding this section and all the exceptions or equivalencies afforded by the current model code language.
"The American Wood Council partnered with the International Association of Firefighters, International Association of Fire Chiefs, and the National Association of Homebuilders, to develop a code change that was included in the 2012 edition of the International Residential Code (IRC). The IRC requires floor framing members to be protected with a membrane consisting of either 1/2-inch gypsum wallboard, 5/8-inch wood structural panel (plywood, oriented-strand board [OSB] or composite panels), or equivalent. There are exceptions to the requirement for fire protection of floors, as described in Section R302.13 of the 2021 IRC. These exceptions include: 1) floor assemblies over an area protected by a sprinkler system, 2) floor assemblies located directly over a crawl space not intended for storage or heating appliances, 3) small areas up to 80 ft^2 of the floor assembly separated from the remainder of the floor assembly by fireblocking, and 4) floor assemblies framed with dimension lumber or structural composite lumber equal to or greater than 2-inch by 10-inch nominal dimension, or other approved floor assemblies demonstrating equivalent fire performance. A new ASTM standard was recently published, which provides a consistent and clear methodology for determining equivalent fire performance of floors when subjected to an ASTM E119 fire exposure. A reference to ASTM D8391 – Standard Specification for Demonstrating Equivalent Fire Performance for Wood-Based Floor Framing Members to Unprotected 2 by 10 Dimension Lumber or Equal-Sized Structural Composite Lumber has been submitted for consideration..." - American Wood Council *Woodpost* 2.21.22

"...basement fires present significant safety issues for firefighters. An Underwriters Laboratory (UL) study in conjunction with the National Institute of Standards and Technology (NIST) established the universal instability of all types of floor construction during a basement fire. There are no reliable and repeatable warning signs of collapse, and there is no way to know when it is safe to operate on top of a basement fire.6 In addition to unpredictable changes in flow paths, other aspects of basements that pose threats to firefighters include limited access, cluttered storage, and nonstandard room and furnishings arrangement." - United States Fire Administration, *One- and Two-Family Residential Building Basement Fires*, March 2015.

"The change addresses concerns for firefighter safety and incidents of injury or death to firefighters while fighting residential fires due to the collapse of floors. The application of gypsum wallboard or other approved material intends to provide some protection to the floor system against the effects of fire and delay collapse of the floor. This provision primarily is aimed at light-frame construction consisting of I-joists, manufactured floor trusses, cold-formed steel framing, and other materials and manufactured products considered most susceptible to collapse in a fire." - International Code Council, IRC Significant Changes page 69-70.

https://www.apawood.org/Data/Sites/1/documents/fireprotection/basis-of-irc-membrane-protection-provisions.pdf

https://www.cdc.gov/niosh/docs/wp-solutions/2009-114/pdfs/2009-114.pdf?id=10.26616/NIOSHPUB2009114

https://westfordma.gov/DocumentCenter/View/51/I-Joist-Floor-Protection-Systems-PDF

https://d1gi3fvbl0xj2a.cloudfront.net/files/2021-07/2009_NIST_ARRA_Compilation_Report.pdf

http://media.iccsafe.org/news/eNews/2013v10n4/2012_irc_sigchanges_p69-70.pdf

https://www.usfa.fema.gov/downloads/pdf/statistics/v15i10.pdf

Cost Impact: The code change proposal will increase the cost of construction
This proposal is expected to increase the cost of construction within Virginia as this section has been previously deleted. Since the section was originally deleted in the 2012 edition, significant options and equivalencies have been developed to reduce the cost of compliance. The proposal is simply to follow the model code for this section which is already in effect in surrounding states.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal increases the resiliency of residential construction by enhancing the fire protection afforded to exposed floor assemblies.

Attached Files

- **Wooden I-joist Failure - DSC_0074.pdf**
  https://va.cdpaccess.com/proposal/999/1557/files/download/673/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: RB302.13-21

This proposal doesn't have any public comments.

RB302.13-21 – Staff Summary

Proponent: Andrew Milliken

Brief Description:

The proposal re-instates the IRC provisions for the underside protection of floor systems with ½” drywall, 5/8” wood structural panels, or equivalent, if the floor systems are not required to be fire-resistance rated by other sections of the code.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Jeff Shapiro, representing self.

- Jeff Shapiro, representing self, testified that this proposal brings Virginia back in-line with the model codes and this code provision was a collaboration between the National Association of Homebuilders and fire services to protect fire safety.

Opposition:

Names: Anthony Clatterbuck, representing self.

- Anthony Clatterbuck, representing self, testified that requiring drywall on the underside of a basement or crawlspace would be costly, require more labor, and could cause mold, especially in unconditioned spaces.
  Note: Jeff Shapiro argued that there are other options allowed by the code besides drywall.

DHCD Staff Notes: *N/A*

Meeting summaries and proposal related information: Tab 10 - Page 96.

RM1601.4.11-21

Proponents: DHCD Staff (sbco@dhcd.virginia.gov)

2021 International Residential Code

Add new text as follows:

1601.4.11 Registers, grilles and diffusers. Duct registers, grilles and diffusers shall be installed in accordance with the manufacturer's instructions.

1601.4.11.1 Prohibited locations. Diffusers, registers and grilles shall be prohibited in the floor or its upward extension within toilet and bathing rooms

Reason Statement: This proposal was created by staff in response to a request from Delegate Bulova to address a concern about floor registers in toilet and bathing spaces. When a toilet overflows, contaminated water will spill onto the floor and flow down into the supply duct. In order to sanitize the duct, the HVAC system must be turned off, the sewage must be pumped from the ductwork, and then the ductwork will need to be sanitized. If the HVAC fan happens to be running when the toilet overflows, sewage particulates will be sprayed into the air.

Cost Impact: The code change proposal will increase the cost of construction
The proposal could increase the cost of construction for certain homes where the HVAC system is located in the crawlspace and the duct would have to be routed within a wall cavity to an elevation above the bathroom floor, so that the register could be installed above the bathroom floor.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

Attached Files

- **Delegate Bulova Letter.pdf**
  https://va.cdpaccess.com/proposal/1127/1575/files/download/813/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: RM1601.4.11-21

This proposal doesn't have any public comments.

Proposal # 1127

RM1601.4.11-21 – Staff Summary

Proponent: DHCD Staff

Brief Description:

The proposal prohibits the installation of diffusers, registers and grilles in the floor or its upward extension within toilet and bathing rooms.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Dan Willham, representing self

- Dan Willham, representing self, wanted to get on the record as supporting the proposal as a homeowner and architect.

Opposition:

Names: John Ainslie, Home Builders Association of Virginia (HBAV)

- John Ainslie, HBAV, expressed opposition to the proposal, indicated that it increases the cost of construction and asked whether there is any data on how problematic the current code is.

Additional (neutral) comments:

- Robert Glass, Daikin Comfort Technologies, did not support nor opposed the proposal but asked how registers would be added to a bathroom in a place other than the floor if the ductwork is in a crawlspace or basement and all registers are in the floor. If the ductwork and registers are in the attic, there's no conflict. He suggested saying instead that register shouldn't be within "xx" feet of a toilet or tub.
- Richard Grace, Virginia Plumbing and Mechanical Inspectors Association, and Virginia Building and Code Officials Association, did not support nor opposed the proposal, but answered to the question above by indicating that if the ductwork and HVAC unit are located in a crawlspace, the duct could be routed inside a wall and the register could be placed somewhere else, not on the floor.
- Andrew Clark, HBAV, noted that he had conversations with Delegate Bulova in the past in regards to this subject, recognized that there are legitimate concerns on both sides and requested for the proposal to move forward as non-consensus (vs. consensus for disapproval) in an effort to work through those concerns with Delegate Bulova prior to the Board of Housing and Development meeting later in the year.

DHCD Staff Notes:

- The proposal was submitted by DHCD staff in response to a request from Delegate Bulova. The language used in the proposal is the same language used in Section 603.18.2 of the 2018 Virginia Mechanical Code (which applies to all occupancies other than townhouses and one- and two-family dwellings).

Meeting summaries and proposal related information: Tab 10 - Page 103.

Commonwealth of Virginia

Moldovan, Florin <florin.moldovan@dhcd.virginia.gov>

Fwd: Building Code Suggestion

1 message

---------- Forwarded message ---------
From: **David Bulova** <delegate@davidbulova.com>
Date: Tue, Mar 23, 2021 at 9:37 PM
Subject: RE: Building Code Suggestion
To: Johnston, Erik <erik.johnston@dhcd.virginia.gov>

Thanks Eric -- much appreciated!

David L. Bulova

Sign up for my General Assembly updates at www.davidbulova.com

Virginia House of Delegates
37th District
Mail: P.O. Box 106, Fairfax Station, Va. 22039
Office: 9900 Main Street, Plaza 102, Fairfax, Va. 22031
(703) 310-6752
delegate@davidbulova.com

> -------- Original Message --------
> Subject: Re: Building Code Suggestion
> From: "Johnston, Erik" <erik.johnston@dhcd.virginia.gov>
> Date: Tue, March 23, 2021 6:58 am
> To: David Bulova <delegate@davidbulova.com>
> Cc: Andrew Clark <AClark@hbav.com>, Kristen Dahlman
> <Kristen.Dahlman@dhcd.virginia.gov>
>
> Delegate Bulova,
>
> Currently the USBC does not prohibit infloor location of HVAC vents in bathrooms. It is prohibited in commercial toilet and bathing room locations where a hard, nonabsorbent surface is required, but there is an exception for residential dwellings. So no code violation exists for the situation described. DHCD staff is happy to bring this up for discussion during the next code update cycle.
>
> Let me know if you need any additional information.
>
> Sincerely,
>
> Erik
>
> On Sun, Mar 21, 2021 at 10:26 PM David Bulova <delegate@davidbulova.com> wrote:
>> Hi Erik and Andrew -- I received the following from a constituent and thought she raised a valid/interesting issue. See below. Not sure if this is already addressed in the Virginia Uniform Building Code (and the contractor/County just missed it), or if it is something that ought to be considered in the next round.
>>
>> Anyway, would be interested in your thoughts.
>>
>> David
>>
>>> Dear Delegate Bulova,
>>>
>>> I am wondering who determines building code requirements in Virginia.

We put an addition on our house recently and I am convinced that the air vent location in the bathroom is a potential sanitary nightmare.

One air vent is located in the floor near the toilet. When (not if - eventually even the best toilet gets clogged) the toilet overflows, contaminated water will spill onto the floor and flow down into the air duct. Which means we will have to turn off the HVAC system, pump the overflow out of the ductwork and then sanitize the ductwork before we turn the HVAC system back on. If the HVAC fan happens to be running when the toilet overflows, contaminated water will be sprayed into the air.

Who can I contact to urge them to modify the building code to eliminate this sanitary hazard from future bathrooms?

Thanks,
Karen Grycewicz

David L. Bulova

Sign up for my General Assembly updates at www.davidbulova.com

Virginia House of Delegates
37th District
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--
Erik Johnston
Director
Virginia Department of Housing and Community Development (DHCD)
804.371.7077
erik.johnston@dhcd.virginia.gov

If you or someone you know is having difficulty in making rent payments due to the COVID-19 pandemic, you may be eligible for the Virginia Rent Relief Program (RRP). To find out if you may be eligible, visit www.dhcd.virginia.gov/eligibility. Mortgage relief applications are no longer being accepted at this time.

Join DHCD for Creating Community Vitality, a yearlong training series that is focused on building your place's identity, supportive ecosystems and community in a format promoting monthly education, inspiration and application. For more information on the monthly topics, to download a workbook or to register, visit virginiamainstreet.com.

--
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Join DHCD for Creating Community Vitality, a yearlong training series that is focused on building your place's identity, supportive ecosystems and community in a format promoting monthly education, inspiration and application. For more information on the monthly topics, to download a workbook or to register, visit virginiamainstreet.com.

EC-C1301.1.1.1-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Construction Code

Revise as follows:

1301.1.1.1 Changes to the International Energy Conservation Code (IECC). Error creating auto-diffed output. (0x01)
The following changes shall be made to the IECC:

1. ~~Add Sections C402.1.4.2, C402.1.4.2.1, C402.1.4.2.2, C402.1.4.2.3, C402.2.1.2, C402.2.1.3, C402.2.1.4, C402.2.1.5 and Change Section C402.2.1.1 to read:~~

   ~~**C402.1.4.2 Roof/ceiling assembly.** The maximum roof/ceiling assembly *U*-factor shall not exceed that specified in Table C402.1.4 based on *construction* materials used in the roof/ceiling assembly.~~

   ~~**C402.1.4.2.1 Tapered, above-deck insulation based on thickness.** Where used as a component of a maximum roof/ceiling assembly *U*-factor calculation, the tapered roof insulation *R*-value contribution to that calculation shall use the average thickness in inches (mm) along with the material *R*-value-per-inch (per-mm) for *U*-factor compliance as prescribed in Section C402.1.4.~~
   ~~**C402.1.4.2.2 Suspended ceilings.** Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the assembly *U*-factor of the roof/ceiling *construction.*~~
   ~~**C402.1.4.2.3 Multiple layers and staggered joints.** Continuous insulation board shall be installed in not less than two layers and the edge joints between each layer of insulation shall be staggered. Multiple layers and staggered joints are not required where insulation tapers to the *roof deck* at a gutter edge, roof drain or scupper.~~

   ~~**C402.2.1 Roof assembly** The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table C402.1.3, based on *construction* materials used in the *roof assembly.*~~

   ~~**C402.2.1.1 Tapered, above-deck insulation based on thickness.** Where used as a component of a roof/ceiling assembly *R*-value calculation, the tapered roof insulation *R*-value contribution to that calculation shall use the average thickness in inches (mm) along with the material *R*-value per inch (per mm) for *R*-value compliance as prescribed in Section C402.1.3.~~
   ~~**C402.2.1.2 Minimum thickness, lowest point.** The minimum thickness of above-deck roof insulation at its lowest point, gutter edge, roof drain or scupper, shall be no less than 1 inch (25 mm).~~
   ~~**C402.2.1.3 Suspended ceilings.** Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the minimum thermal resistance (*R*-value) of roof insulation in roof/ceiling *construction.*~~
   ~~**C402.2.1.4 Multiple layers and staggered joints.** Continuous insulation board shall be installed in not less than two layers and the edge joints between each layer of insulation shall be staggered. Multiple layers and staggered joints are not required where insulation tapers to the *roof deck* at a gutter edge, roof drain or scupper.~~
   ~~**C402.2.1.5 Skylight curbs.** Skylight curbs shall be insulated to the level of roofs with insulation entirely above the deck or R-5, whichever is less.~~

   ~~**Exception:** Unit skylight curbs included as a component of a skylight listed and labeled in accordance with NFRC 100 shall not be required to be insulated.~~

2. ~~Change the SHGC for Climate Zone 4 (Except Marine) of Table C402.4 to read:~~

~~3. Delete Section C402.4.1.2, change Sections C402.4.2, C402.4.2.1, C402.4.2.2 and C402.4.3.~~

~~**C402.4.2 Skylight area with daylight response controls.** The skylight area shall be permitted to be not more than 5 percent of the roof area provided daylight responsive controls complying with Section C405.2.3.1 are installed in daylight zones under skylights.~~

~~**C402.4.2.1 Daylight Zone Controls under skylights.** Daylight responsive controls complying with Section C405.2.3.1 shall be provided to control all electric lights within daylight zones under skylights.~~
~~**C402.4.2.2 Haze factor.** Skylights that are installed in office, storage, automotive service, manufacturing, nonrefrigerated warehouse, retail store and distribution/sorting area spaces shall have a glazing material or diffuser with a haze factor greater than 90 percent when tested in accordance with ASTM D1003.~~

~~**Exception:** Skylights designed and installed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles or the geometry of skylight and light well.~~

~~**C402.4.3 Maximum *U*-factor and SHGC.** The maximum *U*-factor and solar heat gain coefficient (SHGC) for fenestration shall be as specified in Table C402.4.~~

~~The window projection factor shall be determined in accordance with Equation 4-5.~~

PF = A/B ~~**(Equation 4-5)**~~

~~where:~~

~~PF = Projection factor (decimal).~~

~~A = Distance measured horizontally from the farthest continuous extremity of any overhand, eave, or permanently attached shading device to the vertical surface of the glazing.~~

~~B = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave, or permanently attached shading device.~~
~~Where different windows or glass doors have different PF values, they shall each be evaluated separately.~~

~~Where the fenestration projection factor for a specific vertical fenestration product is greater than or equal to 0.20, the required maximum SHGC from Table C402.4 shall be adjusted by multiplying the required maximum SHGC by the multiplier specified in Table C402.4.3 corresponding with the orientation of the fenestration product and the projection factor.~~

~~4. Add Table C402.4.3 to read:~~

~~5. Add an exception to the first paragraph of Section 403.7.7 to read:~~

~~**Exception:** Any grease duct serving a Type I hood installed in accordance with the *International Mechanical Code* (IMC) Section 506.3 shall not be required to have a motorized or gravity damper.~~

~~6. Add Section C403.2.2.1 to read:~~

~~**C403.2.2.1 Dwelling unit mechanical ventilation.** Mechanical ventilation shall be provided for *dwelling units* in accordance with the IMC.~~

~~7. Delete Section C403.7.5 and Table C403.7.5.~~

~~8. Delete Sections C404.5 through C404.5.2.1, including Tables.~~

~~9. Change Section C405.4 to read:~~

~~**C405.4 Exterior lighting (Mandatory).** All exterior lighting, other than low-voltage landscape lighting, shall comply with Section C405.4.1.~~

~~**Exception:** Where *approved* because of historical, safety, signage, or emergency considerations.~~

~~10. Change Section C502.1 to read:~~

~~**C502.1 General.** Additions to an existing building, building system or portion thereof shall conform to the provisions of Section 805 of the *Virginia Existing Building Code* (VEBC).~~

11. Delete Sections C502.2 through C502.2.6.2.

12. Change Section C503.1 to read:

C503.1 General. Alterations to any *building* or *structure* shall comply with the requirements of Chapter 6 of the VEBC.

13. Delete Sections C503.2 through C503.6.

14. Change Section C504.1 to read:

C504.1 General. *Buildings* and *structures*, and parts thereof, shall be repaired in compliance with Section 510 of the VEBC.

15. Delete Section C504.2.

16. Change Section R401.2 to read:

R401.2 Compliance. Projects shall comply with all provisions of Chapter 4 labeled "Mandatory" and one of the following:

1. Sections R401 through R404.
2. Section R405.
3. Section R406.
4. The most recent version of REScheck, keyed to the 2018 IECC.

17. Change Section R401.3 to read:

R401.3 A permanent certificate shall be completed by the builder or other *approved* party and posted on a wall in the space where the furnace is located, a utility room or an *approved* location inside the *building*. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label, or other required labels. Where *approved*, certificates for multifamily *dwelling units* shall be permitted to be located off-site at an identified location. The certificate shall indicate the predominant *R*-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, basement walls, crawl space walls and floors, and ducts outside conditioned spaces; *U*-factors of fenestration and the solar heat gain coefficient (SHGC) of fenestration; and the results from any required duct system and *building* envelope air leakage testing performed on the *building*. Where there is more than one value for each component, the certificate shall indicate the value covering the largest area. The certificate shall indicate the types and efficiencies of heating, cooling, and service water heating *equipment*. Where a gas-fired unvented room heater, electric furnace, or baseboard electric heater is installed in the residence, the certificate shall indicate "gas-fired unvented room heater," "electric furnace," or "baseboard electric heater," as appropriate. An efficiency shall not be indicated for gas-fired unvented room heaters, electric furnaces, and electric baseboard heaters.

18. Change the wood frame wall *R*-value categories for Climate Zone 4 (Except Marine) in Table R402.1.2 to read:

19. Change the frame wall *U*-factor categories for Climate Zone 4 (Except Marine) in Table R402.1.4 to read:

20. Change Section R402.2.4 to read:

R402.2.4 Access hatches and doors. Access doors from conditioned spaces to unconditioned spaces (e.g., *attics* and crawl spaces) shall be weatherstripped and insulated in accordance with the following values:

1. Hinged vertical doors shall have a minimum overall R-5 insulation value;
2. Hatches and scuttle hole covers shall be insulated to a level equivalent to the insulation on the surrounding surfaces; and
3. Pull down stairs shall have a minimum of 75 percent of the panel area having R-5 rigid insulation.

Access shall be provided to all *equipment* that prevents damaging or compressing the insulation. A wood framed or equivalent baffle or retainer is required to be provided when loose fill insulation is installed, the purpose of which is to prevent the loose fill insulation from spilling into the living space when the attic access is opened and to provide a permanent means of maintaining the installed *R*-value of the loose fill insulation.

21. Change Sections R402.4 and R402.4.1.1 to read:

R402.4 Air leakage. The *building* thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.5.

R402.4.1.1 Installation (Mandatory). The components of the *building* thermal envelope as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in Table R402.4.1.1, as applicable to the method of *construction*. Where required by the code official, an *approved* third party shall inspect all components and verify compliance.

22. Change the title of the "Insulation Installation Criteria" category of Table R402.4.1.1; change the "Shower/tub on exterior wall" category of Table R402.4.1.1, and add footnotes "b" and "c" to Table R402.4.1.1 to read:

23. Change Section R402.4.1.2 to read:

R402.4.1.2 Testing. The *building* or *dwelling unit* shall be tested and verified as having an air leakage rate not exceeding five air changes per hour in Climate Zone 4. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). A written report of the results of the test shall be signed by the party conducting the test and provided to the *building official*. Testing shall be conducted by a Virginia licensed general contractor, a Virginia licensed HVAC contractor, a Virginia licensed home inspector, a Virginia *registered design professional*, a certified BPI Envelope Professional, a certified HERS rater, or a certified duct and envelope tightness rater. The party conducting the test shall have been trained on the *equipment* used to perform the test. Testing shall be performed at any time after creation of all penetrations of the *building* thermal envelope.

Note: Should additional sealing be required as a result of the test, consideration may be given to the issuance of a temporary certificate of occupancy in accordance with Section 116.1.1.

During testing:

1. Exterior windows and doors and *fireplace* and stove doors shall be closed, but not sealed beyond the intended weatherstripping or other infiltration control measures;
2. Dampers, including exhaust, intake, makeup air, backdraft, and flue dampers, shall be closed, but not sealed beyond intended infiltration control measures;
3. Interior doors, if installed at the time of the test, shall be open;
4. Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling systems, if installed at the time of the test, shall be turned off; and
6. Supply and return registers, if installed at the time of the test, shall be fully open.

24. Change Section R403.3.3 to read:

R403.3.3 Duct testing (Mandatory). Ducts shall be pressure tested to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.
2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exception: A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.

A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. The licensed mechanical contractor installing the mechanical system shall be permitted to perform the duct testing. The contractor shall have been trained on the equipment used to perform the test.

25. Delete Section R403.3.5.

26. ~~Change Section R403.7 to read:~~

~~**R403.7 Equipment and appliance sizing.** Heating and cooling equipment and appliances shall be sized in accordance with ACCA Manual S or other *approved* sizing methodologies based on *building* loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies.~~

~~**Exception:** Heating and cooling equipment and appliance sizing shall not be limited to the capacities determined in accordance with Manual S or other *approved* sizing methodologies where any of the following conditions apply:~~

1. ~~The specified equipment or appliance utilizes multistage technology or variable refrigerant flow technology and the loads calculated in accordance with the *approved* heating and cooling methodology fall within the range of the manufacturer's published capacities for that equipment or appliance.~~
2. ~~The specified equipment or appliance manufacturer's published capacities cannot satisfy both the total and sensible heat gains calculated in accordance with the *approved* heating and cooling methodology and the next larger standard size unit is specified.~~
3. ~~The specified equipment or appliance is the lowest capacity unit available from the specified manufacturer.~~

27. ~~Change footnote "a" in Table R406.4 to read:~~

a. ~~When onsite renewable energy is included for compliance using the ERI analysis of Section R406.4, the building shall meet the mandatory requirements of Section R406.2 and the building thermal envelope shall be greater than or equal to levels of energy efficiency and solar heat gain coefficient in Table R402.1.2, with a ceiling *R*-value of 49 and a wood frame wall *R*-value of 20 or 13 + 5, or Table R402.1.4, with a ceiling *U*-factor of 0.026 and a frame wall *U*-factor of 0.060.~~

28. ~~Change Section R501.1 to read:~~

~~**R501.1 Scope.** The provisions of the *Virginia Existing Building Code* (VEBC) shall control the alteration, repair, addition and change of occupancy of existing *buildings* and *structures*.~~

29. ~~Delete Sections R501.1.1 through R501.6.~~
30. ~~Change Section R502.1 to read:~~

~~**R502.1 General.** Additions to an existing *building*, *building* system or portion thereof shall conform to the provisions of Section 811 of the VEBC.~~

31. ~~Delete Sections R502.1.1 through R502.1.2.~~
32. ~~Change Section R503.1 to read:~~

~~**R503.1 General.** Alterations to any *building* or *structure* shall comply with the requirements of Chapter 6 of the VEBC.~~

33. ~~Delete Sections R503.1.1 through R503.2~~
34. ~~Change Section R504.1 to read:~~

~~**R504.1 General.** *Buildings*, structures and parts thereof shall be repaired in compliance with Section 510 of the VEBC.~~

35. ~~Delete Section R504.2.~~

2018 Virginia Energy Conservation Code

Delete without substitution:

~~TABLE C402.4 BUILDING ENVELOPE FENESTRATION MAXIMUM U-FACTOR AND SHGC REQUIREMENTS~~

~~CLIMATE ZONE~~	~~1~~	~~2~~	~~3~~	~~4 EXCEPT MARINE~~	~~5 AND MARINE 4~~	~~6~~	~~7~~	~~8~~
~~Vertical fenestration~~								
~~U-factor~~								
~~Fixed fenestration~~	~~0.50~~	~~0.50~~	~~0.46~~	~~0.38~~	~~0.38~~	~~0.36~~	~~0.29~~	~~0.29~~
~~Operable fenestration~~	~~0.65~~	~~0.65~~	~~0.60~~	~~0.45~~	~~0.45~~	~~0.43~~	~~0.37~~	~~0.37~~
~~Entrance doors~~	~~1.10~~	~~0.83~~	~~0.77~~	~~0.77~~	~~0.77~~	~~0.77~~	~~0.77~~	~~0.77~~
~~SHGC~~								
~~SHGC~~	~~0.25~~	~~0.25~~	~~0.25~~	~~0.36~~	~~0.40~~	~~0.40~~	~~0.45~~	~~0.45~~
~~Skylights~~								
~~U-factor~~	~~0.75~~	~~0.65~~	~~0.55~~	~~0.50~~	~~0.50~~	~~0.50~~	~~0.50~~	~~0.50~~
~~SHGC~~	~~0.35~~	~~0.35~~	~~0.35~~	~~0.40~~	~~0.40~~	~~0.40~~	~~NR~~	~~NR~~

~~NR = No Requirement~~

Revise as follows:

~~TABLE C402.4.3 SHGC ADJUSTMENT MULTIPLIERS~~

~~PROJECTION FACTOR~~	~~ORIENTED WITHIN 45 DEGREES OF TRUE NORTH~~	~~ALL OTHER ORIENTATIONS~~
~~0.2 ≤ PF < 0.5~~	~~1.1~~	~~1.2~~
~~PF ≥ 0.5~~	~~1.2~~	~~1.6~~

TABLE R402.1.2 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT [a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR [b]	SKYLIGHT [b] *U*-FACTOR	GLAZED FENESTRATION SHGC [b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE [i]	FLOOR *R*-VALUE	BASEMENT [c] WALL *R*-VALUE	SLAB [d] *R*-VALUE & DEPTH	CRAWL SPACE [c] WALL *R* VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13+5 [h]	8/13	19	5/13 [f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	15 or 13+1 [h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13+5 [h]	13/17	30 [g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20+5 [h] or 13+10 [h]	15/20	30 [g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20+5 [h] or 13+10 [h]	19/21	38 [g]	15/19	10, 4 ft	15/19

NR = Not Required.

For SI: 1 foot = 304.8 mm.

a. R-values are minimums. U-factors and SHGC are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed R-value of the insulation shall be not less than the R-value specified in the table.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.

Exception: In Climate Zones 1 through 3, skylights shall be permitted to be excluded from glazed fenestration SHGC requirements provided that the SHGC for such skylights does not exceed 0.30.

c. "10/13" means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation on the interior of the basement wall.

"15/19" means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. Alternatively, compliance with "15/19" shall be R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home.

d. R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation *R*-value for slabs. as indicated in the table. The slab edge insulation for heated slabs shall not be required to extend below the slab.

e. There are no SHGC requirements in the Marine Zone.

f. Basement wall insulation is not required in warm-humid locations as defined by Figure R301.1 and Table R301.1.

g. Alternatively, insulation sufficient to fill the framing cavity and providing not less than an *R*-value of R-19.

h. The first value is cavity insulation, the second value is continuous insulation. Therefore, as an example, "13+5" means R-13 cavity insulation plus R-5 continuous insulation.

i. Mass walls shall be in accordance with Section R402.2.5. The second R-value applies where more than half of the insulation is on the interior of the mass wall.

Delete without substitution:

~~TABLE R402.1.4 EQUIVALENT U-FACTORS [a]~~

~~**TABLE R402.4.1.1 AIR BARRIER AND INSULATION INSTALLATION [a]**~~

Reason Statement: This proposal is intended to fully adopt and implement the 2021 IECC by eliminating exceptions that the Base Document would cause to displace language in the 2021 IECC. Full adoption of the 2021 IECC will carry out Virginia law and protect both residents and the public generally.

The BHCD's NOIRA published November 22, 2021, https://townhall.virginia.gov/L/viewstage.cfm?stageid=9475 states:

> "The 2021 editions of the International Codes are now completed and available from ICC. *The use of the newest available model codes and standards in the USBC assures that the statutory mandate is met to base the regulation on the latest editions of nationally recognized model codes to assure the protection of the health, safety and welfare of the residents of Virginia and that buildings and structures are constructed and maintained at the least possible cost.*"

The BHCD's NOIRA also states: "As the basis for Virginia's building code it is important to stay in sync with the national model codes." These statements are consistent with Section 36-99A of the Virginia Code has long prescribed that the purposes of the USBC are to protect the public and implement recognized standards of energy conservation and water conservation:

> "The provisions of the Building Code and modifications thereof shall be such as *to protect the health, safety and welfare of the residents of the Commonwealth*, provided that buildings and structures should be permitted to be constructed, rehabilitated and maintained at the least possible cost *consistent with recognized standards of health, safety, energy conservation and water conservation*…."

Legislation (H2227), enacted by the General Assembly and signed by the Governor in 2021, supplements the pre-existing law's commitment to protecting residents and the public "consistent with recognized standards of … energy conservation" by specifically endorsing adoption of energy standards "at least as stringent as" the latest IECC when the benefits "over time" to residents and the public exceed the incremental costs of construction.

In view of the NOIRA and applicable law, Virginia should adopt the full 2021 IECC. More stringent standards and non-weakening amendments may be proposed, but the expectation is that the code should be "at least as stringent" as the 2021 IECC. Adopting such standards would perform the important function of keeping Virginia's building code "in sync with the national model codes," except where more stringent standards are feasible and beneficial to residents and the public.

In further support of benefits residents and the public will gain from full implementation of the 2021 IECC, we note:

- The ICC process that produced the IECC was a multi-year effort that carefully vetted the amendments that were eventually adopted.

- DOE and the Pacific Northwest National Laboratory (PNNL) have already published findings demonstrating that the net savings to Virginia residents and to the public from implementing the full 2021 IECC exceed the incremental costs of construction. https://www.energycodes.gov/technical-assistance/publications?page=29

- DOE/PNNL has reached the same conclusion on a national basis. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-31437.pdf

- The DOE/PNNL studies show that the public will benefit from reductions of air and climate pollution as measured by the Social Cost of Carbon.

- DOE/PNNL has previously found that earlier IECC updates dated 2012, 2015 and 2018 produced savings and benefits greater than construction costs. Consequently, moving implementation the 2021 IECC from pre-2012 standards that still apply to wall insulation and air leakage will result in net benefits and savings.

- Remaining more than a decade out of date in key areas, such as wall insulation and air leakage, is plainly inconsistent with Virginia law and the economic and health interests of residents and the public.

- Improved insulation, reduced air leakage and more efficient equipment will improve residents' comfort and health, reduce residents' problems of utility bill fluctuations, and improve their resiliency to low and high temperatures during power outages. Measures to reduce air leakage will have the added benefit of reducing access to dwellings by rodents and insects, which is a distinct concern identified in the Virginia Code.

Cost Impact: The code change proposal will increase the cost of construction

The code change proposal will increase the cost of construction, but lower the cost of occupancy.

As documented by DOE/PNNL, the cost savings to residents from fully implementing the 2021 IECC exceed the increased cost of construction on both a life-cycle and simple payback basis. Their analysis also shows that the public savings even more greatly exceed the incremental costs of construction.

- https://www.energycodes.gov/technical-assistance/publications?page=29
- https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-31437.pdf

In addition to saving residents money and energy, adoption and implementation will create added benefits including greater comfort, less exposure to pests, and greater resiliency.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal will increase resiliency in multiple ways, including:

- Local and regional power outages are a recurring problem that will get worse as climate impacts (storms, floods, rising seas, higher temperatures) make power outages more frequent and consequential. Better insulated houses with lower air leakage will continue to provide comfort to residents for longer periods during power outages.
- Better insulated houses with lower air leakage will better protect residents from the economic consequences of rate and bill increases due to energy price increases and fluctuations. This enhanced economic resiliency is very important. High utility bills and energy consumption can result in residents falling behind on mortgages and rents, potentially resulting in eviction or loss of homes. Evictions have adverse impacts to people, especially seniors, parents and children, that extend beyond a need to change dwellings.
- Landlords, lenders and surrounding communities will indirectly benefit from energy conservation measures that reduce risks of customer defaults.
- By reducing health impacts from air pollution, temperature impacts of power outages or cost-driven reductions of heating or cooling, and evictions, conservation measures will improve health resiliency for residents and communities.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐Approved
☐Approved with Modifications
☐Carryover
☐Disapproved
☐None

Public Comments for: EC-C1301.1.1.1-21

Discussion by William Penniman
Jun 8, 2022 16:07 UTC

Improving energy efficiency in buildings is more important now than ever, and its importance is increasing fast for consumers, the Commonwealth and the Nation. Energy efficiency is the first step to reducing energy costs, energy pollution, climate impacts and dependence on foreign energy. Today's high energy prices mean greater savings and faster payback from energy efficiency. Better insulated, tighter and more efficient buildings will provide benefits for the many decades that building are used.

The 2021 IECC was the product of years of hard work and careful analysis of costs, benefits and practicality. It continues a gradual process of improvements over the past decade or more. It increases the requirements for wall insulation, which were last updated by the IECC in 2012; and it leaves in place the 2012 IECC's requirement for testing air leakage (3 ACH50) for Climate Zones 3-5. Unfortunately, Virginia's residential codes remain behind the 2012 IECC with respect to wall insulation and air leakage even though independent analysis has found that each IECC update for 2012, 2015, 2018 and 2021 would provide net economic benefits to residents.

<u>The Economic and Public Benefits of Full 2021 IECC Compliance Exceed the Costs</u>

According to independent analysis by the Department of Energy and the Pacific Northwest National Laboratory (PNNL), full implementation of the 2021 IECC in Virginia will save money for residents beginning the first year of occupancy and through the life of the dwelling. It will also significantly reduce pollutants that harm the public and individuals. In PNNL-31627, ***"Cost-Effectiveness of the 2021 IECC for Residential Buildings in Virginia"*** (July 2021), the Pacific Northwest National Laboratory found:

> "Moving to the 2021 International Energy Conservation Code (IECC) is cost-effective for both single-family and low-rise multifamily residential buildings in Virginia. The 2021 IECC will provide statewide energy savings of 17.9% across all climate zones compared to the current state energy code. This equates to $413 of annual utility bill savings for the average Virginia household. It will reduce statewide CO2 emissions over 30 years by 28,420,000 metric tons, equivalent to the annual CO2 emissions of 6,181,000 cars on the road (1 MMT CO2 = 217,480 cars driven/year). Updating the state energy code based on the 2021 IECC will also stimulate the creation of high-quality jobs across the state. Adopting the 2021 IECC in Virginia is expected to result in homes that are energy efficient, more affordable to own and operate, and based on current industry standards for health, comfort and resilience.
>
> "The average expected statewide economic impact (per dwelling unit) of upgrading to the 2021 IECC is shown in the tables below based on cost-effectiveness and carbon metrics established by the U.S. Department of Energy.1

Consumer Impact Metric	Compared to the 2015 IECC with amendments
Life-cycle cost savings of the 2021 IECC	$8,376
Net annual consumer cash flow in year 1 of the 2021 IECC2	$250
Annual (first year) energy cost savings of the 2021 IECC ($)3	$413
Annual (first year) energy cost savings of the 2021 IECC (%)4	17.9%

> "1 A weighted average is calculated across building configurations and climate zones.
>
> 2 The annual cash flow is defined as the net difference between annual energy savings and annual cash outlays (mortgage payments, etc.), including all tax effects but excluding up-front costs (mortgage down payment, loan fees, etc.). First-year net cash flow is reported; subsequent years' cash flow will differ due to the effects of inflation and fuel price escalation, changing income tax effects as the mortgage interest payments decline, etc.
>
> 3 Annual energy savings is reported at time zero, before any inflation or price escalations are considered.
>
> 4 Annual energy savings is reported as a percentage of end uses regulated by the IECC (HVAC, water heating, and interior lighting). "

Particularly relevant to Virginia's wall insulation and air leakage standards, which predate the 2012 IECC, DOE/PNNL previously found that the 2012 IECC updates would save money for residents beginning even in the first year of occupancy and continuing annually for the 30 years studied. In, ***"Virginia Energy and Cost Savings for New Single- and Multifamily Homes: 2012 IECC as Compared to the 2009 Virginia Construction Code"*** PNNL 21346 (April 2012), PNNL and the U.S. DOE Building Technologies Program concluded:

> **"The 2012 International Energy Conservation Code (IECC) yields positive benefits for Virginia homeowners.**
>
> "Moving to the 2012 IECC from the current Virginia Construction Code is cost-effective over a 30-year life cycle. On average, Virginia homeowners will save $5,836 with the 2012 IECC.

Each year, the reduction to energy bills will significantly exceed increased mortgage costs. After accounting for up-front costs and additional costs financed in the mortgage, homeowners should see net positive cash flows (i.e., cumulative savings exceeding cumulative cash outlays) in 1 year for the 2012 IECC. Average annual energy savings are $388 for the 2012 IECC."

This report continued,

"Cost-effectiveness against a Virginia Construction Code baseline:

• Life-cycle cost savings, averaged across building types, are $5,836 for the 2012 IECC

• Simple payback period is 5.2 years for the 2012 IECC

Consumer savings compared to a Virginia Construction Code baseline:

• Households save an average of $388 per year on energy costs with the 2012 IECC

• Net annual consumer savings, including energy savings, mortgage cost increases, and other

associated costs in the first year of ownership, average $272 for the 2012 IECC

• Energy costs, on average, are 27.4% lower for the 2012 IECC"

Total savings in Virginia from full adoption of the 2021 IECC would be $7,192,000 in the first year and $2,487,000,000 over 30 years. Analyzing air pollution reductions from full IECC compliance, DOE/PNNL analysis also showed very substantial public savings in the form of reductions of pollutants that harm people's health and compound climate change impacts. These benefits are in addition to large statewide energy cost savings and creation of new jobs. Additional community benefits include helping residents minimize energy burdens and risks of mortgage defaults.

In other words, independent analysis shows that full implementation of the 2021 IECC will produce savings to residents over the marginal costs of construction and produce health and safety benefits to the public, and the long-neglected 2012 IECC updates for wall insulation and air leakage. On that basis, the Board should approve full compliance consistent with our proposal. Alternatively, the Board should at least eliminate the principal weakening amendments that have held Virginia back, as we have proposed in REC-R402.1.2(2)-21 (wall insulation) and REC-R402.4-21 (air leakage). Wall insulation and minimizing air leakage are critical to saving energy and cannot practically be retrofitted during the 70+ year life of the housing.)

"Non-Consensus" Is Not a Lawful Basis for Rejecting IECC Compliance

Notwithstanding past practices, "non-consensus" in work groups is not a lawful basis for holding Virginia back from full compliance with the IECC due to past exceptions.

Virginia law has long required that Virginia's code follow national standards, such as the ICC, and that costs to builders be minimized only to the extent "consistent with" applicable national codes, including codes for energy conservation. In the 2021 legislative session, the General Assembly enacted HB2227 which clearly identifies costs and benefits to residents and the public over time as the appropriate considerations for meeting or exceeding the IECC. HB2227 also requires consideration of adopting efficiency standards "at least as stringent as" the latest IECC based on those factors. Absence of builder consent is not a stated standard.

As noted, Virginia's code is more than a decade behind the IECC with respect to wall insulation and air leakage. DOE/PNNL have shown that the savings to residents exceed the incremental cost of construction in each of those areas.

Builders' generalized claims about higher housing construction costs are misleading. Housing prices have gone up for many reasons, including costs of land, materials, labor, money, and the perceived market for larger, fancier houses with higher margins.

Unlike those other costs, *energy efficiency investments will actually save residents money and make housing more affordable for owners or tenants*. The initial costs are spread over the life of a mortgage and are more than recouped in monthly energy cost savings to the residents. Efficiency investments also help to protect communities, landlords and lenders from defaults and evictions. With higher energy costs today, the savings will be even greater. Consistent with HB2227, these are clear benefits to residents and the public which exceed the initial costs of construction.

Moreover, retrofitting to cure air leakage and wall insulation deficiencies is extremely unlikely once walls have been closed. Excess energy costs and pollution will last for decades.

Significantly, many builders in Virginia also construct homes in jurisdictions, like Maryland and the District of Columbia, which require full implementation of the IECC or even go beyond the IECC. If builders can build and sell IECC-compliant houses in those jurisdictions, our builders should be able to do so in Virginia. Making the conservation component of our building code fully consistent with the 2021 IECC would yield net benefits to residents and the public.

Discussion by Richard Potts
Jun 3, 2022 14:20 UTC

Attached are two public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.
Attachments:
https://va.cdpaccess.com/proposal/966/discuss/137/file/download/716/HBAV_Clarifying%20ACEEE%20Report%20on%20Virginia%27s%20Residentia
https://va.cdpaccess.com/proposal/966/discuss/137/file/download/715/HBAV_DoE%20Data%20on%20New%20Construction%20EE%20Improvement

Discussion by Andrew Clark
Mar 18, 2022 15:13 UTC

Contrary to the proponent's reason statement, HB 2227 does not "specifically endorse" the adoption of the latest International Energy Conservation Code. The legislation, as enacted by the General Assembly and signed by the Governor, simply states that the Board of Housing and Community Development "…*consider* adopting amendments to the Uniform Statewide Building Code (Building Code) to address changes in the IECC relating to energy efficiency and conservation" (emphasis added). If the proponent's logic were to be accepted – and the provisions of HB 2227 be interpreted as a mandate to adopt the latest IECC – they would effectively be endorsing the provisions of HB 1289, which was passed by the General Assembly during the 2022 Session and contained nearly identical provisions directing the Board "…to consider…" exempting several use and occupancy classifications from any energy efficiency standards in the Virginia Uniform Statewide Building Code/2018 Virginia Energy Conservation Code. As originally introduced, both HB 1289 and HB 2227 were mandates to the Board to adopt certain code provisions – however, the General Assembly made it clear, through their public comments and amendments to both bills, that they did not want to "legislate the building code" or mandate that the Board to adopt certain building code provisions.

Comment by William Penniman
Mar 23, 2022 15:20 UTC

In addition to the discussion in the Reason Statement, we note the following in response to Mr. Clark:

Unlike HR1298 (2022) referenced by Mr. Clark, the 2021 amendment to the code (H2227) requires consideration of standards "at least as stringent" as those in the IECC *and provides a clear standard for adopting the IECC or more stringent standards,* which overlays the pre-existing statutory guidance for keeping Virginia's building codes consistent with national codes. That is, in addition to directing the BHCD to *consider* code proposals "at least as stringent" as the latest IECC, H2227 states: "*In conducting its review, the Board shall assess the public health, safety, and welfare benefits of adopting standards that are at least as stringent as those contained in the IECC, including potential energy savings and air quality benefits over time compared to the cost of initial construction."* Taken as a whole, the law calls for adoption of energy standards "at least as stringent as" the latest IECC when the long-term savings and other benefits to residents and the public exceed the incremental costs of construction.
We believe that this proposal to implement the full IECC meets the applicable tests under Virginia law, particularly in view of the cited analysis by PNNL. We will work with builders who identify ways to meet or exceed the IECC's efficiency standards at lower construction costs where possible.

EC-C1301.1.1.1-21– Staff Summary

Proponent: William Penniman (Sierra Club – Virginia Chapter)

Brief Description:

Removes existing state amendments to fully adopt the 2021 International Energy Conservation Code (IECC).

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on March 24, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- Eric Lacey (RECA)
    - Eric Lacey – Supports this proposal as it essentially strikes all of the Virginia specific amendments to the IECC and gets VA on track with the national codes. Others have submitted proposals to remove some of these amendments one by one. William's proposal would delete them all and if we feel some are necessary, we can add them back. I would like to see VA fully adopt the 2021 IECC. The 2021 IECC saw considerable support from public officials across the country and there's more support for this code than ever before. This would save homeowners money in the long run and will have a positive effect on the environment. I would encourage you to take a look at all the VA amendments and see if they are worthwhile going forward.
- Chelsea Harnish (VAEEC)
    - Someone was talking about the need to make existing homes more energy efficient and I want to point out that the two are not mutually exclusive. Organizations like mine are working on policies and initiatives to get older homes weatherized and retrofitted.
- Brian Clark (Habitat for Humanity)
- Andrew McKinney (American Institute of Architects)
- Maggie Kelley Riggins (Southeast Energy Efficiency Alliance)
- William Penniman (Sierra Club)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association.

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (HBAV)
    - Had concerns with this particular proposal with adopting the 2021 IECC in full. Staff provided a breakdown of some of the specific proposals that were included in there. Our preference would be to evaluate each of those on their own instead of adopting the 2021 IECC in full. Where our association comes down on these changes, as

builders, a lot of the messages we hear from local government officials is, "What are we doing to increase the supply of housing for folks at the lower to the middle end of the spectrum?" We're not talking about folks who are 30% Area Median Income (AMI), we're talking to 50-80% AMI. The Joint Legislative Audit & Review Commission (JLARC) in VA had a report this last year that home prices increased 15% and we've seen some that increased 35%. They found that we are 2,000 rental units short for people on the low end. The percentage of homes that sold under $200k decreased since 2015. There's the discussion with respect to upfront costs vs paybacks over time. The biggest impediment is for people at the lower end to be able to bring the cash to the table to cover those upfront costs. When we're talking about reducing energy burdens the focus should be on existing homes. You've seen significant progress with homes built in the last 10 to 20 years. We're establishing a baseline standard for safety and features and it should be up to the homeowner to choose above-baseline features for their home. If we keep raising the baseline, the gap in homeownership will get wider and wider. We'd be happy to look at some of the individual proposals but we do have concerns about adopting the 2021 IECC in full.

- Steve Shapiro (AOBA/VAMA)
  - Raised the point that we're coming out of this terrible pandemic and didn't think now is the time to enact changes to drive costs up. Andrew did a good job of framing it and we are not in support of this proposal.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- KC Bleile (Viridiant)

Energy Sub-Workgroup members not in attendance during the March 24, 2022 meeting:

- Jim Canter: Virginia Building and Code Officials Association
- Bettina Bergoo: Virginia Department of Energy Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association
- Corey Caney: International Association of Electrical Inspectors, Virginia

Other stakeholders in attendance and supporting the proposal:

- Ross Shearer
  - Supports this proposal for the reasons Eric mentioned. He gave the example of his house, which was built in 1964. It would have been nice if Virginia had paid just some attention to energy conservation in those days.
- Linda Baskerville
  - Arlington has a long-range energy conservation plan and to meet that by 2030, which isn't that far away now, we are going to really need to improve our energy efficiency. Going to the 2021 energy conservation criteria is going to help that.
- Steve Sunderman

    - Speaking in support of this proposal. We are looking to get into the 21st century here with energy conservation measures, which is what this is all about. Very much in favor.

Other stakeholders in attendance and opposing the proposal:

- John Ainslie
    - Wanted to clarify one thing that's been mentioned. It's been mentioned that VA is not up to the national model energy codes, and while that may be a true statement, he argued that based on what he's looking at, only 3 states of the 50 have adopted the 2021 IECC. So, most states are on the 2009, maybe 2012 code. The reason they are not is because it substantially increases the cost of housing. It keeps people from buying new, more energy efficient homes. While we may not be up to the national energy codes, most states are not.
- Mike O'Connor (VA Petroleum Marketers)
    - Our concern is the issue of rate-payer subsidization of conversion. We're seeing that through things like the Regional Greenhouse Gas Initiative (RGGI) and other initiatives. We're also concerned that there are about 400,000 homes that continue to be heated by heating oil, kerosene, or propane, and those people have made substantial investments and those people will not be pleased when the government wants to come in and pull out those gas cooktops, heaters, etc. We are opposed to anything that would make rate-payers subsidize those costs.

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Eric Lacey (RECA); Ben Rabe (NBI); Dawn Oleksy (City of Richmond); Dan Willham (Fairfax County); Linda Baskerville (Arlington County)

- Eric Lacey (RECA)
    - Responsible Energy Codes Alliance is in support of this proposal. They support the adoption of the latest model energy code. There are significant energy savings. It makes sense for Virginia to catch up with the model codes. He thinks that Virginia should start with the latest model code each cycle and look at historic amendments to see if they are still pertinent. In the ACEEE scorecard, Virginia is behind.
- Ben Rabe (NBI)
    - The comments he made in the Sub-workgroup will carry over for all proposals. He does support this proposal. When contractors work across state lines, it's helpful to have consistency. The vetting process in the IECC is very rigorous.
- Dawn Oleksy (City of Richmond)
    - The Richmond Office of Sustainability supports this proposal. Building energy is 56% of the carbon footprint. In order to meet 2030 and 2050 greenhouse gas reduction goals, energy efficiency needs to be supported.

- Dan Willham (Fairfax County)
    - Fairfax County supports this proposal
- Linda Baskerville (Arlington County)
    - Arlington County supports this proposal. The housing stock problems that Andrew mentioned are not all attributable to the energy code. Putting them all on the back of the energy code is shortsighted. Virginia residents have undeniable long term benefits. Looking at this in the short term is not in accordance with Virginia's long term goals.

Opposition:

Names: Steve Shapiro (AOBA/VAMA); Andrew Clark (HBAV); Michael O'Connor;

- Steve Shapiro (AOBA/VAMA)
    - Won't repeat what he said at the Sub-workgroup. AOBA and VAMA are opposed to this change.
- Andrew Clark (HBAV)
    - In addition to his comments from the Energy Sub-workgroup on this proposal, from the Home Builders' perspective, they oppose this proposal. The housing industry constantly hears about the need for low to moderate income housing. Home buyers have the option to construct their home to higher standards if that's affordable to them. With full adoption of the 2021 IECC, there's a big cost added to home owners and renters. In the ACEEE scorecard, Virginia earns a near-perfect score on building codes, but is ranking 25th because it loses 50% of energy points on utilities and transportation.
    - Is not making the claim that the energy code is the sole driver of housing cost. This is potentially another factor driving costs up. The building code process has been effective in lowering energy costs for residents. Data cited in an affordable housing study report as a part of HB854 (2020 session) breaks down energy cost by homeowner, renter, year built and AMI. In homes built after 2000, virtually every income bracket is not having energy cost burdens. Homes built before 2000, and before 1980, those at the lower income spectrum are energy cost burdened. We've made a significant amount of progress. There's a need to find out when diminishing returns come in. Adding costs to the construction creates impediments and barriers to home buyers. He encourages the group to look at the report with data pulled from the Department of Energy. He said he would send the report to the group. It shows pretty clearly that most folks are not energy cost burdened.
- Michael O'Connor
    - He reviewed HB2227. This was originally mandatory and mirrored what is being presented today. The bill was amended to say that it shall be considered by the Department of Housing and Community Development, making it permissive instead of mandatory. He understands that there was also legislation this past session that aimed to accomplish the same thing. He suggests that this is an attempt to go around the legislature.

DHCD Staff Note:

As a technical comment on this proposal, there is correlation between codes that will need to be done for a change this large.

Also, there is a similar proposal from the same proponent, EC1301.1.1.1(2), that keeps the existing building provisions of the energy code. Only one of these proposals should be approved if the board chooses to do so.

Meeting summaries and proposal related information: Tab 10 - Page 36; Tab 11 - Page 2; Tab 11 - Page 58.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

Clarifying the *American Council for an Energy-Efficient Economy's* Report on Virginia's Energy Policy and Building Codes

The American Council for an Energy-Efficient Economy (ACEEE) periodically releases a report ranking each state's energy efficiency policies and programs. This report is *widely* cited by energy efficiency stakeholders as justification for additional advancements in Virginia's energy codes – particularly, the report's ranking of Virginia as 25th in the country for energy efficiency[1].

Although the Home Builders Association of Virginia has partnered with these stakeholders during the 2015 and 2018 code cycles (which resulted in several significant advancements) and has continued to do so during the 2021 cycle, we felt it important to clarify the ACEEE's findings on Virginia's energy codes.

While the ACEEE report is a helpful resource for policymakers and regulatory boards, a state's ***overall ranking*** in the report is not particularly informative when evaluating the "strength" or "weakness" of a state's residential and commercial energy codes or specific energy code proposals. A deeper analysis of the ACEEE report shows that Virginia's ***overall ranking*** distorts the fact that Virginia receives extremely high scores for residential and commercial energy codes.

Virginia loses nearly half (24.5 points) of its points in categories *unrelated* to building codes

The ACEEE report ranks states based on five categories: (i) utility and public benefits programs and policies; (ii) transportation policies; (iii) building energy efficiency policies; (iv) state government initiatives; (v) appliance efficiency standards.

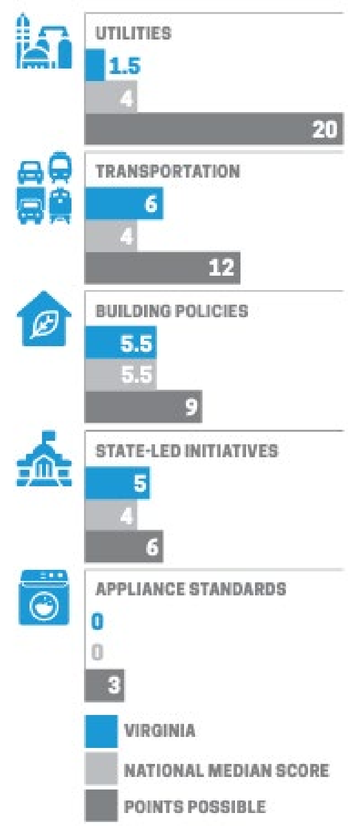
A state can only earn a certain number of points in each category:

- Utility and public benefits programs and policies (20 pts)
- Transportation policies (12 pts)
- Building energy efficiency policies (9 pts)
- State government initiatives (6 pts)
- Appliance efficiency standards (3 pts)

In the ACEEE's most recent report (2020), Virginia earned 18 out of 50 points – which is 25th in the nation.

However, a deeper analysis of the ACEEE's findings shows that Virginia lost nearly 50% of its points (24.5) in categories that are *unrelated* to energy efficiency building codes. Specifically, Virginia only earned 1.5 out of 20 pts for "Utility and Public Benefits Programs and Policies" and only received 6 out of 12 points for "Transportation Policies". *(See figure to the right)*

Due to the report's scoring system, it is inaccurate to claim that Virginia's 25th-in-the-Nation ranking in this report is the result of the Commonwealth's "weak energy code".



[1] American Council for an Energy-Efficient Economy – 2020 State Energy Efficiency Scorecard

Virginia receives a near-perfect score for residential code stringency and perfect score for commercial code stringency.

In the "Building Energy Efficiency Policy" category, Virginia receives 5.5 out of 9 points – by comparison, Virginia is only .5 points behind Maryland and 2 points behind California, which are the two states most frequently described by energy efficiency stakeholders as "leaders" in energy efficiency.

The "Building Energy Efficiency Policy" category consists of 8 sub-categories, including "residential code stringency" and "commercial code stringency". Contrary to statements made during several sub-workgroup and workgroup meetings, Virginia receives a near perfect score for "residential energy efficiency" (1.5 points out of 2) and a perfect score for "commercial energy efficiency" (2 points out of 2).

It is HBAV's understanding that these rankings were determined while Virginia was in the middle of the last code development cycle. While Virginia received exemplary scores for residential and commercial energy code stringency in ACEEE's report, the rankings only reflect a *portion* of the progress which was made in Virginia's energy codes during the last code cycle. During the last code cycle, the Home Builders Association of Virginia and other organizations reached consensus with energy efficiency stakeholders on several proposals, including:

1. Removed visual option for verifying building envelope air tightness and required blower door testing for all new residential buildings. Also added requirement that all new homes pass the blower door test with 5 air changes per hour;
2. Require an "energy certificate" in all new residential buildings to inform current and future homeowners about the key energy characteristics of their home;
3. Increase minimum ceiling insulation requirements (R-38 to R-49) for all new residential buildings;
4. ResCheck compliance updated to 2018 IECC, without Virginia amendments. Previously, a work around had been created for VA amendments that weakened the current IECC;
5. Increased fenestration requirements.

While the ACEEE has yet to release an updated report, it is highly likely that Virginia will receive further recognition for the full scope of energy efficiency code proposals that were adopted during the last code cycle – and possibly for the energy efficiency code proposals which are likely to be forwarded to the Board as "consensus" during the current code development cycle.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

U.S. Department of Energy Data Shows Significant Advancements in Residential Energy Efficiency and Reduction in Energy Cost Burdens in New Construction

"The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs."

Building code regulations were first established – and are continually revised – to ensure a *baseline standard* of quality, safety, and efficiency in new residential structures. For example, they provide assurance for consumers that they are residing in safe structures, guidelines for builders/design professionals as to what constitutes a safe and durable structure, and certainty for lenders of the value and quality of structure.

Similarly, energy efficiency standards were first adopted by the U.S. Housing and Home Finance Agency in the 1950's to address a concerning *public health and welfare* issue at the time: the rising number of mortgage defaults on federally insured loans on homes with high utility bills.

While increasing the efficiency of new residential structures is a laudable objective, it is critically important for policymakers to balance that objective with the growing concerns over the cost of housing in Virginia and the dramatic undersupply of housing that is attainable for households across the income spectrum. Furthermore, it is important for policymakers to distinguish between building code requirements that are essential to providing that baseline standard of quality, safety, and efficiency, and code requirements that are "aspirational".

Consumers can make a personal financial decision to purchase or build a home that is constructed to a higher energy efficiency standard, if that is an amenity that they are willing and able to afford. While energy efficiency requirements can reduce negative environmental externalities, promote high-quality housing stock, and protect consumers from soaring energy costs over time, the ability to afford the **upfront costs** of additional energy efficiency code requirements will vary widely by income.

The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs.

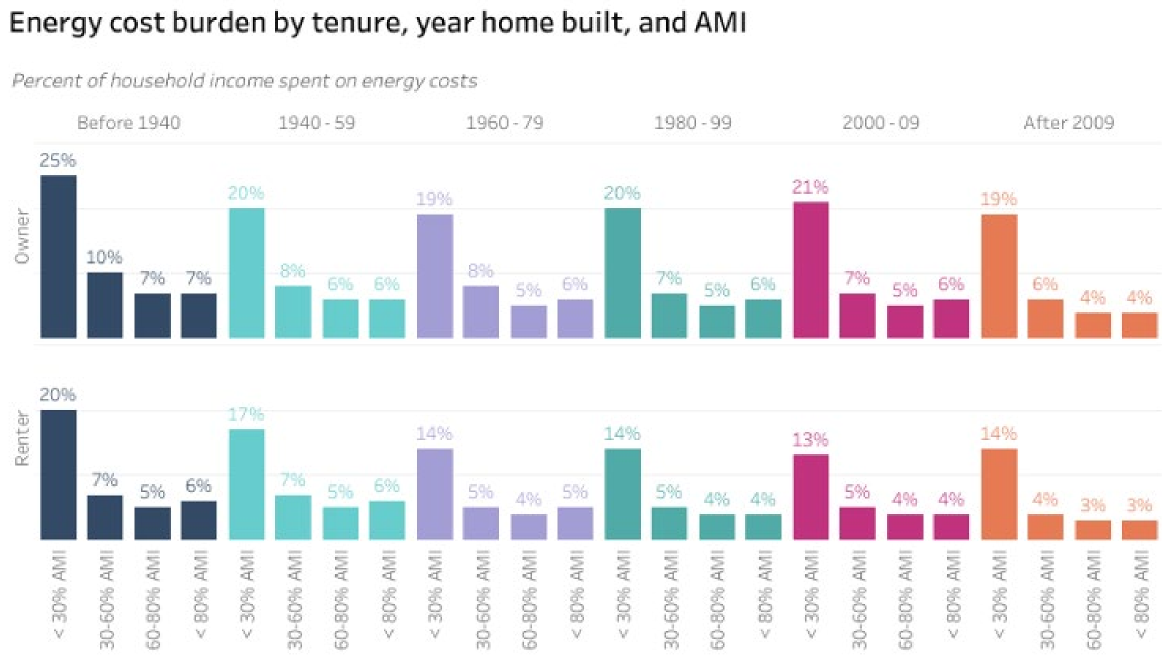
U.S. Department of Energy Data

Data from the U.S. Department of Energy's *Low-Income Energy Affordability Data (LEAD) Tool* validates the claim that Virginia *has* made vast improvements in residential energy efficiency over the last 80 years and has significantly reduced household energy costs to a level considered sustainable for individuals and families across the income spectrum.

A household is considered "energy cost burdened" when over 6% of the household income is dedicated to covering energy bills – this calculation includes all costs associated with energy used by the house (e.g., electricity and natural gas). When a household is "energy cost burdened", it impacts their ability to use electricity and heat or cool their home – and forces households to choose between paying utility bills, paying a mortgage or rent, or other essential expenses. In short, high energy cost burdens results in higher levels of housing instability, including evictions and foreclosures.

The chart below was compiled using data from the U.S. Department of Energy and included in a recent report released by Virginia Housing (formerly, Virginia Housing Development Authority) and the Department of Housing and Community Development[1].

[1] HB 854 Statewide Housing Study Report (January 2022)



Source: National Renewable Energy Laboratory, Low-Income Energy Affordability Data (LEAD) Tool, 2018.

The data from the U.S. Department of Energy (chart above) provides several important insights:

First, renters and owners residing in residential structures built since 2000 are below the 6% "energy cost burdened" threshold, with two exceptions: (i) Owner households in structures built between 2000 and 2009 are slightly over the 6% energy cost burdened threshold; (ii) Owners and renters with incomes below 30% of AMI residing in structures built between 2000 and 2019 are experiencing extremely high energy cost burdens. More analysis is needed to understand the latter - there are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Second, the highest "energy cost burdened" households (owner and renter) are residing in structures built prior to 1980's/1990's. The most "energy cost burdened" demographic – regardless of age of structure – are households earning under 30% AMI. Again, more analysis is needed to understand this dynamic. There are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Conclusion:

Data from the U.S. Department of Energy shows that residential structures constructed in the last 20 years are significantly more energy efficient than older homes, which has reduced household energy costs to levels considered sustainable for individuals and families across the income spectrum. The data also reflects the reality that efforts to reduce household energy cost burdens would be best focused on older, existing structures occupied by individuals and families at the lower end of the income spectrum.

Several energy proposals submitted during the 2021 code cycle seek to impose stricter energy efficiency requirements on all new homes, thus increasing the upfront cost of all new homes and exacerbating an issue raised by the Virginia Joint Legislative Audit and Review Commission's recent report on housing affordability: "Rising prices make it more difficult for low- and middle-income households to afford to purchase homes because of the increased monthly mortgage costs, as well as the increased upfront costs associated with purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes.[2]"

[2] Joint Legislative Audit and Review Commission: Affordable Housing in Virginia (2021)

EC-C1301.1.1.1(2)-21

Proponents: William Penniman (wpenniman@aol.com)

2018 Virginia Construction Code

Revise as follows:

1301.1.1.1 Changes to the International Energy Conservation Code (IECC). The following changes shall be made to the IECC:

1. ~~Add Sections C402.1.4.2, C402.1.4.2.1, C402.1.4.2.2, C402.1.4.2.3, C402.2.1.2, C402.2.1.3, C402.2.1.4, C402.2.1.5 and Change Section C402.2.1.1 to read:~~

    ~~**C402.1.4.2 Roof/ceiling assembly.** The maximum roof/ceiling assembly *U*-factor shall not exceed that specified in Table C402.1.4 based on *construction* materials used in the roof/ceiling assembly.~~

    ~~**C402.1.4.2.1 Tapered, above-deck insulation based on thickness.** Where used as a component of a maximum roof/ceiling assembly *U*-factor calculation, the tapered roof insulation *R*-value contribution to that calculation shall use the average thickness in inches (mm) along with the material *R*-value-per-inch (per-mm) for *U*-factor compliance as prescribed in Section C402.1.4.~~
    ~~**C402.1.4.2.2 Suspended ceilings.** Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the assembly *U*-factor of the roof/ceiling *construction*.~~
    ~~**C402.1.4.2.3 Multiple layers and staggered joints.** Continuous insulation board shall be installed in not less than two layers and the edge joints between each layer of insulation shall be staggered. Multiple layers and staggered joints are not required where insulation tapers to the *roof deck* at a gutter edge, roof drain or scupper.~~

    ~~**C402.2.1 Roof assembly** The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table C402.1.3, based on *construction* materials used in the *roof assembly*.~~

    ~~**C402.2.1.1 Tapered, above-deck insulation based on thickness.** Where used as a component of a roof/ceiling assembly *R*-value calculation, the tapered roof insulation *R*-value contribution to that calculation shall use the average thickness in inches (mm) along with the material *R*-value per inch (per mm) for *R*-value compliance as prescribed in Section C402.1.3.~~
    ~~**C402.2.1.2 Minimum thickness, lowest point.** The minimum thickness of above-deck roof insulation at its lowest point, gutter edge, roof drain or scupper, shall be no less than 1 inch (25 mm).~~
    ~~**C402.2.1.3 Suspended ceilings.** Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the minimum thermal resistance (*R*-value) of roof insulation in roof/ceiling *construction*.~~
    ~~**C402.2.1.4 Multiple layers and staggered joints.** Continuous insulation board shall be installed in not less than two layers and the edge joints between each layer of insulation shall be staggered. Multiple layers and staggered joints are not required where insulation tapers to the *roof deck* at a gutter edge, roof drain or scupper.~~
    ~~**C402.2.1.5 Skylight curbs.** Skylight curbs shall be insulated to the level of roofs with insulation entirely above the deck or R-5, whichever is less.~~

    ~~**Exception:** Unit skylight curbs included as a component of a skylight listed and labeled in accordance with NFRC 100 shall not be required to be insulated.~~

2. ~~Change the SHGC for Climate Zone 4 (Except Marine) of Table C402.4 to read:~~

3. ~~Delete Section C402.4.1.2, change Sections C402.4.2, C402.4.2.1, C402.4.2.2 and C402.4.3.~~

~~**C402.4.2 Skylight area with daylight response controls.** The skylight area shall be permitted to be not more than 5 percent of the roof area provided daylight responsive controls complying with Section C405.2.3.1 are installed in daylight zones under skylights.~~

~~**C402.4.2.1 Daylight Zone Controls under skylights.** Daylight responsive controls complying with Section C405.2.3.1 shall be provided to control all electric lights within daylight zones under skylights.~~
~~**C402.4.2.2 Haze factor.** Skylights that are installed in office, storage, automotive service, manufacturing, nonrefrigerated warehouse, retail store and distribution/sorting area spaces shall have a glazing material or diffuser with a haze factor greater than 90 percent when tested in accordance with ASTM D1003.~~

~~**Exception:** Skylights designed and installed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles or the geometry of skylight and light well.~~

~~**C402.4.3 Maximum *U*-factor and SHGC.** The maximum *U*-factor and solar heat gain coefficient (SHGC) for fenestration shall be as specified in Table C402.4.~~

~~The window projection factor shall be determined in accordance with Equation 4-5.~~

PF = A/B ~~**(Equation 4-5)**~~

~~where:~~

~~PF = Projection factor (decimal).~~

~~A = Distance measured horizontally from the farthest continuous extremity of any overhand, eave, or permanently attached shading device to the vertical surface of the glazing.~~

~~B = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave, or permanently attached shading device.~~
~~Where different windows or glass doors have different PF values, they shall each be evaluated separately.~~

~~Where the fenestration projection factor for a specific vertical fenestration product is greater than or equal to 0.20, the required maximum SHGC from Table C402.4 shall be adjusted by multiplying the required maximum SHGC by the multiplier specified in Table C402.4.3 corresponding with the orientation of the fenestration product and the projection factor.~~

4. ~~Add Table C402.4.3 to read:~~

5. ~~Add an exception to the first paragraph of Section 403.7.7 to read:~~

~~**Exception:** Any grease duct serving a Type I hood installed in accordance with the *International Mechanical Code* (IMC) Section 506.3 shall not be required to have a motorized or gravity damper.~~

6. ~~Add Section C403.2.2.1 to read:~~

~~**C403.2.2.1 Dwelling unit mechanical ventilation.** Mechanical ventilation shall be provided for *dwelling units* in accordance with the IMC.~~

7. ~~Delete Section C403.7.5 and Table C403.7.5.~~

8. ~~Delete Sections C404.5 through C404.5.2.1, including Tables.~~

9. ~~Change Section C405.4 to read:~~

~~**C405.4 Exterior lighting (Mandatory).** All exterior lighting, other than low-voltage landscape lighting, shall comply with Section C405.4.1.~~

~~**Exception:** Where *approved* because of historical, safety, signage, or emergency considerations.~~

10. Change Section C502.1 to read:

C502.1 General. Additions to an existing building, building system or portion thereof shall conform to the provisions of Section 805 of the *Virginia Existing Building Code* (VEBC).

11. Delete Sections C502.2 through C502.2.6.2.

12. Change Section C503.1 to read:

C503.1 General. Alterations to any *building* or *structure* shall comply with the requirements of Chapter 6 of the VEBC.

13. Delete Sections C503.2 through C503.6.
14. Change Section C504.1 to read:

C504.1 General. *Buildings* and *structures*, and parts thereof, shall be repaired in compliance with Section 510 of the VEBC.

15. Delete Section C504.2.
16. ~~Change Section R401.2 to read:~~

~~**R401.2 Compliance.** Projects shall comply with all provisions of Chapter 4 labeled "Mandatory" and one of the following:~~

1. ~~Sections R401 through R404.~~
2. ~~Section R405.~~
3. ~~Section R406.~~
4. ~~The most recent version of REScheck, keyed to the 2018 IECC.~~

17. ~~Change Section R401.3 to read:~~

~~**R401.3** A permanent certificate shall be completed by the builder or other *approved* party and posted on a wall in the space where the furnace is located, a utility room or an *approved* location inside the *building*. Where located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label, or other required labels. Where *approved*, certificates for multifamily *dwelling units* shall be permitted to be located off-site at an identified location. The certificate shall indicate the predominant *R*-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, basement walls, crawl space walls and floors, and ducts outside conditioned spaces; *U*-factors of fenestration and the solar heat gain coefficient (SHGC) of fenestration; and the results from any required duct system and *building* envelope air leakage testing performed on the *building*. Where there is more than one value for each component, the certificate shall indicate the value covering the largest area. The certificate shall indicate the types and efficiencies of heating, cooling, and service water heating *equipment*. Where a gas-fired unvented room heater, electric furnace, or baseboard electric heater is installed in the residence, the certificate shall indicate "gas-fired unvented room heater," "electric furnace," or "baseboard electric heater," as appropriate. An efficiency shall not be indicated for gas-fired unvented room heaters, electric furnaces, and electric baseboard heaters.~~

18. ~~Change the wood frame wall *R*-value categories for Climate Zone 4 (Except Marine) in Table R402.1.2 to read:~~

19. ~~Change the frame wall *U*-factor categories for Climate Zone 4 (Except Marine) in Table R402.1.4 to read:~~

20. ~~Change Section R402.2.4 to read:~~

~~**R402.2.4 Access hatches and doors.** Access doors from conditioned spaces to unconditioned spaces (e.g., *attics* and crawl spaces) shall be weatherstripped and insulated in accordance with the following values:~~

1. ~~Hinged vertical doors shall have a minimum overall R-5 insulation value;~~
2. ~~Hatches and scuttle hole covers shall be insulated to a level equivalent to the insulation on the surrounding surfaces; and~~
3. ~~Pull down stairs shall have a minimum of 75 percent of the panel area having R-5 rigid insulation.~~

~~Access shall be provided to all *equipment* that prevents damaging or compressing the insulation. A wood framed or equivalent baffle or retainer is required to be provided when loose fill insulation is installed, the purpose of which is to prevent the loose fill insulation from spilling into the living space when the attic access is opened and to provide a permanent means of maintaining the installed *R*-value of the loose fill insulation.~~

~~21. Change Sections R402.4 and R402.4.1.1 to read:~~

~~**R402.4 Air leakage.** The *building* thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.5.~~

~~**R402.4.1.1 Installation (Mandatory).** The components of the *building* thermal envelope as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in Table R402.4.1.1, as applicable to the method of *construction*. Where required by the code official, an *approved* third party shall inspect all components and verify compliance.~~

~~22. Change the title of the "Insulation Installation Criteria" category of Table R402.4.1.1; change the "Shower/tub on exterior wall" category of Table R402.4.1.1, and add footnotes "b" and "c" to Table R402.4.1.1 to read:~~

~~23. Change Section R402.4.1.2 to read:~~

~~**R402.4.1.2 Testing.** The *building* or *dwelling unit* shall be tested and verified as having an air leakage rate not exceeding five air changes per hour in Climate Zone 4. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779, or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). A written report of the results of the test shall be signed by the party conducting the test and provided to the *building official*. Testing shall be conducted by a Virginia licensed general contractor, a Virginia licensed HVAC contractor, a Virginia licensed home inspector, a Virginia *registered design professional*, a certified BPI Envelope Professional, a certified HERS rater, or a certified duct and envelope tightness rater. The party conducting the test shall have been trained on the *equipment* used to perform the test. Testing shall be performed at any time after creation of all penetrations of the *building* thermal envelope.~~

~~**Note:** Should additional sealing be required as a result of the test, consideration may be given to the issuance of a temporary certificate of occupancy in accordance with Section 116.1.1.~~

~~During testing:~~

1. ~~Exterior windows and doors and *fireplace* and stove doors shall be closed, but not sealed beyond the intended weatherstripping or other infiltration control measures;~~
2. ~~Dampers, including exhaust, intake, makeup air, backdraft, and flue dampers, shall be closed, but not sealed beyond intended infiltration control measures;~~
3. ~~Interior doors, if installed at the time of the test, shall be open;~~
4. ~~Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;~~
5. ~~Heating and cooling systems, if installed at the time of the test, shall be turned off; and~~
6. ~~Supply and return registers, if installed at the time of the test, shall be fully open.~~

~~24. Change Section R403.3.3 to read:~~

~~**R403.3.3 Duct testing (Mandatory).** Ducts shall be pressure tested to determine air leakage by one of the following methods:~~

1. ~~Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.~~
2. ~~Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.~~

~~**Exception:** A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.~~

~~A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. The licensed mechanical contractor installing the mechanical system shall be permitted to perform the duct testing. The contractor shall have been trained on the equipment used to perform the test.~~

~~25. Delete Section R403.3.5.~~

~~26. Change Section R403.7 to read:~~

~~**R403.7 Equipment and appliance sizing.** Heating and cooling equipment and appliances shall be sized in accordance with ACCA Manual S or other *approved* sizing methodologies based on *building* loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies.~~

~~**Exception:** Heating and cooling equipment and appliance sizing shall not be limited to the capacities determined in accordance with Manual S or other *approved* sizing methodologies where any of the following conditions apply:~~

~~1. The specified equipment or appliance utilizes multistage technology or variable refrigerant flow technology and the loads calculated in accordance with the *approved* heating and cooling methodology fall within the range of the manufacturer's published capacities for that equipment or appliance.~~

~~2. The specified equipment or appliance manufacturer's published capacities cannot satisfy both the total and sensible heat gains calculated in accordance with the *approved* heating and cooling methodology and the next larger standard size unit is specified.~~

~~3. The specified equipment or appliance is the lowest capacity unit available from the specified manufacturer.~~

~~27. Change footnote "a" in Table R406.4 to read:~~

~~a. When onsite renewable energy is included for compliance using the ERI analysis of Section R406.4, the building shall meet the mandatory requirements of Section R406.2 and the building thermal envelope shall be greater than or equal to levels of energy efficiency and solar heat gain coefficient in Table R402.1.2, with a ceiling *R*-value of 49 and a wood frame wall *R*-value of 20 or 13 + 5, or Table R402.1.4, with a ceiling *U*-factor of 0.026 and a frame wall *U*-factor of 0.060.~~

28. Change Section R501.1 to read:

R501.1 Scope. The provisions of the *Virginia Existing Building Code* (VEBC) shall control the alteration, repair, addition and change of occupancy of existing *buildings* and *structures*.

29. Delete Sections R501.1.1 through R501.6.

30. Change Section R502.1 to read:

R502.1 General. Additions to an existing *building*, *building* system or portion thereof shall conform to the provisions of Section 811 of the VEBC.

31. Delete Sections R502.1.1 through R502.1.2.

32. Change Section R503.1 to read:

R503.1 General. Alterations to any *building* or *structure* shall comply with the requirements of Chapter 6 of the VEBC.

33. Delete Sections R503.1.1 through R503.2

34. Change Section R504.1 to read:

R504.1 General. *Buildings*, structures and parts thereof shall be repaired in compliance with Section 510 of the VEBC.

35. Delete Section R504.2.

~~TABLE C402.4 BUILDING ENVELOPE FENESTRATION MAXIMUM U-FACTOR AND SHGC REQUIREMENTS~~

~~CLIMATE ZONE~~	~~4 EXCEPT MARINE~~
~~SHGC~~	~~0.36~~

~~**TABLE C402.4.3 SHGC ADJUSTMENT MULTIPLIERS**~~

~~**PROJECTION FACTOR**~~	~~**ORIENTED WITHIN 45 DEGREES OF TRUE NORTH**~~	~~**ALL OTHER ORIENTATIONS**~~
~~$0.2 \le PF < 0.5$~~	~~1.1~~	~~1.2~~
~~$PF \ge 0.5$~~	~~1.2~~	~~1.6~~

TABLE R402.1.2 INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	WOOD FRAME WALL *R*-VALUE
4 except Marine	15 or 13 + 1[h]

~~TABLE R402.1.4 EQUIVALENT U-FACTORS[a]~~

~~CLIMATE ZONE~~	~~FRAME WALL *U*-FACTOR~~
~~4 except Marine~~	~~0.079~~

~~TABLE R402.4.1.1 AIR BARRIER AND INSULATION INSTALLATION[a]~~

~~COMPONENT~~	~~AIR BARRIER CRITERIA~~	~~INSULATION INSTALLATION CRITERIA[b]~~
~~Shower/tub on exterior wall[e]~~	~~The air barrier installed at exterior walls adjacent to showers and tubs shall be installed on the interior side and separate the exterior walls from the showers and tubs.~~	~~Exterior walls adjacent to showers and tubs shall be insulated.~~

Reason Statement: This proposal is intended to fully adopt and implement the 2021 IECC with respect to NEW CONSTRUCTION by eliminating exceptions that the Base Document would cause to displace language in the 2021 IECC with respect to NEW CONSTRUCTION. Full adoption of the 2021 IECC will best carry out Virginia law and protect both residents and the public generally and we support adopting the IECC with respect to new and existing buildings. However, this proposal focuses on the IECC's 2021 updates for new construction, recognizing that Virginia law has a special provision addressing rehabilitation of existing buildings and that, per the Base Document, 2021 IECC updates for new construction would be picked up for certain work done on existing buildings to the same extent as is now provided in the VECC. Specific additional amendments can be addressed in the VECC update process.

Nevertheless, the proposal would carryout the Commonwealth's goals at least with respect to new buildings. The BHCD's NOIRA published November 22, 2021, https://townhall.virginia.gov/L/viewstage.cfm?stageid=9475 states:

> "The 2021 editions of the International Codes are now completed and available from ICC. *The use of the newest available model codes and standards in the USBC assures that the statutory mandate is met to base the regulation on the latest editions of nationally recognized model codes to assure the protection of the health, safety and welfare of the residents of Virginia and that buildings and structures are constructed and maintained at the least possible cost*."

The BHCD's NOIRA also states: "As the basis for Virginia's building code it is important to stay in sync with the national model codes." These statements are consistent with Section 36-99A of the Virginia Code has long prescribed that the purposes of the USBC are to protect the public and implement recognized standards of energy conservation and water conservation:

> "The provisions of the Building Code and modifications thereof shall be such as *to protect the health, safety and welfare of the residents of the Commonwealth*, provided that buildings and structures should be permitted to be constructed, rehabilitated and maintained at the least possible cost *consistent with recognized standards of health, safety, energy conservation and water conservation*…."

Legislation (H2227), enacted by the General Assembly and signed by the Governor in 2021, supplements the pre-existing law's commitment to protecting residents and the public "consistent with recognized standards of … energy conservation" by specifically endorsing adoption of energy standards "at least as stringent as" the latest IECC when the benefits "over time" to residents and the public exceed the incremental costs of construction.

In view of the NOIRA and applicable law, Virginia should, at a minimum, adopt the full 2021 IECC with respect to new construction. More stringent standards and non-weakening amendments may be proposed, but the expectation is that the code should be "at least as stringent" as the 2021 IECC. Adopting such standards would perform the important function of keeping Virginia's building code "in sync with the national model codes," except where more stringent standards are feasible and beneficial to residents and the public.

In further support of benefits residents and the public will gain from full implementation of the 2021 IECC, we note:

- The ICC process that produced the IECC was a multi-year effort that carefully vetted the amendments that were eventually adopted.
- DOE and the Pacific Northwest National Laboratory (PNNL) have already published findings demonstrating that the net savings to Virginia residents and to the public from implementing the full 2021 IECC exceed the incremental costs of construction. https://www.energycodes.gov/technical-assistance/publications?page=29
- DOE/PNNL has reached the same conclusion on a national basis. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-31437.pdf
- The DOE/PNNL studies show that the public will benefit from reductions of air and climate pollution as measured by the Social Cost of Carbon.
- DOE/PNNL has previously found that earlier IECC updates dated 2012, 2015 and 2018 produced savings and benefits greater than construction costs. Consequently, moving implementation the 2021 IECC from pre-2012 standards that still apply to wall insulation and air leakage will result in net benefits and savings.
- Remaining more than a decade out of date in key areas, such as wall insulation and air leakage, is plainly inconsistent with Virginia law and the economic and health interests of residents and the public.
- Improved insulation, reduced air leakage and more efficient equipment will improve residents' comfort and health, reduce residents' problems of utility bill fluctuations, and improve their resiliency to low and high temperatures during power outages. Measures to reduce air leakage will have the added benefit of reducing access to dwellings by rodents and insects, which is a distinct concern identified in the Virginia Code.

Cost Impact: The code change proposal will increase the cost of construction
The code change proposals will increase the cost of construction, but lower the cost of occupancy thereby saving residents money and reducing risks of mortgage or lease default.

As documented by DOE/PNNL, the cost savings to residents from fully implementing the 2021 IECC exceed the increased cost of construction on both a life-cycle and simple payback basis. The savings to building occupants are shown to be large, and the construction cost impacts are small relative to the prices for new buildings. The DOE/PNNL analysis also shows that the public's savings even more greatly exceed the incremental costs of construction.

- https://www.energycodes.gov/technical-assistance/publications?page=29
- https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-31437.pdf

No data presented would justify failing to adopt the full 2021 IECC at least with respect to new construction.

In addition to saving residents money and energy, adoption and implementation will create added benefits including enhanced comfort, healthier indoor and outdoor air, and greater economic stability by reducing the impacts of fluctuating energy costs,

Resiliency Impact Statement: This proposal will increase Resiliency
Although it focuses on new construction, this proposal will increase resiliency in multiple ways, including:

- Local and regional power outages are a recurring problem that will get worse as climate impacts (storms, floods, rising seas, higher temperatures) make power outages more frequent and consequential. Better insulated houses with lower air leakage will continue to provide comfort to residents for longer periods during power outages.
- Better insulated houses with lower air leakage will better protect residents from power outages since homes will stay comfortable longer. More efficient homes will also help to protect residents from the economic consequences of rate and bill increases due to energy price increases and fluctuations. This enhanced economic resiliency is very important. High utility bills and energy consumption can result in residents falling behind on mortgages and rents, potentially resulting in eviction or loss of homes. Evictions have adverse impacts to people, especially seniors, parents and children, that extend beyond a need to change dwellings.
- Landlords, lenders and surrounding communities will indirectly benefit from energy conservation measures that reduce risks of customer defaults.
- By reducing health impacts from air pollution, temperature impacts of power outages or cost-driven reductions of heating or cooling, and evictions, conservation measures will improve health resiliency for residents and communities.
- Buildings are a major direct and indirect cause of climate pollution, and the 70+ years of expected building operation make building energy efficiency a critical path to addressing the climate crisis.
- The most recent IPCC report confirms that rapid reductions of greenhouse gas emissions is essential to avoid catastrophic climate impacts around the world. IPCC Sixth Assessment Report (February 2022), https://www.ipcc.ch/report/ar6/wg2/ Substantial harm has already occurred nationally and locally from global warming and much worse will follow without rapid reductions of greenhouse gases (particularly CO2 and methane associated with fossil fuel production and combustion). Virginia's coastal areas are among the most vulnerable to sea level rise and destructive storms. They already experience “sunny day flooding,” and sea level rise is accelerating. https://www.vims.edu/newsandevents/topstories/2020/slrc_2019.php Climate change is already harming Virginia and the harms will get much worse if we do not sharply reduce GHG emissions (particularly CO2 and methane associated with fossil fuel production and combustion). The most recent report from NOAA indicates that Virginia may face 2 feet of sea level rise by 2050 due toworsening climate change from human greenhouse gas emissions. https://www.noaa.gov/news-release/us-coastline-to-see-up-to-foot-of-sealevel-rise-by-2050 Virginia faces climate-driven sea level rise of 6.69 feet this century; the rate of sea level rise is accelerating; the danger ofclimate-driven severe storms, storm-surges and flooding are rising; and climate change will increasingly harm human health and lives, agriculture, businesses, military installations, private and public property, and Virginia’s economy. http://www.vasem.org/reports/2021-the-impact-of-climatechange-on-virginias-coastal-areas/ Growing dangers also include rising atmospheric and water temperatures that worsen heat-related illnesses, disruptions of economic activity, and harms to agriculture, fisheries, and our natural heritage.
- Because atmospheric CO2 from emissions is cumulative, Virginia has less chance of mitigating and recovering from those harms the longer we delay maximizing energy savings and minimizing greenhouse gas pollution

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐Approved
☐Approved with Modifications
☐Carryover
☐Disapproved
☐None

Public Comments for: EC-C1301.1.1.1(2)-21

Discussion by Richard Potts
Jun 3, 2022 14:22 UTC

Attached are two public comment documents submitted on behalf of the Home Builders Association of Virginia in opposition.
Attachments:
https://va.cdpaccess.com/proposal/1014/discuss/138/file/download/718/HBAV_Clarifying%20ACEEE%20Report%20on%20Virginia%27s%20Residenti
https://va.cdpaccess.com/proposal/1014/discuss/138/file/download/717/HBAV_DoE%20Data%20on%20New%20Construction%20EE%20Improvemer

Comment by William Penniman
Jun 8, 2022 16:33 UTC

Approval of this proposal (EC-C1301.1.1.1(2)-21) would fully implement the 2021 IECC for *new construction*. It would mean Virginia's building code would become "at least as stringent as" the most current IECC for ***new construction***, finally catching up in the areas Virginia has been behind for more than a decade. (Although the efficiency standards applicable to existing buildings should continue to be updated consistent with the IECC, for the sake of simplicity, this proposal would not alter a 2018 cycle compromise that restructured the efficiency standards for existing buildings. It is offered as an alternative to our "full compliance" proposal (EC-C1301.1.1(2)-21).)

Improving energy efficiency in buildings is more important now than ever, and its importance is increasing fast for consumers, the Commonwealth and the Nation. Energy efficiency is the first step to reducing energy costs, energy pollution, climate impacts and dependence on foreign energy. Today's high energy prices mean greater savings and faster payback from energy efficiency. Better insulated, tighter and more efficient buildings will provide benefits for the many decades that building are used.

The 2021 IECC was the product of years of hard work and careful analysis of costs, benefits and practicality. It continues a gradual process of improvements over the past decade or more. It increases the requirements for wall insulation, which were last updated by the IECC in 2012; and it leaves in place the 2012 IECC's requirement for testing air leakage (3 ACH50) for Climate Zones 3-5. Unfortunately, Virginia's residential codes remain behind the 2012 IECC with respect to wall insulation and air leakage even though independent analysis has found that each IECC update for 2012, 2015, 2018 and 2021 would provide net economic benefits to residents.

The Economic and Public Benefits of Full 2021 IECC Compliance Exceed the Costs

According to independent analysis by the Department of Energy and the Pacific Northwest National Laboratory (PNNL), full implementation of the 2021 IECC in Virginia will save money for residents beginning the first year of occupancy and through the life of the dwelling. It will also significantly reduce pollutants that harm the public and individuals. In PNNL-31627, ***"Cost-Effectiveness of the 2021 IECC for Residential Buildings in Virginia"*** (July 2021), the Pacific Northwest National Laboratory found:

> "Moving to the 2021 International Energy Conservation Code (IECC) is cost-effective for both single-family and low-rise multifamily residential buildings in Virginia. The 2021 IECC will provide statewide energy savings of 17.9% across all climate zones compared to the current state

energy code. This equates to $413 of annual utility bill savings for the average Virginia household. It will reduce statewide CO_2 emissions over 30 years by 28,420,000 metric tons, equivalent to the annual CO_2 emissions of 6,181,000 cars on the road (1 MMT CO_2 = 217,480 cars driven/year). Updating the state energy code based on the 2021 IECC will also stimulate the creation of high-quality jobs across the state. Adopting the 2021 IECC in Virginia is expected to result in homes that are energy efficient, more affordable to own and operate, and based on current industry standards for health, comfort and resilience.

"The average expected statewide economic impact (per dwelling unit) of upgrading to the 2021 IECC is shown in the tables below based on cost-effectiveness and carbon metrics established by the U.S. Department of Energy.1

Consumer Impact Metric	**Compared to the 2015 IECC with amendments**
Life-cycle cost savings of the 2021 IECC	$8,376
Net annual consumer cash flow in year 1 of the 2021 IECC2	$250
Annual (first year) energy cost savings of the 2021 IECC ($)3	$413
Annual (first year) energy cost savings of the 2021 IECC (%)4	17.9%

"1 A weighted average is calculated across building configurations and climate zones.

2 The annual cash flow is defined as the net difference between annual energy savings and annual cash outlays (mortgage payments, etc.), including all tax effects but excluding up-front costs (mortgage down payment, loan fees, etc.). First-year net cash flow is reported; subsequent years' cash flow will differ due to the effects of inflation and fuel price escalation, changing income tax effects as the mortgage interest payments decline, etc.

3 Annual energy savings is reported at time zero, before any inflation or price escalations are considered.

4 Annual energy savings is reported as a percentage of end uses regulated by the IECC (HVAC, water heating, and interior lighting). "

Particularly relevant to Virginia's wall insulation and air leakage standards, which predate the 2012 IECC, DOE/PNNL previously found that the 2012 IECC updates would save money for residents beginning even in the first year of occupancy and continuing annually for the 30 years studied. In, ***"Virginia Energy and Cost Savings for New Single- and Multifamily Homes: 2012 IECC as Compared to the 2009 Virginia Construction Code"*** PNNL 21346 (April 2012), PNNL and the U.S. DOE Building Technologies Program concluded:

"The 2012 International Energy Conservation Code (IECC) yields positive benefits for Virginia homeowners.

"Moving to the 2012 IECC from the current Virginia Construction Code is cost-effective over a 30-year life cycle. On average, Virginia homeowners will save $5,836 with the 2012 IECC.

Each year, the reduction to energy bills will significantly exceed increased mortgage costs. After accounting for up-front costs and additional costs financed in the mortgage, homeowners should see net positive cash flows (i.e., cumulative savings exceeding cumulative cash outlays) in 1 year for the 2012 IECC. Average annual energy savings are $388 for the 2012 IECC."

This report continued,

"Cost-effectiveness against a Virginia Construction Code baseline:

• Life-cycle cost savings, averaged across building types, are $5,836 for the 2012 IECC

• Simple payback period is 5.2 years for the 2012 IECC

Consumer savings compared to a Virginia Construction Code baseline:

• Households save an average of $388 per year on energy costs with the 2012 IECC

• Net annual consumer savings, including energy savings, mortgage cost increases, and other

associated costs in the first year of ownership, average $272 for the 2012 IECC

• Energy costs, on average, are 27.4% lower for the 2012 IECC"

Total savings in Virginia from full adoption of the 2021 IECC would be $7,192,000 in the first year and $2,487,000,000 over 30 years. Analyzing air pollution reductions from full IECC compliance, DOE/PNNL analysis also showed very substantial public savings in the form of reductions of pollutants that harm people's health and compound climate change impacts. These benefits are in addition to large statewide energy cost savings and creation of new jobs. Additional community benefits include helping residents minimize energy burdens and risks of mortgage defaults.

In other words, independent analysis shows that full implementation of the 2021 IECC will produce savings to residents over the marginal costs of construction and produce health and safety benefits to the public, and the long-neglected 2012 IECC updates for wall insulation and air leakage. On that basis, the Board should approve full compliance consistent with our proposal. Alternatively, the Board should at least eliminate the principal weakening amendments that have held Virginia back, as we have proposed in REC-R402.1.2(2)-21 (wall insulation) and REC-R402.4-21 (air leakage). Wall insulation and minimizing air leakage are critical to saving energy and cannot practically be retrofitted during the 70+ year life of the housing.)

HBAV's June 3 Comments Are Misleading

HBAV's June 3 comments are misleading. First, the ACEEE ratings gave Virginia only 75% of the points for residential construction, which is well below "near perfect." The central problems are the ongoing deficiency of wall insulation and air leakage. Residents are harmed by higher energy costs and other harms from those decade-old deficiencies. Second, the cited DOE graph shows that some owners and tenants of dwellings constructed after 2009 do continue to be "energy cost burdened" and the rising energy prices mean that more likely are "energy cost burdened" today. Not surprisingly, the "cost burdened" label applies mainly to lower-income residents. Third, even higher income residents suffer from excessive energy costs and burdens as a result of deficiencies in Virginia's building code. As shown by DOE/PNNL data above, the annual cost savings from full compliance would begin in the first year of residency and would last for decades, *i.e.*, full compliance is cost-effective and should be implemented. The money saved by residents can be spent on better things than polluting energy usage, thereby creating more jobs in Virginia.

"Non-Consensus" Is Not a Lawful Basis for Rejecting IECC Compliance

Notwithstanding past practices, "non-consensus" in work groups is not a lawful basis for holding Virginia back from full compliance with the IECC due to past exceptions.

Virginia law has long required that Virginia's code follow national standards, such as the ICC, and that costs to builders be minimized only to the extent "consistent with" applicable national codes, including codes for energy conservation. In the 2021 legislative session, the General Assembly enacted HB2227 which clearly identifies costs and benefits to residents and the public over time as the appropriate considerations for meeting or exceeding the IECC. HB2227 also requires consideration of adopting efficiency standards "at least as stringent as" the latest IECC based on those factors. Absence of builder consent is not a stated standard.

As noted, Virginia's code is more than a decade behind the IECC with respect to wall insulation and air leakage. DOE/PNNL have shown that the savings to residents exceed the incremental cost of construction in each of those areas.

Builders' generalized claims about higher housing construction costs are misleading. Housing prices have gone up for many reasons, including costs of land, materials, labor, money, and the perceived market for larger, fancier houses with higher margins.

Unlike those other costs, *energy efficiency investments will actually save residents money and make housing more affordable for owners or tenants*. The initial costs are spread over the life of a mortgage and are more than recouped in monthly energy cost savings to the residents. Efficiency investments also help to protect communities, landlords and lenders from defaults and evictions. With higher energy costs today, the savings will be even greater. Consistent with HB2227, these are clear benefits to residents and the public which exceed the initial costs of construction.

Moreover, retrofitting to cure air leakage and wall insulation deficiencies is extremely unlikely once walls have been closed. Excess energy costs and pollution will last for decades.

Significantly, many builders in Virginia also construct homes in jurisdictions, like Maryland and the District of Columbia, which require full implementation of the IECC or even go beyond the IECC. If builders can build and sell IECC-compliant houses in those jurisdictions, our builders should be able to do so in Virginia. Making the conservation component of our building code fully consistent with the 2021 IECC for new construction would yield net benefits to residents and the public in the first year and over time.

Proposal # 1014

EC-C1301.1.1.1(2)-21– Staff Summary

Proponent: William Penniman (Sierra Club – Virginia Chapter)

Brief Description:

Similar to EC-C1301.1.1.1, this proposal removes existing state amendments to fully adopt the 2021 International Energy Efficiency Code (IECC) except this proposal keeps the existing building amendments.

Many of the comments from the EC-C1301.1.1.1 staff summary are applicable to this proposal and are provided below for convenience.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Energy Sub-Workgroup members in attendance at the Sub-Workgroup's meeting on May 12, 2022, but consensus was not reached.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- William Penniman (Sierra Club)
- Eric Lacey (RECA)
    - (Comments from EC-C1301.1.1.1-21 during March 24, 2022 meeting) Supports this proposal as it essentially strikes all of the Virginia specific amendments to the IECC and gets VA on track with the national codes. Others have submitted proposals to remove some of these amendments one by one. William's proposal would delete them all and if we feel some are necessary, we can add them back. I would like to see VA fully adopt the 2021 IECC. The 2021 IECC saw considerable support from public officials across the country and there's more support for this code than ever before. This would save homeowners money in the long run and will have a positive effect on the environment. I would encourage you to take a look at all the VA amendments and see if they are worthwhile going forward.

Energy Sub-Workgroup members in attendance and opposing the proposal:

- Andrew Clark (HBAV)
    - (Comments from EC-C1301.1.1.1-21 during March 24, 2022 meeting) Had concerns with this particular proposal with adopting the 2021 IECC in full. Staff provided a breakdown of some of the specific proposals that were included in there. Our preference would be to evaluate each of those on their own instead of adopting the 2021 IECC in full. Where our association comes down on these changes, as builders, a lot of the messages we hear from local government officials is, "What are we doing to increase the supply of housing for folks at the lower to the middle end of the spectrum?" We're not talking about folks who are 30% Area Median Income (AMI), we're talking to 50-80% AMI. The Joint Legislative Audit & Review Commission

(JLARC) in VA had a report this last year that home prices increased 15% and we've seen some that increased 35%. They found that we are 2,000 rental units short for people on the low end. The percentage of homes that sold under $200k decreased since 2015. There's the discussion with respect to upfront costs vs paybacks over time. The biggest impediment is for people at the lower end to be able to bring the cash to the table to cover those upfront costs. When we're talking about reducing energy burdens the focus should be on existing homes. You've seen significant progress with homes built in the last 10 to 20 years. We're establishing a baseline standard for safety and features and it should be up to the homeowner to choose above-baseline features for their home. If we keep raising the baseline, the gap in homeownership will get wider and wider. We'd be happy to look at some of the individual proposals but we do have concerns about adopting the 2021 IECC in full.

- Steve Shapiro (AOBA/VAMA)
    - (Comments from EC-C1301.1.1.1-21 during March 24, 2022 meeting) Raised the point that we're coming out of this terrible pandemic and didn't think now is the time to enact changes to drive costs up. Andrew did a good job of framing it and we are not in support of this proposal.

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Chelsea Harnish: Virginia Energy Efficiency Council
- KC Bleile (Viridiant)

Energy Sub-Workgroup members not in attendance during the May 12, 2022 meeting:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance

Other stakeholders in attendance and opposing the proposal:

- John Ainslie (HBAV Alternate)
    - (Comments from EC-C1301.1.1.1-21 during March 24, 2022 meeting) Wanted to clarify one thing that's been mentioned. It's been mentioned that VA is not up to the national model energy codes, and while that may be a true statement, he argued that based on what he's looking at, only 3 states of the 50 have adopted the 2021 IECC. So, most states are on the 2009, maybe 2012 code. The reason they are not is because it substantially increases the cost of housing. It keeps people from buying new, more energy efficient homes. While we may not be up to the national energy codes, most states are not.

- Mike O’Connor (VA Petroleum Marketers)
    - (Comments from EC-C1301.1.1.1-21 during March 24, 2022 meeting) Our concern is the issue of rate-payer subsidization of conversion. We’re seeing that through things like the Regional Greenhouse Gas Initiative (RGGI) and other initiatives. We’re also concerned that there are about 400,000 homes that continue to be heated by heating oil, kerosene, or propane, and those people have made substantial investments and those people will not be pleased when the government wants to come in and pull out those gas cooktops, heaters, etc. We are opposed to anything that would make rate-payers subsidize those costs.

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Eric Lacey (RECA); Ben Rabe (NBI)

- Eric Lacey (RECA)

  Is in support of this proposal. Virginia is capable of meeting the requirements of the model energy code.

Opposition:

Names: Steve Shapiro (AOBA/VAMA); Jimmy Moss (Self); Andrew Clark (HBAV)

- Jimmy Moss (Self)
    - Speaking for himself. He oversees affordable housing for people at 80% AMI and below in South West Virginia. They do attempt to provide energy efficiency, but they are very limited due to the costs. He opposes this proposal.
- Andrew Clark (HBAV)
    - HBAV is opposed to this proposal. It would add a significant cost to housing for the consumer. He also thinks this may be more aspirational than practical. Virginia has an almost perfect score on residential and commercial energy efficiency in the ACEEE report. Michael O’Connor
        - Eric Lacey (RECA)
            - Responded that he disagrees, Virginia doesn’t get an almost perfect score on the ACEEE report, and Virginia is specifically behind in the residential category.

DHCD Staff Notes:

As a technical comment on this proposal, there is correlation between codes that will need to be done for a change this large. As mentioned in the description, this proposal is the same as EC-C1301.1.1.1 except that this proposal only removes the state amendments for new construction and keeps the existing building provisions. Only one should be approved if the board chooses to do so.

Meeting summaries and proposal related information: Tab 10 - Page 80; Tab 11 - Page 35.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

Clarifying the *American Council for an Energy-Efficient Economy's* Report on Virginia's Energy Policy and Building Codes

The American Council for an Energy-Efficient Economy (ACEEE) periodically releases a report ranking each state's energy efficiency policies and programs. This report is *widely* cited by energy efficiency stakeholders as justification for additional advancements in Virginia's energy codes – particularly, the report's ranking of Virginia as 25th in the country for energy efficiency[1].

Although the Home Builders Association of Virginia has partnered with these stakeholders during the 2015 and 2018 code cycles (which resulted in several significant advancements) and has continued to do so during the 2021 cycle, we felt it important to clarify the ACEEE's findings on Virginia's energy codes.

While the ACEEE report is a helpful resource for policymakers and regulatory boards, a state's ***overall ranking*** in the report is not particularly informative when evaluating the "strength" or "weakness" of a state's residential and commercial energy codes or specific energy code proposals. A deeper analysis of the ACEEE report shows that Virginia's ***overall ranking*** distorts the fact that Virginia receives extremely high scores for residential and commercial energy codes.

Virginia loses nearly half (24.5 points) of its points in categories *unrelated* to building codes

The ACEEE report ranks states based on five categories: (i) utility and public benefits programs and policies; (ii) transportation policies; (iii) building energy efficiency policies; (iv) state government initiatives; (v) appliance efficiency standards.

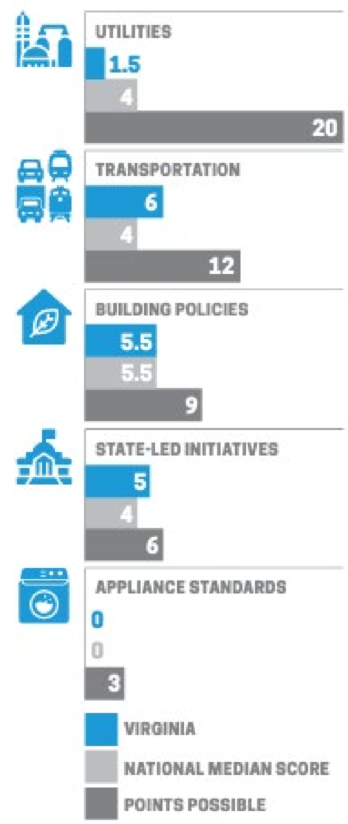
A state can only earn a certain number of points in each category:

- Utility and public benefits programs and policies (20 pts)
- Transportation policies (12 pts)
- Building energy efficiency policies (9 pts)
- State government initiatives (6 pts)
- Appliance efficiency standards (3 pts)

In the ACEEE's most recent report (2020), Virginia earned 18 out of 50 points – which is 25th in the nation.

However, a deeper analysis of the ACEEE's findings shows that Virginia lost nearly 50% of its points (24.5) in categories that are *unrelated* to energy efficiency building codes. Specifically, Virginia only earned 1.5 out of 20 pts for "Utility and Public Benefits Programs and Policies" and only received 6 out of 12 points for "Transportation Policies". *(See figure to the right)*

Due to the report's scoring system, it is inaccurate to claim that Virginia's 25th-in-the-Nation ranking in this report is the result of the Commonwealth's "weak energy code".



[1] American Council for an Energy-Efficient Economy – 2020 State Energy Efficiency Scorecard

Virginia receives a near-perfect score for residential code stringency and perfect score for commercial code stringency.

In the "Building Energy Efficiency Policy" category, Virginia receives 5.5 out of 9 points – by comparison, Virginia is only .5 points behind Maryland and 2 points behind California, which are the two states most frequently described by energy efficiency stakeholders as "leaders" in energy efficiency.

The "Building Energy Efficiency Policy" category consists of 8 sub-categories, including "residential code stringency" and "commercial code stringency". Contrary to statements made during several sub-workgroup and workgroup meetings, Virginia receives a near perfect score for "residential energy efficiency" (1.5 points out of 2) and a perfect score for "commercial energy efficiency" (2 points out of 2).

It is HBAV's understanding that these rankings were determined while Virginia was in the middle of the last code development cycle. While Virginia received exemplary scores for residential and commercial energy code stringency in ACEEE's report, the rankings only reflect a *portion* of the progress which was made in Virginia's energy codes during the last code cycle. During the last code cycle, the Home Builders Association of Virginia and other organizations reached consensus with energy efficiency stakeholders on several proposals, including:

1. Removed visual option for verifying building envelope air tightness and required blower door testing for all new residential buildings. Also added requirement that all new homes pass the blower door test with 5 air changes per hour;
2. Require an "energy certificate" in all new residential buildings to inform current and future homeowners about the key energy characteristics of their home;
3. Increase minimum ceiling insulation requirements (R-38 to R-49) for all new residential buildings;
4. ResCheck compliance updated to 2018 IECC, without Virginia amendments. Previously, a work around had been created for VA amendments that weakened the current IECC;
5. Increased fenestration requirements.

While the ACEEE has yet to release an updated report, it is highly likely that Virginia will receive further recognition for the full scope of energy efficiency code proposals that were adopted during the last code cycle – and possibly for the energy efficiency code proposals which are likely to be forwarded to the Board as "consensus" during the current code development cycle.

Submitted By: Andrew Clark - Vice President of Government Affairs, Home Builders Association of Virginia

U.S. Department of Energy Data Shows Significant Advancements in Residential Energy Efficiency and Reduction in Energy Cost Burdens in New Construction

"The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs."

Building code regulations were first established – and are continually revised – to ensure a *baseline standard* of quality, safety, and efficiency in new residential structures. For example, they provide assurance for consumers that they are residing in safe structures, guidelines for builders/design professionals as to what constitutes a safe and durable structure, and certainty for lenders of the value and quality of structure.

Similarly, energy efficiency standards were first adopted by the U.S. Housing and Home Finance Agency in the 1950's to address a concerning *public health and welfare* issue at the time: the rising number of mortgage defaults on federally insured loans on homes with high utility bills.

While increasing the efficiency of new residential structures is a laudable objective, it is critically important for policymakers to balance that objective with the growing concerns over the cost of housing in Virginia and the dramatic undersupply of housing that is attainable for households across the income spectrum. Furthermore, it is important for policymakers to distinguish between building code requirements that are essential to providing that baseline standard of quality, safety, and efficiency, and code requirements that are "aspirational".

Consumers can make a personal financial decision to purchase or build a home that is constructed to a higher energy efficiency standard, if that is an amenity that they are willing and able to afford. While energy efficiency requirements can reduce negative environmental externalities, promote high-quality housing stock, and protect consumers from soaring energy costs over time, the ability to afford the **upfront costs** of additional energy efficiency code requirements will vary widely by income.

The adoption of additional energy efficiency requirements in the building code should be based on a thorough analysis of Virginia household energy cost burden data to determine whether the housing industry is failing to provide consumers with a baseline protection against high energy costs.

U.S. Department of Energy Data

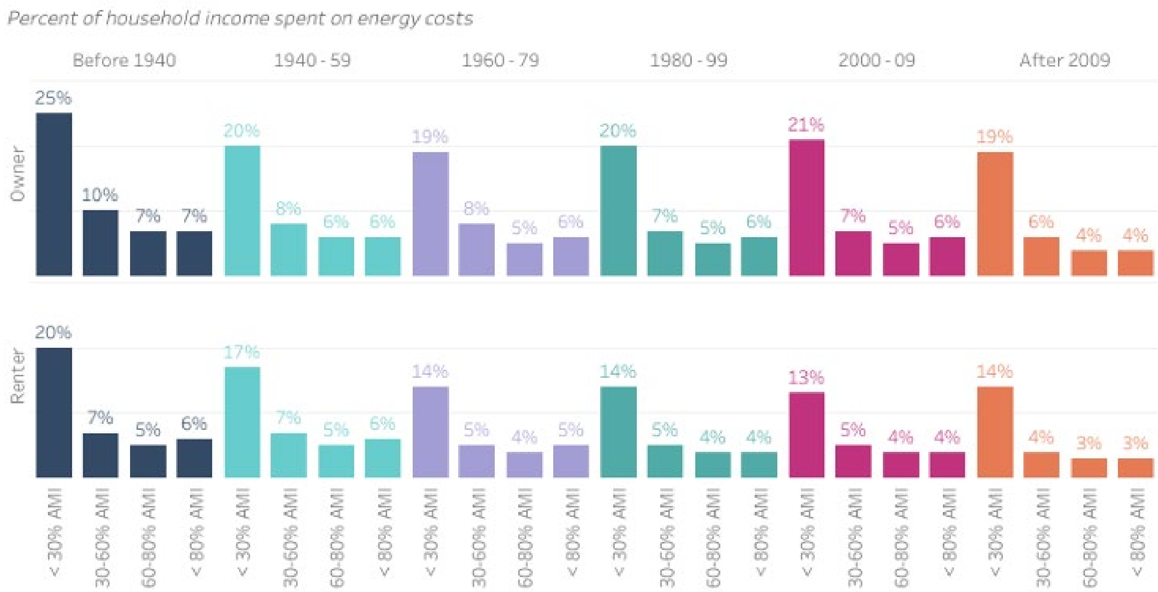
Data from the U.S. Department of Energy's *Low-Income Energy Affordability Data (LEAD) Tool* validates the claim that Virginia *has* made vast improvements in residential energy efficiency over the last 80 years and has significantly reduced household energy costs to a level considered sustainable for individuals and families across the income spectrum.

A household is considered "energy cost burdened" when over 6% of the household income is dedicated to covering energy bills – this calculation includes all costs associated with energy used by the house (e.g., electricity and natural gas). When a household is "energy cost burdened", it impacts their ability to use electricity and heat or cool their home – and forces households to choose between paying utility bills, paying a mortgage or rent, or other essential expenses. In short, high energy cost burdens results in higher levels of housing instability, including evictions and foreclosures.

The chart below was compiled using data from the U.S. Department of Energy and included in a recent report released by Virginia Housing (formerly, Virginia Housing Development Authority) and the Department of Housing and Community Development[1].

[1] HB 854 Statewide Housing Study Report (January 2022)

Energy cost burden by tenure, year home built, and AMI



Source: National Renewable Energy Laboratory, Low-Income Energy Affordability Data (LEAD) Tool, 2018.

The data from the U.S. Department of Energy (chart above) provides several important insights:

First, renters and owners residing in residential structures built since 2000 are below the 6% "energy cost burdened" threshold, with two exceptions: (i) Owner households in structures built between 2000 and 2009 are slightly over the 6% energy cost burdened threshold; (ii) Owners and renters with incomes below 30% of AMI residing in structures built between 2000 and 2019 are experiencing extremely high energy cost burdens. More analysis is needed to understand the latter - there are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Second, the highest "energy cost burdened" households (owner and renter) are residing in structures built prior to 1980's/1990's. The most "energy cost burdened" demographic – regardless of age of structure – are households earning under 30% AMI. Again, more analysis is needed to understand this dynamic. There are very few private sector and non-profit housing providers that are able to finance projects for households at that income level.

Conclusion:

Data from the U.S. Department of Energy shows that residential structures constructed in the last 20 years are significantly more energy efficient than older homes, which has reduced household energy costs to levels considered sustainable for individuals and families across the income spectrum. The data also reflects the reality that efforts to reduce household energy cost burdens would be best focused on older, existing structures occupied by individuals and families at the lower end of the income spectrum.

Several energy proposals submitted during the 2021 code cycle seek to impose stricter energy efficiency requirements on all new homes, thus increasing the upfront cost of all new homes and exacerbating an issue raised by the Virginia Joint Legislative Audit and Review Commission's recent report on housing affordability: "Rising prices make it more difficult for low- and middle-income households to afford to purchase homes because of the increased monthly mortgage costs, as well as the increased upfront costs associated with purchasing a home. Rising home prices mean that down payments and closing costs can be over $10,000 on even moderately priced homes.[2]"

[2] Joint Legislative Audit and Review Commission: Affordable Housing in Virginia (2021)

EB805.2-21

Proponents: Ben Rabe (ben@newbuildings.org); Energy Sub-Workgroup

2018 Virginia Existing Building Code

Revise as follows:

805.2 Residential compliance. Residential *additions* shall comply with ~~Section~~ the following:
1. Sections 805.2.1 or 805.2.2.

2. Sections 805.2.3 through R805.2.4.1.

Add new text as follows:

805.2.3 Heating and cooling systems. HVAC ducts newly installed as part of an addition shall comply with Section R403 of the VECC.

Exception: Where ducts from an existing heating and cooling system are extended to an addition , Sections R403.3.5 and R403.3.6 of the VECC

shall not be required..

805.2.4 Heating and cooling systems. New heating, cooling and duct systems newly installed as part of an alteration shall comply with Section R403 of the VECC. Alterations to heating, cooling and duct systems shall comply with this section.
Exception: Where ducts from an existing heating and cooling system are extended to an addition.

805.2.4.1 Duct Leakage. Where an alteration includes any of the following, ducts shall be tested in accordance with Section R403.3.5 of the VECC and shall have a total leakage less than or equal to 12.0 cubic feet per minute (339.9 L/min) per 100 square feet (9.29 m2) of conditioned floor area:

1. Where 25% or more of the registers that are part of the duct system are relocated.

2. Where 25% or more of the total length of the ducts in the system are relocated.

3. Where the total length of all ducts in the system is increased by 25% or more.

Exception: Duct systems located entirely inside a conditioned space in accordance with R403.3.2.

Reason Statement: This proposal requires that existing ductwork serving new equipment in additions and alterations is tested. In an alteration, all ductwork serving new equipment will need to be tested. In additions, the ductwork serving the addition, both existing and new ductwork, will need to be tested if it increases the total volume of the ductwork serving the addition by more than 20%. The proposal does not include a performance criterion for the testing; the testing is informational.
The requirements for duct construction and sealing in the IECC have developed substantially over recent code cycles. Fiberboard materials, cloth tape, un-sealed duct joints, cavity plenum returns and other materials and approaches that can lead to very leaky ducts were once commonplace but are not now allowed by the IECC. The result is that the ductwork in many existing buildings fall far below modern standards.

Cost Impact: The code change proposal will increase the cost of construction
Duct tightening can be a very cost-effective energy retrofit. The replacement of equipment or substantial expansion of existing ductwork present prime opportunities to undertake this testing and will provide project teams and building owners important information about the relative need and savings opportunity that could come from duct tightening projects. It will also give project teams important information for configuring new equipment and ductwork to ensure the whole system performs effectively.

Resiliency Impact Statement: This proposal will increase Resiliency
Resiliency is an essential component of adapting to the effects of climate change. Requiring duct testing for alterations increases efficiency and wasted energy though leaky ducts. As explained in reason statement, by delivering air where it was intended and not into wall cavities, homeowners benefit from proper temperature distribution in their homes, which should also decrease the amount of energy needed to overheat or overcool some parts of the home to get others to the right temperature. This also reduces the buildings overall reliance on energy, reducing carbon emissions directly and indirectly, lessening the impact on climate change and climate related events. By reducing overall energy use, this measure may contribute to a reduction in peak demand increasing the resiliency of the grid during high usage events.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: EB805.2-21

This proposal doesn't have any public comments.

Proposal # 1074

EB805.2-21 – Staff Summary

Proponent: Ben Rabe, New Buildings Institute

Brief Description:

The proposal requires existing ductwork serving new equipment in additions and alterations to be tested for leaks.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was heard by the Energy Sub-Workgroup members at the Sub-Workgroup's meetings on May 12 and 19, 2022. A vote taken at the May 19th meeting resulted in four members supporting the proposal and one abstention.

Energy Sub-Workgroup members in attendance and supporting the proposal:

- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey (Lara Baker alternate): Responsible Energy Codes Alliance
- K.C. Bleile: Viridiant
- William Penniman: Sierra Club - Virginia Chapter

Energy Sub-Workgroup members in attendance but abstaining from the vote:

- Andrew Clark (Alternates - Chris Fox, David Owen, and John Ainslie): Home Builders Association of Virginia

Energy Sub-Workgroup members not in attendance:

- Andy McKinley: American Institute of Architects – Virginia Chapter
- Jim Canter: Virginia Building and Code Officials Association
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)
- Bettina Bergoo: Virginia Department of Energy
- Eric Lacey (Lara Baker alternate): Responsible Energy Codes Alliance
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Corey Caney: International Association of Electrical Inspectors – Virginia Chapter
- Brian Clark: Habitat for Humanity

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Andrew Grigsby, Viridiant; William Penniman, Sierra Club.

- Andrew Grigsby, Viridiant, expressed full support for the proposal and indicated that he sees new heat pumps being installed in existing homes and people are still not comfortable, because there is a problem with the ductwork. Anything that addresses ductwork is beneficial and would save people a lot of money. He also added, in response to Allison Cook's statements below, that repairing duct leakage is not as invasive as the assumption is. A lot can be achieved with some caulking and a bucket of mastic. He argued that, in most cases, addressing air leakage is the more affordable solution for residents by ensuring that the ducts do not leak just as we do not want the plumbing pipes to leak either.
- William Penniman, Sierra Club, expressed support for the proposal and endorsed the comments made by Andrew Grigsby.

Opposition:

Names: Steve Shapiro, AOBA and VAMA; Allison Cook, Arlington County; Andrew Clark, HBAV; Richard Grace, VPMIA; Mike O'Connor, Virginia Petroleum and Convenience Marketers and Virginia Propane Gas Associations.

- Steve Shapiro, AOBA and VAMA, expressed opposition to the proposal and opined that the purpose of the existing building code is not to apply new code provisions to existing building.
- Allison Cook, Arlington County, recorded her full support for more energy efficient requirements for new construction but spoke in opposition to the proposal. She understands the duct leakage issues, speaking from personal experience, but this puts a lot of problems on existing houses and increases cost, all while she keeps hearing about the missing middle housing and the pressure to reduce costs by reducing safety (she gave the example of proposal intending to eliminate the second required exit stairway). She also noted that we cannot retroactively require people to make all these upgrades to their existing house, they can make that choice if they want to, but especially on the duct leakage issue, that involves a considerable cost.
- Andrew Clark, HBAV, expressed opposition to the proposal and concurred with Allison Cook that it should be the consumer's choice to make those upgrades.
- Richard Grace, VPMIA, agreed with the logic behind Allison Cook's testimony and recorded his opposition to the proposal.
- Mike O'Connor, Virginia Petroleum and Convenience Marketers and Virginia Propane Gas Associations, recorded his opposition to the proposal by typing in the Adobe Platform chat box the following: "*The problem is that heat pumps do not provide sufficient heat in cold weather locations. Virginia Petroleum and Convenience marketers and Virginia Propane Gas Associations opposed.*"

DHCD Staff Notes:

The Sub-Workgroup members supporting the proposal during the May 19th meeting, did not provide any specific reasons for the support.

Meeting summaries and proposal related information: Tab 10 - Page 73; Tab 11 - Page 37; Tab 11 - Page 42.

FP906.1-21

Proponents: Dwayne Garriss (DwayneSCG@gmail.com)

2018 Virginia Statewide Fire Prevention Code

Revise as follows:

906.1 Where required. Portable fire extinguishers shall be installed in all of the following locations:

1. In Groups A, B, E, F, H, I, M, R-1, R-4, and S occupancies.

   Exceptions:

   1. ~~In Groups A, B, and E occupancies equipped throughout with quick response sprinklers, portable fire extinguishers shall be required only in locations specified in Items 2 through 6.~~
   2. In Group I-3 occupancies, portable fire extinguishers shall be permitted to be located at staff locations and the *access to* such extinguishers shall be permitted to be locked.

   Note: In *existing buildings*, whether fire extinguishers are needed is determined by the *USBC* or other code in effect when such *buildings* were constructed.

2. Within 30 feet (9144 mm) distance of travel from commercial cooking equipment and from domestic cooking equipment in Group I-1; I-2, Condition 1; and R-2 college dormitory occupancies.
3. In areas where flammable or combustible liquids are stored, used or dispensed.
4. On each floor of structures under construction, except Group R-3 occupancies, in accordance with Section 3315.1.
5. Where required by the sections indicated in Table 906.1.
6. Special-hazard areas, including but not limited to laboratories, computer rooms and generator rooms, where required by the *fire code official*.

2018 Virginia Construction Code

Revise as follows:

906.1 Where required. Portable fire extinguishers shall be installed in all of the following locations:

1. In Groups A, B, E, F, H, I, M, R-1, R-4, and S occupancies.

   Exception:

   1. ~~In Groups A, B, and E occupancies equipped throughout with quick response sprinklers, portable fire extinguishers shall be required only in locations specified in Items 2 through 6.~~
   2. In Group I-3 occupancies, portable fire extinguishers shall be permitted to be located at staff locations and the access to such extinguishers shall be permitted to be locked.

2. Within 30 feet (9144 mm) distance of travel from commercial cooking equipment and from domestic cooking equipment in Group I-1; I-2, Condition 1; and R-2 college dormitory occupancies.
3. In areas where flammable or *combustible liquids* are stored, used or dispensed.
4. On each floor of structures under construction, except Group R-3 occupancies, in accordance with Section 3315.1 of the *International Fire Code*.
5. Where required by the *International Fire Code* sections indicated in Table 906.1.
6. Special-hazard areas, including but not limited to laboratories, computer rooms and generator rooms, where required by the fire code official.

Reason Statement: The concept of trading off portable extinguishers in sprinklered buildings has been largely abandoned by fire protection principles. The National Fire Codes of both NFPA 1 and the ICC- IFC require portable fire extinguishers in all occupancy classes. A portable fire extinguisher is an effective item of fire protection which allows for small fires to be tackled by the occupants of a building and saves 100s of thousands of dollars in property loss. It is important to appreciate that while different to official assumptions and desire for evacuation, research shows the public's priorities to be rational and appropriate. The public's experience of fire is vastly different to that of the professionals involved in the planning for and responding to fire.

Some key findings from research studies have been identified and the public's-oriented outcomes include, avoidance of embarrassment, inconvenience, damage to the premises or property, concern for others, pets and possessions and lastly personal injury. The evidence further identifies that the public is willing and will accept minor consequences in their pursuit of achieving personal humanistic priorities and instinct. Concern for people, pets and possessions are strong and established drivers of behavior in the event of a fire. Therefore, this should be no surprise to see it as an influential feature of most individual's response to a fire. Limiting a fire to the smallest area within a building is a sensible aspiration.

Official policy and attitudes are most singularly directed at avoiding the risk when the public encounters a fire. This is well meaning but the research has shown that this DOES NOT I REPEAT DOES NOT align with the publics' attitude or the ability of the general public.

Thus, it is important to give the public the intelligently designed and placed tools intended for their use and not the necessarily firefighters. NFPA 10 states: 5.1.2 The selection of extinguishers shall be independent of whether the building is equipped with automatic sprinklers, standpipe and hose, or other fixed protection equipment. Other codes, and other occupancy chapters have abandoned this concept in recognition of the fact that portable extinguishers are a valuable, cost-effective layer of fire protection, and are intended for a different purpose than sprinklers. To avoid addressing fires in their earliest stages is counter-intuitive, and studies have shown that people will almost always attempt to extinguish a fire if it's small and they believe they can mitigate the hazard. If a fire extinguisher is not available, people have (and will continue to) use makeshift means to try to extinguish the fire, which is far less safe than using a portable extinguisher that is designed for safe and effective use by novices. (Ref: An Evaluation of the Role of Fire Extinguishers by David Wales)

A significant amount of data has been collected to support the requirement for portable extinguishers, including: WPI/EKU Study: "Ordinary People and the Effective Operation of Fire Extinguishers", which clearly showed that the vast majority of people who have never used an extinguisher can operate one safely and effectively.

2013 NFPA Report: "U.S. Experience with Sprinklers" reports that there were 48,460 reported structure fires annually in buildings equipped with sprinkler systems between 2007-2011, and 40,440 (83 percent) never grew large enough to activate the system. Based on this report alone, it's clear that people are reacting to small fires and extinguishing them prior to sprinkler activation.

A study by Richard Bukowski in 2014, the life cycle cost of portable fire extinguishers was determined to be between one and a half and four cents per foot annually; if coverage could be maximized to that allowable by code, the cost drops to between a half cent and one cent per foot annually. It's unlikely that any other layer of fire protection is so cost-effective.

Portable fire extinguishers are required in certain instances to give the occupants the means to suppress a fire in its incipient stage. The capability for manual fire suppression can contribute to the following:

· The protection of the occupants, especially if there are evacuation difficulties associated with the occupancy.

· The protection of our environment by reducing large amounts of airborne pollutants.

· The protection of our environment by reducing large amounts of contaminated water runoff associated to large fires.

· The reduction of impact of the carbon footprint by requiring potential less repair/reconstruction of the area involved when the fire is extinguished or contained in the early stages in lieu of waiting for a fire to grow large enough for the activation of the automatic sprinkler system.

· The potential reduction in downtime for facilities suffering from a fire if used in the incipient stages of fire discovery reducing the economic impact on the community.

Portable fire extinguishers are required in occupancies in Groups A, B, and E in both the National Model Fire Codes of the ICC and NFPA because of the need to control the fire in its early stages and because evacuation can be slowed by the density of the occupant load, the capability of the occupants to evacuate or the overall fuel load in the building. Because the IBC (building code) references the IFC (fire code) for fire extinguisher requirements in new buildings, the code is applicable to new buildings. The current exception 1 to 906.1 that exempts the installation of portable fire extinguishers (PFEs) in low-hazard areas of Group A, B and E occupancies when the fire areas are equipped with an automatic sprinkler system utilizing quick-response automatic sprinklers was deleted from the 2012 edition of the IBC and the IFC after considering a proposal from the National Association of State Fire Marshals (NASFM). NASFM, and other supporters of the exception's removal, rightly argued that exempting occupancies from fire extinguisher requirements can leave those buildings without a proper firefighting tool for small, controllable fires. The ICC agreed with this rationale and removed the exception in the last 5 versions (2012, 2015, 2018, 2021 and currently sustained in the 2024 edition under development) of the International Fire Code.

Many code officials believed it is inappropriate to place complete reliance on automatic sprinkler systems for the protection of assembly, business and educational occupancies. An analysis of fire loss data for Group A occupancies, performed by the National Institute of Science and Technology (NIST) during the investigation of a large life loss fire confirmed that assumption was correct. While investigating the Station Fire, a nightclub fire where 100 people died in 2003, NIST also analyzed the performance of portable fire extinguishers in night clubs. NIST also analyzed NFPA fire loss data for nightclubs from 1990 through 1994 and found that almost 36 percent of fires in public assembly structures were extinguished by PFEs or other means during the incipient phase. These data show that without PFEs, occupants commonly used other tools to try to extinguish incipient fires. The NIST analysis found that 28 percent of all incipient fires were extinguished using PFEs and the remaining 8 percent used makeshift means. The study concluded that it was important for fire code officials to reinforce and educate nightclub employees on the purpose and capability of PFEs for controlling incipient fires.

The removal of PFEs is believed to reduce the level of protection in the building. Based on the referenced NIST report we believe the deletion of the exception for Group A occupancies is warranted.Virginia is not unique in the decision to base the building and fire codes on these national model codes, as most jurisdictions do the same. The reasons are relatively simple: by utilizing a national consensus process the requirements of the ICC model codes are well vetted by a cross-section of regulators and industries. This results in appropriate safety provisions for the vast majority of jurisdictions, based upon national consensus processes. Amendments that weaken the model codes upon their state adoption should be carefully considered and only made through deliberate, well-reasoned processes, resulting in changes that only make the model codes safer for the residents of Virginia.

Fire extinguishers are the first line of defense for small, controllable fires. They are intended to be used for fires of limited size and easily controlled. If a fire is discovered in its early stages, the most effective means of protecting life and preventing property loss is to sound an alarm and then to control and/or extinguish the incipient stage fire with a portable fire extinguisher. To simply wait for the fire to grow large enough in size for a sprinkler head to activate, is contrary to lessons and guidance from fire service and fire protection professionals. Since fire extinguishers provide a first line of defense versus sprinklers, it remains unclear as to the justification for this exception.

As the state of Virginia bases its building and fire codes on these national model codes, when drafting the update of the State Fire Protection Code for Virginia, we believe the Codes and regulations adopted by the Board of Housing and Community Development should not be one of only three other states varying from the National Mode Codes when it comes to layered fire protection in buildings by providing one of the first lines of defense for building occupants. We believe the Division should maintain the model codes level of fire safety and not be one of only three other states varying from the National Mode Codes when it comes to layered fire safety in buildings by maintaining exception 1 to Section 906.1, eliminating extinguishers in some of the most populated public buildings.

By providing a layered approach to fire and life safety for business properties, educational facilities and assembly occupancies, located throughout Virginia, you are providing a level of safety to the citizens of Virginia and its visitors at a level already established throughout the rest of the country for businesses and properties located throughout the country. The more we can reduce fires or fire growth, the better we can protect lives, property, and our environment. The reduction in fire sizes and fire growth will help reduce the carbon footprint impact on our environment by producing less fire byproducts released into the atmosphere, producing less contaminates introduced into our groundwater with smaller amounts of water runoff with smaller fires and with smaller fires requiring less reconstruction or renovation the overall impact on the carbon footprint is further reduced. As with the current Federal Administration's concern for the protection of our environment, the resiliency of our communities and reduction of the carbon footprint, the AIA, NFPA , ICC, as well as others, are striving to make a difference for our future generations.

A 2021 report supported by the Independent Fire Engineering & Distributors Association (IFEDA) considers the fundamental discrepancy between policy directives and public response in the face of a fire event. The report finds that people will naturally attempt extinguish a fire, especially an incipient fire, either using portable extinguishers or other improvised means. They are usually successful in doing so, with 70-80 percent of fires dealt with by the public without training or professional assistance. (A separate study conducted by Worcester Polytechnic Institute and Eastern Kentucky University titled “Ordinary People and Fire Extinguisher Effectiveness” also found that of 276 untrained persons, over 90 percent operated the extinguisher effectively on a simulated fire.)

RJA's Study on the Life Cycle Cost of Portable Fire Extinguishers demonstrates that installing fire extinguishers cost only a fraction of a penny to a few penny's per square foot over their lifetime, probably the most cost-effective layer of fire protection available. Use of extinguishers often minimize costly damage to property and human life by intervening before sprinklers are activated. Additionally, a separate study conducted by Worcester Polytechnic Institute and Eastern Kentucky University found that of 276 untrained persons, over 90 percent operated the extinguisher effectively on a simulated fire, decreasing the costs association with training employees.

The NFPA's study on the U.S. Experience with Sprinklers and Other Automatic Fire Extinguishing Equipment notes the value of sprinklers but critically reports that the majority of reported never grew large enough to activate operational equipment. In one study, 65 percent of fire events in a space with automatic sprinklers, the sprinklers were not activated. This report, intended to showcase the benefits of automatic sprinklers, clearly indicates that someone is successfully intervening in fire events prior to sprinkler activation.

FM Global's technical report on the Environment Impact of Automatic Fire Sprinklers shows that benefits gained from effective green initiatives can be negated by a single fire event. While the report looks at the value of sprinkler systems, it acknowledges the shortcomings of the sprinkler systems to adequately manage all fires and again emphasizes the need for a layered approach that includes portable extinguishers.

In 2010, The International Code Council's Code Development Committee recommended to remove the exception to Line 1 of 906.1 of the International Fire Code (IFC) that allows certain buildings to function without portable fire extinguishers. The history of code change committee debates in 2010 for the International Fire Code (IFC) on the sprinkler/portable extinguisher exception show a consistent consensus decision by fire safety experts from across the country to require portable fire extinguishers since the reinstatement of the requirements into the International Fire Code since 2012 edition over 10 years ago. This decision has been challenged in every code development cycle since. Each time, after detailed consideration of the argument, the Committee reasoned that even within sprinklered buildings, fire extinguishers have made a difference in controlling fires and the exception for quick response sprinklers in certain buildings should be deleted. The Committee also reasoned that citizen are accustomed to seeing extinguishers within buildings and expect them to be available for use. This decision has also been supported overwhelming by the Governmental Voting Members of the ICC membership including those in the VA fire service.

Evidence shows that people will intervene in fire events that are small and manageable. Providing proper tools, such as fire extinguishers, is the clear means to assure the best outcome in fire prevention. Additionally, the installation and maintenance of fire extinguishers is more economical than other fire protection features.

· In 2004, portable fire extinguishers were used on 371,500 residential fires (CPSC report published 2009).

· In 2008, portable fire extinguishers were used on 190,400 commercial fires.

· Fire in residences were mitigated in over 95% of the cases without intervention from the fire department. In over 75% of the cases, someone in the home extinguished the fires. (CPSC report published 2009)

Again, both national model fire codes, NFPA 1 and the International Fire Code (IFC), embrace portable extinguishers as key parts of overall fire safety – regardless of the presence of sprinklers. None of the source documents for the *International Fire Code* (IFC) being the BOCA (*Building Officials and Code Administrators International* building code), SBCCI (the *Southern Building Code Congress International* building and fire construction codes) and the USBC (*Uniform Standard Building Code* which the State of Virginia followed before the adoption of the IFC) had the exception for these occupancies. It was inserted at the end of a multi-year drafting process for the IFC. Realizing the importance and success of portable fire extinguishers and need for layered fire protection states very quickly began amending this section as they adopted the IFC as the basis of their state fire code since portable fire extinguishers were not previously omitted from sprinklered buildings. NASFM and other supporters rightly argued that exempting occupancies from fire extinguisher requirements can leave those buildings without a proper firefighting tool for small, controllable fires. This representative has proposed to reverse the 2012 decision in every code development cycle since.

With more than a decade's worth of experience with the issue, FEMA has been able to curate the following detailed account for the model codes' requirements for portable fire extinguishers.· If there is any question as to whether the citizenry in the United States is acting early to extinguish incipient fires, the report of the U.S. Consumer Products Safety Commission should put those doubts to rest. According to their report, only 5-10 percent of fires are reported to fire departments in the U.S. We submit that, since people are, in fact, extinguishing small fires in their incipient stage on a very regular basis, the code should provide for the proper tools to do so - that is, maintain the requirements for portable extinguishers. According to this report, people use portable extinguishers on 371,000 residential fires in the U.S. annually. In this same report, the agency stated that extinguishers were effective in 80 percent of the cases where they were used. The entire 234 page report, published in 2009, can be found at: https://www.cpsc.gov/PageFiles/105297/UnreportedResidentialFires.pdf

Some of these fires are extinguished using fire extinguishers; others are being extinguished with makeshift means. Extinguishers are the appropriate tool and designed for use on incipient fires. Providing portable fire extinguishers in facilities greatly enhances safety, including the safety of those who choose to extinguish a fire in its incipient phase; extinguishers should be available in all buildings.· An NFPA report on fires in sprinklered buildings published in 2010 states that in fires reported in buildings equipped with sprinkler systems, the fire didn't grow large enough to activate the sprinklers in 65 percent of the cases (page 11). The fires cited in this report were large enough to be reported to the fire department; the sprinkler systems were operational and would have activated if the fire had grown larger, but were extinguished or otherwise mitigated prior to sprinkler activation. This report verifies that people are intervening when a fire is small, saving the property owner(s) substantial sums of money by putting the fire out before it grows larger, doing more damage and before sprinklers activate, while protecting the lives of building occupants. You can see that report here: http://www.tvsfpe.org/_images/us_experience_with_sprinklers.pdf

· Where cost is a consideration, portable fire extinguishers are, without a doubt, one of the most cost effective layers of fire protection available. A life cycle cost analysis was conducted in 2014 by Richard Bukowski, P.E, then working for RJA. In that study, the actual cost of portable extinguishers in several facilities was used to determine the real-world cost of these devices. Using 12 health care facilities, the costs of initial purchase, installation, monthly and annual maintenance, as well as all associated maintenance required by NFPA-10 (the standard referenced in ICC Codes) were compiled and analyzed. According to this study, the actual costs of portable extinguishers in these facilities ranged from $.015 (one and one half cent) to $.04 (four cents) per square foot per year. His study also states that, if a facility were able to utilize the minimum number of extinguishers required by the Codes based upon coverage of an area, the costs would be between $.005 (one half cent) and $.01 (one cent) per square foot per year. This report can be found at: http://www.femalifesafety.org/docs/006GRCAtt01RJAFinalReport011714.pdf

· Finally, the question of whether a person needs to be trained in order to use a portable extinguisher has been mentioned. While we encourage training those who may utilize portable extinguishers, there is substantial evidence that people without training can and do use extinguishers safely and effectively. Specifically, Worcester Polytechnic Institute and Eastern Kentucky University conducted a study titled "Ordinary People and Fire Extinguisher Effectiveness". In that study of 276 untrained persons, over 90 percent operated the extinguisher effectively on a simulated fire, with 98% successfully pulling the pin, squeezing the trigger, and discharging the agent. 74% used proper techniques including aiming at the base of the fire and using a sweeping motion. This study dispels any doubt that extinguishers can be effective in the hands of novice users.
http://www.femalifesafety.org/docs/WPIStudyFinal.pdf

It is recommended to look at the strengths and weaknesses of automatic sprinkler systems. Although we do support automatic sprinkler system installation in buildings, the NFPA's 2017 study on the U.S. Experience with Sprinklers and Other Automatic Fire Extinguishing Equipment notes the value of sprinklers but critically reports that the majority of reported fires were too small to activate operational equipment. In 65 percent of fire events in a space with automatic sprinklers, the sprinklers were not activated, making a layered fire safety approach that includes portable extinguishers vital.

· Confined fires and unconfined fires that were too small to activate the sprinkler system equate to 84% of reported fires in sprinklered buildings.

· Sprinklers are ineffective in 12% of fires that grow large enough to activate the system.

· Reported sprinkler failures were twice as common as reported fires in which sprinklers were ineffective.

o 40 % of the combined sprinkler problems were due to system shut-offs.

o 59% of incidents in which sprinklers failed to operate, the system had been shut off.

o 51% of fires in which sprinklers were ineffective, the water did not reach the fire.

· Fire departments responded to an estimated 29,800 sprinkler activations caused by a system failure or malfunction and 33,600 unintentional sprinkler activations in 2014.

There has been argument that training is required if portable fire extinguishers are provided as an OSHA requirement. OSHA requirements are only applicable to OSHA regulated or participating governments. Even then, training is not required unless personnel are specifically designated to respond to fires and use extinguishers. FEMA highly recommends training regardless but provides for such with VIDEO links and instructions found in 2-3 minute video training at https://fireextinguisherssavelives.org/.

Lastly, we must explore human instinct and the use of portable fire extinguishers. In 2021, David Wales, with support from the Independent Fire Engineering & Distributors Association (IFEDA), published a report evaluating the role of fire extinguishers in buildings through an evidence-based assessment. The report aims to relay the public's perception of and behavior around fire extinguishers in order to ensure manufacturers provide the most relevant instructions.

There is a fundamental discrepancy between official/policy assumptions and the public in relation to priorities in the event of a fire. Government and professionals focus on avoiding injuries and see that as the sole aspiration. As a result, they consider the public role to be one of compliance in which they simply exit the premises on becoming aware of a fire.

· In contrast, the public have a wide and largely unrecognized range of priorities when encountering a fire, based on their individual circumstances. These can include:

o The avoidance or embarrassment/inconvenience.

o Mitigating the impact of damage to the property by avoiding the risk of being unable to remain in their home.

o Concern for the wellbeing of other people, pets, or valued possessions.

· A desire to achieve their self-appointed tasks is a strong motivation for the public's behavior when encountering a fire. This includes investigating the initial cues and tackling the fire, often using improvised means. They are usually successful in doing so, with 70-80 percent of fires dealt with by the public without requiring professional assistance.

· People's disaster response actions differ significantly from disaster myths that commonly portray victims as dazed, panicked, or disorganized. Instead, most people respond adaptively.

Cost Impact: The code change proposal will increase the cost of construction
A life cycle cost analysis was conducted in 2014 by Richard Bukowski, P.E, then working for RJA. In that study, the actual cost of portable extinguishers in several facilities was used to determine the real-world cost of these devices. Based upon his study, the costs of initial purchase, installation, monthly and annual maintenance, as well as all associated maintenance required by NFPA-10 (the standard referenced in ICC Codes) were compiled and analyzed. According to this study, the actual costs of portable extinguishers in these facilities ranged from $.015 (one and one half cent) to $.04 (four cents) per square foot per year. His study also states that, if a facility were able to utilize the minimum number of extinguishers required by the Codes based upon coverage of an area, the costs would be between $.005 (one half cent) and $.01 (one cent) per square foot per year.
This report can be found at: http://www.femalifesafety.org/docs/006GRCAtt01RJAFinalReport011714.pdf

Resiliency Impact Statement: This proposal will increase Resiliency
FM Global's 2010 technical report on the Environment Impact of Automatic Fire Sprinklers shows that benefits gained from effective green initiatives can be negated by a single fire event. While the report looks at the value of sprinkler systems, it acknowledges the shortcomings of the sprinkler systems to adequately manage all fires and again emphasizes the need for a layered approach that includes portable extinguishers.

· In all occupancies, from residential dwellings to office buildings, the lack of proper risk management and effective fire protection statistically increases carbon emissions over the lifecycle of the occupancy.

· Typical benefits gained from green construction and energy efficient appliances and equipment can be negated by a single fire event.This is due to subsequent carbon dioxide, and other greenhouse gasses, generated from burning combustible material, in addition to the embodied carbon associated with disposal of damaged materials and reconstruction.

· U.S. fires release about 290 million metric tons of carbon dioxide per year, the equivalent of 4-6 percent of the nation's carbon dioxide emissions from fossil fuel burning.

· While automatic sprinklers can be a key factor in reducing the carbon footprint of building fires, sprinkler systems only cover 10% of all building fires. In the other 90% of fires where a sprinkler system is not activated, fires can be reduced by fire extinguishers which provide a safe and accessible way to mitigate the climate impact of building fires.

By providing a layered approach to fire and life safety for business properties, educational facilities and assembly occupancies, located throughout Virginia, you are providing a lave of safety to the citizens of Virginia and its visitors at a level already established throughout the rest of the country for businesses and properties located throughout the country. The more we can reduce fires or fire growth, the better we can protect lives, property, and our environment. The reduction in fire sizes and fire growth will help reduce the carbon footprint impact on our environment by producing less fire byproducts released into the atmosphere, producing less contaminates introduced into our groundwater with smaller amounts of water runoff with smaller fires and with smaller fires requiring less reconstruction or renovation the overall impact on the carbon footprint is further reduced. As with the current Federal Administration's concern for the protection of our environment, the resiliency of our communities and reduction of the carbon footprint, the American Institute of Architects, The National Fire Protection Association, The International Code Council, as well as others, are striving to make a difference for our future generations.

Attached Files

- **FM Global Sprinkler Environmental report.pdf**
  https://va.cdpaccess.com/proposal/1169/1680/files/download/798/
- **NFPA Sprinkler Report 2017.pdf**
  https://va.cdpaccess.com/proposal/1169/1680/files/download/685/
- **Life Cycle Cost Analysis of Portable extinguishers - Copy.pdf**
  https://va.cdpaccess.com/proposal/1169/1680/files/download/684/
- **Ordinary People and Fire Extinguisher Effectiveness.pdf FINAL.pdf**
  https://va.cdpaccess.com/proposal/1169/1680/files/download/683/
- **UnreportedResidentialFires.pdf**
  https://va.cdpaccess.com/proposal/1169/1680/files/download/682/
- **An evaluation of the role of fire extinguishers (3).pdf**
  https://va.cdpaccess.com/proposal/1169/1680/files/download/681/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved

☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: FP906.1-21

Discussion by Florin Moldovan
Jun 10, 2022 18:05 UTC

See attached floor modification discussed at the General Stakeholders Workgroup Meeting on 06/10/2022.
Attachments: https://va.cdpaccess.com/proposal/1169/discuss/151/file/download/737/FP906.1-21%20Floor%20Modification.pdf

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FP906.1-21 – Staff Summary

Proponent: Dwayne Garriss

Brief Description:

The proposal deletes existing Virginia amendment which exempts groups A, B and E occupancies from the requirements to provide portable fire extinguishers (if the buildings are equipped throughout with quick response sprinklers).

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was discussed by the Statewide Fire Prevention Code (SFPC) Sub-Workgroup at their May 11, 2022, meeting but the proposal was not supported by the Sub-Workgroup.

Statewide Fire Prevention Code Sub-Workgroup members in attendance:

- Andrew Milliken: Virginia Fire Services Board (VFSB), Chairman of Fire Codes and Standards Committee
- Dustin Wakefield: Virginia Department of General Services (DGS), Division of Engineering and Buildings (DEB)
- Jimmy Moss: Virginia Building and Code Officials Association (VBCOA)
- Joshua Davis: State Fire Marshal's Office, Virginia Department of Fire Programs (VDFP)
- Linda Hale: Virginia Fire Prevention Association (VFPA)
- Mike O'Connor: Virginia Petroleum and Convenience Marketers Association (VPCMA)
- Robert Melvin: Virginia Restaurant, Lodging and Travel Association (VRLTA). *Note:* alternate voting member to Matthew Lannon, who was not in attendance.
    - VRLTA is in opposition and are concerned about the impact to group A occupancies. The redundancy of sprinklers and fire extinguishers is unnecessary. One specific concern is around patrons consuming alcohol and causing vandalism to portable fire extinguishers.

Statewide Fire Prevention Code Sub-Workgroup members not in attendance:

- Jodi Roth: Virginia Retail Federation (VRF)
- Lou Wolf: SBW Architects, American Institute of Architects (AIA), Virginia Chapter
- Matthew Lannon: Virginia Restaurant, Lodging & Travel Association (VRLTA) ***Note:*** alternate member – Robert Melvin, was in attendance
- Steve Shapiro: Apartment and Office Building Association (AOBA) and Virginia Apartment Management Association (VAMA)
    - Emailed staff in advance of meeting to express opposition to the proposal.

Additional Sub-Workgroup comments:

- Perry Weller (not a Sub-Workgroup member) shared an experience where a fire in a local high school was put out with a portable extinguisher. If the fires can be caught when they are small, before sprinklers are activated, it would save a lot of damage.

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Andrew Milliken, Virginia Fire Services Board (VFSB) - Codes and Standards Committee;

- Andrew Milliken, VFSB - Codes and Standards Committee stated that the Committee discussed the proposal and is in support. The supporting data included in the reason statement shows the usefulness of fire extinguishers and they feel that it would be good for the Board (of Housing and Community Development) to weigh in on the proposal.

Opposition:

Names: Steve Shapiro, Apartment and Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

- Steve Shapiro, AOBA and VAMA, indicated that his members are opposed to this proposal, which has been submitted every code development cycle, over the past several code cycles. The existing exemption has encouraged sprinkler installation and it discourages vandalism to extinguishers. Installing the sprinklers was a tradeoff to not require extinguishers. There is cost to purchase, inspect, maintain and replace extinguishers and there is also the threat of vandalism. It is more likely that the extinguishers would be vandalized than used in a fire and they could also cause personal harm to people using them improperly. Constituents would rather deal with expense due to water damage from sprinklers in the event of a fire, than to deal with injury of patrons trying to use fire extinguishers. He would personally look for escape from a fire than to look for an extinguisher, hope it works and use it to try and fight a fire.

DHCD Staff Notes:

The original code change proposed to amend the SFPC only. A floor modification was submitted at the General Stakeholders Workgroup meeting on June 10, 2022, to apply the same changes to the Virginia Construction Code, for consistency.

Meeting summaries and proposal related information: Tab 10 - Page 87; Tab 11 - Page 123.

FP906.1-21 Floor Modification

NOTE: the original/cdpVA proposal consists of the changes to the 2018 SFPC shown herein. The floor modification consists of supplementing the proposal with the equivalent changes to the 2018 VCC, for correlation purposes. The underlined and strikethrough text identifies proposed changes to the 2018 SFPC and the 2018 VCC.

VFC and VCC: 906.1

Proponents:

Dwayne Garriss (DwayneSCG@gmail.com)

2018 Virginia Statewide Fire Prevention Code

Revise as follows:

906.1 Where required.

Portable fire extinguishers shall be installed in all of the following locations:

1. In Groups A, B, E, F, H, I, M, R-1, R-4, and S occupancies.

    Exceptions:

    1. ~~In Groups A, B, and E occupancies equipped throughout with quick response sprinklers, portable fire extinguishers shall be required only in locations specified in Items 2 through 6.~~

    2. In Group I-3 occupancies, portable fire extinguishers shall be permitted to be located at staff locations and the *access to* such extinguishers shall be permitted to be locked.

    Note: In *existing buildings*, whether fire extinguishers are needed is determined by the *USBC* or other code in effect when such *buildings* were constructed.

2. Within 30 feet (9144 mm) distance of travel from commercial cooking equipment and from domestic cooking equipment in Group I-1; I-2, Condition 1; and R-2 college dormitory occupancies.

3. In areas where flammable or combustible liquids are stored, used or dispensed.

4. On each floor of structures under construction, except Group R-3 occupancies, in accordance with Section 3315.1.

5. Where required by the sections indicated in Table 906.1.

6. Special-hazard areas, including but not limited to laboratories, computer rooms and generator rooms, where required by the *fire code official*.

2018 Virginia Construction Code

Revise as follows:

906.1 Where required.

Portable fire extinguishers shall be installed in all of the following locations:

1. In Groups A, B, E, F, H, I, M, R-1, R-4, and S occupancies.

    Exceptions:

    ~~1. In Groups A, B, and E occupancies equipped throughout with quick response sprinklers, portable fire extinguishers shall be required only in locations specified in Items 2 through 6.~~

    2. In Group I-3 occupancies, portable fire extinguishers shall be permitted to be located at staff locations and the access to such extinguishers shall be permitted to be locked.

2. Within 30 feet (9144 mm) distance of travel from commercial cooking equipment and from domestic cooking equipment in Group I-1; I-2, Condition 1; and R-2 college dormitory occupancies.

3. In areas where flammable or combustible liquids are stored, used or dispensed.

4. On each floor of structures under construction, except Group R-3 occupancies, in accordance with Section 3315.1 of the International Fire Code.

5. Where required by the International Fire Code sections indicated in Table 906.1.

6. Special-hazard areas, including but not limited to laboratories, computer rooms and generator rooms, where required by the fire code official.

RESEARCH TECHNICAL REPORT

Environmental Impact of Automatic Fire Sprinklers

FM Global

TECHNICAL REPORT

Environmental Impact of Automatic Fire Sprinklers

By:

Christopher J. Wieczorek
Benjamin Ditch
Robert G. Bill, Jr.

FM Global Research Division

March 2010

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by
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EXECUTIVE SUMMARY

Currently, efforts to improve sustainability and reduce lifecycle carbon emissions are achieved primarily by increasing the energy efficiency of an occupancy and reducing embodied carbon. Recently, a methodology has been developed that expands the assessment of lifecycle carbon emissions to incorporate risk factors such as fire. The methodology shows that in all occupancies, from residential dwellings, to office buildings, to high hazard facilities, the lack of proper risk management and effective fire protection, e.g., automatic fire sprinklers, statistically increases carbon emissions over the lifecycle of the occupancy.

Furthermore, typical benefits gained from “green” construction and energy efficient appliances and equipment can be negated by a single fire event. This is due to the subsequent carbon dioxide, and other greenhouse gases, generated from burning combustible material, in addition to the embodied carbon associated with disposal of damaged materials and reconstruction.

To further support the risk factor methodology, an experimental study was conducted to quantify the environmental impact of automatic fire sprinklers. Large-scale fire tests were conducted using identically constructed and furnished residential living rooms. In one test, fire extinguishment was achieved solely by fire service intervention. In the other test, a single residential fire sprinkler controlled the fire until final extinguishment was achieved by the fire service.

Quantification of the environmental benefit of automatic fire sprinklers was based on comparisons between the two tests, including total greenhouse gas production, quantity of water required to extinguish the fire, quality of water runoff, potential impact of wastewater runoff on groundwater and surface water, and mass of materials requiring disposal.

The use of automatic fire sprinklers reduced the peak heat release rate from 13,200 kW to 300 kW and reduced the total energy generated by a factor of 76. The fraction of combustible material consumed in the fire was less than 3% in the sprinklered test and between 62% and 95% in the non-sprinklered test.

The total air emissions generated from the sprinklered test were lower than those from the non-sprinklered test. Of the 123 species analyzed in the air emissions, only 76 were detected in either the sprinklered or non-sprinklered tests. Of the species detected, the ratio of non-sprinklered to sprinklered levels for 24 of the species was in excess of 10:1. Eleven were detected at a ratio in excess of 50:1, and of those, six were detected at a ratio in excess of 100:1. The remaining species were detected at the same order of magnitude. The use of automatic fire sprinklers reduced the greenhouse gas emissions, consisting of carbon dioxide, methane, and nitrous oxide, and reported as equivalent mass of carbon dioxide, by 97.8%.

Comparing the water usage between the two tests, it was found that in order to extinguish the fire, the combination of sprinkler and hose stream discharge from the firefighters was 50% less than the hose stream alone. Additional analysis indicates that the reduction in water use achieved by using sprinklers could be as much as 91% if the results are extrapolated to a full-sized home. Furthermore, fewer persistent pollutants, such as heavy metals, and fewer solids were detected in the wastewater sample from the sprinklered test compared to that of the non-sprinklered test. The pH value of the non-sprinklered test wastewater exceeded the allowable discharge range of 5.5 to 9.0 required by most environmental agencies and was four orders of magnitude higher in alkalinity than the wastewater from the sprinklered test. The non-sprinklered test wastewater represents a serious environmental concern.

Analysis of the solid waste samples indicated that the ash/charred materials from neither the sprinklered nor the non-sprinklered test would be considered “hazardous waste,” and that the wastes are not anticipated to significantly leach once disposed of in landfills.

In the sprinklered room, flashover never occurred; however, in the non-sprinklered test, flashover occurred at approximately five minutes after ignition. The occurrence of flashover prior to fire service intervention is an indication that the fire would have propagated to adjacent rooms, resulting in greater production of greenhouse gases, greater water demand to extinguish the fire, and additional materials to be disposed of in landfills. However, in the sprinklered test where the fire was confined to the area of origin, the damage, greenhouse gas production, and water consumption represent maximum values independent of additional rooms.

The greater fire damage in the non-sprinklered test has a direct impact on the carbon emissions of the building. This is due to the embodied carbon associated with the building materials necessary for reconstruction and those associated with the manufacturing of furnishings and contents.

It has been known for years that automatic fire sprinklers provide life safety and limit property damage; the current study has shown quantitatively that automatic fire sprinklers are also a key factor in achieving sustainability. Although the current study was conducted using a residential setting, the environmental benefits of automatic fire sprinklers apply to other occupancies as well.

FOREWORD

Since 1996, the nonprofit Home Fire Sprinkler Coalition (HFSC) has been helping the public understand the need for, and the unique value of, fire sprinkler systems in new houses. The HFSC's effort is necessary because thousands of lives are lost in house fires every year, yet only a tiny fraction of new houses are built with sprinkler protection – a technology proven to save lives if a fire starts.

For as long as data has been collected, the U.S. fire death problem has been a residential one. The numbers have dropped over the past 30 years, but the rate has remained steady. More than eight out of every 10 civilian structure fire deaths and most civilian fire injuries occur in homes. On a percentage basis, these properties are also the most dangerous fireground scene for firefighters. Obviously, these are the properties we must target if we are going to make inroads to the overall fire problem.

Fire sprinklers could save lives if more systems were installed in homes. Increasing awareness about sprinklers leads to more home installations and that protects public safety and improves communities. But educating new homebuyers and others about fire sprinklers isn't simple. Surveys over the years have consistently shown that most people don't believe a fire will happen in their own home or understand that a house fire can grow to deadly flashover within a few minutes.

There is also the challenge of education on fire sprinkler cost, activation and maintenance. Recognizing these outreach challenges, HFSC works to find new partnerships and innovative methods to help the public understand how dangerous house fires truly are, and how critical fire sprinklers are to life safety.

The idea to explore the environmental impact of sprinklered and non-sprinklered house fires was born a few years ago during an HFSC strategic planning session. We were confident that home fire sprinklers are also indeed "green" and we wanted to tap into the nation's heightened interest in the environment as a means to draw attention to their overall benefit. But we wanted to make a scientific case for it.

That led us to FM Global and to a lengthy joint effort that has made it possible to prove, without doubt, that sprinklers not only save lives and protect property; they also protect our planet.

We are grateful to FM Global, one of the world's largest business property insurers, for partnering with HFSC in this residential safety effort. One of the reasons we turned to FM Global is because of the leadership role they have taken in fire sprinkler research over the past 50 years. And we knew the remarkable scientific testing facilities at FM Global's Research Campus would benefit our study and ensure its findings would be unimpeachable.

As you'll see when you read this technical report, the fire safety community's efforts to increase awareness of all aspects of home fire sprinkler technology will benefit from this new environmental data. Consumers, homebuilders, the fire service, and local officials now have a new and important way to view home fire sprinkler protection.

This research would not have been possible were it not for the generosity of FM Global, specifically the management leadership of Dr. Lou Gritzo and the personal commitment of Dr. Christopher Wieczorek. Thanks to their vision, professionalism and dedication, HFSC now has the data to prove that sprinklers are indeed "green" in addition to the benefit they offer to protect lives and property.

Gary S. Keith
Chair, Home Fire Sprinkler Coalition Board of Directors

ABSTRACT

The present study examines the relationship of automatic fire sprinkler technology to environmental sustainability. The work includes the evaluation of risk factors, such as fires, on the total lifecycle carbon emissions of a typical single- or two-family home. Additionally, an experimental quantification of the environmental benefits achieved by the use of automatic fire sprinklers was conducted.

Large-scale fire tests were conducted using identically constructed and furnished residential living rooms. In one test, fire extinguishment was achieved solely by fire service intervention, and in the other, a single residential automatic fire sprinkler was used to control the fire until final extinguishment was achieved by the fire service. Comparisons of the total greenhouse gas production, quantity of water required to extinguish the fire, quality of water runoff, potential impact of wastewater runoff on groundwater and surface water, and mass of materials requiring disposal between the two tests were made.

The results show that in addition to providing life safety and limiting property damage, the use of automatic fire sprinklers is a key factor in achieving sustainability.

ACKNOWLEDGEMENTS

This project would not have been successful without the efforts and contributions of numerous individuals. The authors would like to thank Mr. Gary Keith, Ms. Peg Paul, and the entire board of directors of the nonprofit Home Fire Sprinkler Coalition (HFSC) who worked in partnership with FM Global to define the scope and objectives of this project. The input from the board members in planning the testing was greatly appreciated.

The authors would like to especially thank Mr. Richard Chmura, Mr. Jeffery Chaffee, Mr. Michael Skidmore, Mr. Robert Harriman, and the entire staff of the FM Global Research Campus Large Burn Laboratory and the Calorimetry Laboratory. This project would not have been possible without their efforts and technical abilities.

A special thanks to Mr. Wayne Milette, and all of the firefighters at the Research Campus, along with Mr. Dana Haagensen of the Massachusetts State Fire Marshal's Office, for their input and consultation on appropriate firefighting techniques.

The contributions of Mr. Richard Osburn, Mr. Robert Migliaccio, Mrs. Denise Bernier, and Mr. Joe Marte in documenting the project via photographs and videos beyond the standard practice also are greatly appreciated. Furthermore, the extra efforts of Mr. Richard Osburn in processing and editing the videos for various presentations deserves acknowledgement.

The authors would also like to acknowledge the services of Woodard and Curran, in particular Mr. Zareh Maserejian, Ms. Lisa M. McIntosh, and Mr. Tom Ennis for their assistance in the environmental analysis.

As always, the efforts of Mrs. Cheryl McGrath in processing this report are greatly appreciated.

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NOMENCLATURE

Symbol	Definition	Units
A	Average Area of a Residence	m^2
$ACE_{embodied}$	Annualized Embodied Carbon Emissions	$kg_{CO_2}/year$
$ACE_{operation}$	Annualized Carbon Emissions Associated with Normal Operations	$kg_{CO_2}/year$
$ACE''_{operation}$	Annualized Carbon Emissions Associated with Normal Operations per Unit Area	$\frac{kg_{CO_2}}{(m^2 - year)}$
$CE_{construction}$	Carbon Emissions Associated with Construction Activities	kg_{CO_2}
$CE_{decommissioning}$	Carbon Emissions Associated with Decommissioning Activities	kg_{CO_2}
$CE_{embodied}$	Embodied Carbon Emissions	kg_{CO_2}
$CE''_{embodied}$	Embodied Carbon Emissions per Unit Area	kg_{CO_2}/m^2
CE_{fire}	Carbon Emissions Associated with a Fire Event	kg_{CO_2}
$CE_{replacement}$	Carbon Emissions Associated with Reconstruction	kg_{CO_2}
$CO_{2,equivalent}$	Equivalent Mass of Carbon Dioxide for a Gas	kg_{CO_2}
e_{CO_2}	Mass of CO_2 generated per Unit Mass of Fuel Burned	kg_{CO_2}/kg_{fuel}
F_b	Fraction Burned	--
f_f	Frequency of Residential Fires	Fires/year
F_r	Fraction Replaced	--
GWP_{gas}	Global Warming Potential of a Gas	--
LCE	Lifecycle Carbon Emissions	kg_{CO_2}
$LCE_{operation}$	Lifecycle Carbon Emissions Associated with Normal Operations	kg_{CO_2}
LCE_{risk}	Lifecycle Carbon Emissions Due to Fire Risk	kg_{CO_2}
LT	Lifetime of the Structure	Years
m''_f	Fuel Load per Unit Area	kg/m^2

m_{gas}	Mass of Greenhouse Gas	kg
RF_{fire}	Fraction of Total Carbon Emissions due to Fire Risk	%
$RF_{fire,AS}$	Fraction of Total Carbon Emissions due to Fire Risk with Automatic Sprinklers	%
TCE	Total Lifecycle Carbon Emissions	kg_{CO_2}
$TCE_{construction}$	Total Carbon Emissions Associated with Construction Activities	kg_{CO_2}

1 INTRODUCTION AND BACKGROUND

1.1 PROBLEM STATEMENT

Past research in residential automatic fire sprinkler technology has identified sprinkler characteristics necessary to provide reliable life safety in residential occupancies [1,2,3]. This research further resulted in a standardization of the requirements for reliably certifying and installing residential hardware to meet desired performance requirements [4,5,6,7,8,9,10]. The present study treats a relatively new issue: the relationship of residential sprinkler technology to environmental sustainability.

1.2 BACKGROUND

To date, the use of residential automatic fire sprinkler technology has been extremely limited with less than 3% of one- and two-family dwellings taking advantage of its benefits [11]. The 2007 American Housing Survey reported sprinkler usage in 1.5% of single family detached dwellings and 2.9% in buildings with two to four units [12]. Hall [13] reports that only 1.2% of fires in the U.S. occurred in one- or two-family dwellings with automatic extinguishing systems in 2006. The effectiveness of the residential sprinkler has, however, been increasingly recognized by communities through regulations requiring installation in one- and two- family dwellings. Of particular note are the long-term ordinances for Scottsdale, Arizona, and Prince George's County, Maryland. In both cases, experience with the resulting installations led to clear documentation of the benefits to life safety and property protection (see, e.g., Reference 11 and 14). In 2006, the NFPA model codes, i.e., NFPA 1, *Fire Code*, NFPA 101, *Life Safety Code*, and NFPA 5000, *Building Construction and Safety Code*, adopted the requirement for residential fire sprinklers in one- and two-family dwellings [15,16,17]. The United States Fire Administration (USFA) has supported the position that: "All homes should be equipped with both smoke alarms and automatic fire sprinklers" [18]. Such support led to the approval of a requirement in the International Code Council (ICC), *International Residential Code*, on September 21, 2008, for residential sprinklers in all new one- and two-family homes and townhouses [19]. However, only about 400 out of the thousands of jurisdictions in the U.S. were mandating the installation of residential sprinklers in 2008 [18].

A new factor to be considered in the assessment of the value of residential sprinklers is the desire to achieve sustainability through the potential positive impact of sprinklers on the lifecycle carbon emissions of homes. As part of the sustainability assessment, carbon emissions from a facility are estimated under normal operating conditions. Recently, Gritzo *et al.* [20] have shown that, in industrial and commercial facilities (including light hazard, i.e., hotels and condos), the impact of fire on lifecycle carbon emissions is significant and needs to be accounted for due to the release of emissions during the fire and the carbon associated with rebuilding or reconstruction. Thus, in addition to their life safety and property protection functions, sprinklers promote sustainability.

1.2.1 Methodology for Estimating LCE Including Risk Factors

The construction, renovation, or improvement of facilities increasingly includes measures to improve sustainability by reducing environmental impact over their operational lifecycle. Of primary environmental concern is the emission of greenhouse gases associated with the consumption of energy during normal operations, or required for the production and transportation of materials, and construction. Emphasis to date has focused on reduction in emissions related to energy consumption during normal operations, with a secondary emphasis on reducing carbon emissions associated with the fabrication and transport of construction materials, construction processes, and facilities decommissioning, i.e., the “embodied carbon emissions.” Within the United States, the Leadership in Engineering and Environmental Design Organization (LEED) has established metrics and certification levels for construction and renovation [21]. LEED certification checklists provide guidance for options and measures to reduce the environmental impact of facility construction and operations on carbon emissions. Gritzo *et al.* [20] supplemented the analysis of normal operations with an analysis taking into account risk factors of such events as fire, wind, and flood as well as the use of mitigating technologies such as sprinklers.

The impact of risk factors on lifecycle carbon emission, LCE, is illustrated in Figure 1. The plot indicates the carbon emission for an occupancy as a function of time. Note that proportions are not to scale, but are expanded for readability. The lower curve may be considered the carbon emissions under normal conditions; the upper curve shows the deviation from that of normal conditions due to a fire.

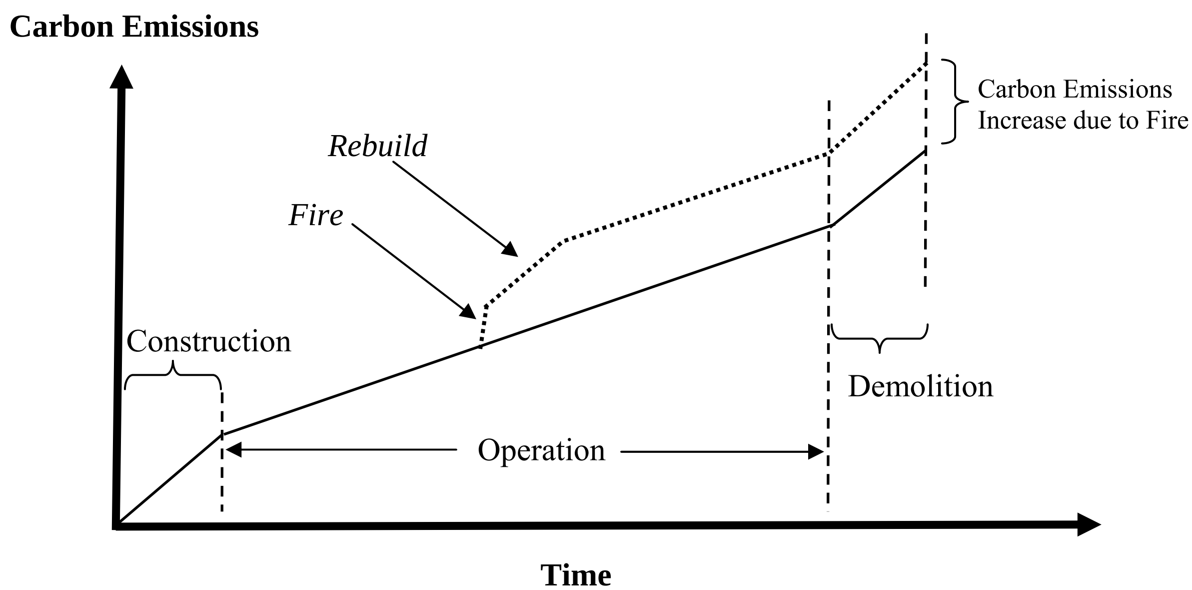

Figure 1: Contribution of risk factors to total lifecycle carbon emissions.

The carbon emission cycle can be divided into three portions: 1) that due to construction, $CE_{construction}$ (including that associated with manufacture of material, transportation, and equipment usage), 2) that due to normal operation over the lifetime of the occupancy, $LCE_{operation}$ (primarily power consumption, utilities, and maintenance if applicable), and 3) that due to decommissioning, $CE_{decommissioning}$ (including that due to equipment usage for demolition, and transportation for disposal).

Thus the total lifetime carbon emissions (TCE) are given as

$$TCE = CE_{construction} + LCE_{operation} + CE_{decommissioning} \tag{1}$$

The carbon emissions associated with normal operations are typically estimated on an annual basis, $ACE_{operation}$, in which case, $LCE_{operation}$ depends on the lifetime of the occupancy, LT:

$$LCE_{operation} = LT \cdot ACE_{operation} \tag{2}$$

The annual rate of emission for operation is typically referred to as the "carbon footprint." Due to the primary importance of energy consumption on emissions associated with normal operations, annual rates of carbon emissions can readily be determined using standard guidance [22].

The emissions due to construction and decommissioning are typically considered one time events and referred to as embodied emissions, $CE_{embodied}$, given their inclusion in the physical facility rather than resulting from normal operations. Hence,

$$CE_{embodied} = CE_{construction} + CE_{decommissioning} \tag{3}$$

Note that the embodied emissions are estimated in the literature on a per unit area basis (see e.g., Reference 22) and can be annualized over the lifetime, LT, of a facility:

$$ACE_{embodied} = \frac{CE''_{embodied} \cdot A}{LT} \tag{4}$$

The event of a fire requires taking into account additional considerations in the analysis, namely, the carbon emissions associated with the fire, CE_{fire}, and those associated with replacement of the damage caused by the fire, $CE_{replacement}$. These may be estimated as

$$CE_{fire} = F_b \cdot m''_f \cdot e_{CO_2} \cdot A \tag{5}$$

and

$$CE_{replacement} = F_r \cdot CE_{embodied} \tag{6}$$

where F_b is the fraction of material burned; $m_f^{"}$ is the total mass of combustible material per unit area; e_{CO_2} is the carbon dioxide released per mass of material burned; and F_r is the fraction of material to be replaced during reconstruction.

Figure 1 reflects additional carbon emissions resulting from the fire, referred to as the lifecycle carbon emissions due to fire risk, LCE_{risk}. Evaluating the risk on a statistical basis over the lifetime of the structure requires knowledge of the frequency of fires, f_f. Thus,

$$LCE_{risk} = f_f \cdot LT \cdot \left(CE_{fire} + CE_{replacement}\right) \quad (7)$$

A risk factor, RF_{fire}, indicating the relative importance of carbon emissions due to risk events such as fire compared to normal operation over the lifetime can be defined as

$$\begin{aligned} RF_{fire} &= \frac{LCE_{risk}}{TCE} = \frac{f_f \cdot LT \cdot \left(CE_{fire} + CE_{replacement}\right)}{TCE} \\ &= f_f \cdot LT \cdot \left(\frac{F_b \cdot m_f^{"} \cdot e_{CO_2} \cdot A}{TCE} + \frac{F_r \cdot CE_{embodied}}{TCE}\right) \end{aligned} \quad . \quad (8)$$

The risk fraction, therefore, represents the increase that risk factors pose to the sustainability posture of a home over its lifetime.

1.2.2 Effect of Automatic Sprinklers on LCE

A reduction in the risk fraction can be achieved through effective risk management strategies, which can serve to reduce the fire frequency and/or serve to reduce the extent of damage produced and reconstruction required. In the context of the home, such risk management includes smoke detectors, fire retardant furnishings, and adoption of ignition source control. The latter two factors can reduce the frequency of fires; however, they cannot in themselves suppress a fire once it has occurred. Automatic fire sprinklers are the most common and cost effective method to reduce both the frequency of large fires and the severity of damage (and hence the fraction required for reconstruction). Fire frequency data implicitly include some minimum threshold for fire size, since very small or incipient fires cause minimal damage and are frequently extinguished without record. Furthermore, fire severity data are often expressed in terms of loss values, which may or may not include full cost of replacement.

The effect of automatic sprinklers on the risk factor is expressed by reductions in the fraction burned, F_b, and the replacement fraction, F_r, values used in Equation 8.

1.2.3 Quantification of TCE in One- and Two-Family Dwellings

Values used in the present study for the variables in Equation 8 are provided in Table 1. In the following sections, justification for these values will be provided relative to typical one- and two-family dwellings and the impact of sprinklers. Due to the uncertainty including variability associated with a number of variables, a lower (Case 1) and upper (Case 2) bound is provided.

Evaluating the TCEs for a typical one- and two-family dwelling from its components as in Equations 1 to 3 is quite complex given the diversity of construction and patterns of energy consumption in the U.S. For example, in a report on per capita carbon footprints from residential energy use of the 100 largest U.S. metropolitan areas, Brown *et al.* [23] indicate a factor of 5.6 between the metropolitan area with the lowest per capita emissions (0.350 metric tons carbon – Bakersfield, CA) and the highest (1.958 metric tons carbon – Washington, DC). The average per capita carbon emission from residential energy use was 0.925 metric tons. The objective of the present study was not to evaluate the range of carbon emissions resulting from such diversity in the housing population, but to provide a typical result indicative of the significance of the use of automatic sprinklers to sustainability.

Table 1: Selected values for variables in Equation 8

Symbol	Parameter (units)	Case 1	Case 2
f_f	Frequency of Residential Fires (fires/year)	0.0032	0.0032
LT	Lifetime (yr)	50	50
m_f	Fuel Density (kg/m^2)	13.2	21
e_{co2}	Mass of CO_2 Generated per Unit Mass of Fuel Burned (kg/kg)	3.0	3.0
TCE	Total Lifecycle Carbon Emissions (kg CO_2)	278,000	278,000
$CE_{embodied}$	Total Embodied Carbon Emissions (kg CO_2)	60,680	60,680
F_b	Fraction Burned, no AFS (-)	0.07	0.34
F_r	Fraction Replaced, no AFS (-)	0.11	1.0
F_{AFS}	Reduction in Property Loss Achieved by AFS (%)	51	90
$F_{b,AS}$	Fraction Burned, AFS (-)	0.03	0.034
$F_{r,AS}$	Fraction Replaced, AFS (-)	0.05	0.051
Results			
RF_{fire}	Fraction of Total Carbon Emissions due to Fire Risk, no active protection (%)	0.40	3.7
$RF_{fire,AS}$	Fraction of Total Carbon Emissions due to Fire Risk, with AS (%)	0.20	0.20

Estimates of annual greenhouse emissions characterized as $ACE_{operation}$ and $ACE_{embodied}$ are taken from Norman *et al.* [24] from a study published in 2006 comparing lifecycle energy use and greenhouse emissions in high and low density residential dwellings. In this study, the low density residential case study consisted of single detached dwellings located near the border of the city of Toronto, Ontario, Canada. All houses consisted of wooden structure and primarily brick façade. The housing is considered to be typical of current and upcoming residential construction.

The major component of TCE is typically that associated with normal operation over the lifetime of the building, $LCE_{operation}$. Norman *et al.* [24] estimate the $LCE_{operation}$ based upon total emission for the residential sector for 1997 obtained from the 2003 Office of Energy Efficiency, Natural Resources Canada. This report, however, did not distinguish between housing types. The authors proportioned the emission based upon the total residential energy use attributable to single-detached dwellings (72%). They also noted that this choice is expected to be reasonable given that the majority of residential greenhouse gas emissions results from the burning of fuel and use of electricity for heating/cooling, which are also the most significant factors in total energy use. In their analysis, they use an annualized value per unit area for $ACE''_{operation}$ of $33.9\ kg_{CO_2}/(m^2 - year)$.*

To calculate $LCE_{operation}$ the lifetime and area of the dwelling need to be taken into account. Following Norman *et al.* [24], a value of 50 years was taken for the lifetime. A reasonable estimate for the area is the average of the median area reported in the American Housing Survey (AHS), conducted by the U.S. Census Bureau, for single-detached and manufactured/mobile homes for 1999, 2001, 2003, 2005, and 2007 [12, 25, 26, 27, 28]. The data are summarized in Table 2. The average area of these dwellings was 164 m^2 (1,765 ft^2). Using these values the $ACE_{operation}$ is equal to 5,560 kg_{CO_2} per year and $LCE_{operation}$ is equal to 278,000 kg_{CO_2}.

Table 2: Home and Fire Statistics from 1999 to 2008

	Home Statistics		Fire Loss Statistics		Loss Estimates	
Year	**Average Size m^2 (ft^2)**	**Median Price**	**Number of Fires**	**Dollar Loss (In Billions)**	**Cost per Loss**	**Percentage Damaged (%)**
1999	161 (1,730)	$108,999	282,500	$5.3	$18,761	17.2
2001	161 (1,737)	$124,569	295,500	$5.7	$19,289	15.5
2003	163 (1,755)	$140,269	297,000	$5.9	$19,865	14.2
2005	167 (1,795)	$165,344	287,000	$6.4	$22,300	13.5
2007	168 (1,807)	$191,471	300,500	$6.5	$21,631	11.3
Average	**164 (1,765)**	**$146,130**	**292,500**	**$6.0**	**$20,525**	**14**

To evaluate the embodied carbon, Norman *et al.* [24] analyzed the annual greenhouse gases emitted and energy used during manufacturing of the home construction materials. Materials that did not form part of the dwelling structure, such as, appliances or carpeting, were not considered in the analysis. Materials considered in the analysis included brick, window (glass

* Note that gases other than CO_2 are considered in terms of CO_2 equivalents normalized in terms of global warming potential calculated according to the United Nations framework Convention on Climate Change. Greenhouse gases considered by Norman *et al.* were carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons [24].

and metal frames), drywall, structural concrete, reinforcing bar, structural steel, plywood, asphalt shingles, aluminum siding, hardwood flooring and stairs, insulation (fiberglass and polystyrene), high-density polyethylene vapor barrier, and sub-foundation aggregate. Of these, the first four materials accounted for between 60% and 70% of the total embodied greenhouse gases. Proportioning the greenhouse gases over a lifetime of 50 years, Norman *et al.* [24] estimated that the average equivalent annual embodied greenhouse gases per unit area is $7.4\ kg_{CO_2} / (m^2 - year)$. For a 50-year lifetime and a typical area of 164 m^2 (1,765 ft^2), the total embodied carbon emissions, $CE_{embodied}$, is 60,680 kg_{CO_2}.

No effects corresponding to decommissioning were discussed by Norman *et al.* [24]. Gritzo *et al.* [20] reported that, for office buildings, the total embodied fraction of total carbon emissions were on the order of 15% to 20%. As the ratio of $CE_{embodied} / (CE_{embodied} + LCE_{operation})$ in the present analysis is 18%, no further additions to the embodied carbon emissions are considered here.

1.2.4 Effect of Fire on LCE in Homes

Some of the parameters needed to estimate LCE_{risk} (Equations 5-7) can be obtained from NFPA [29] and AHS [12, 25-28] statistics—for example, the frequency of fires and some insight into the fraction burned, F_b. Key data needed for these estimates are summarized in Table 2. Using the same years as the AHS statistics, NFPA statistics indicate that the average number of fires per year for one- and two-family dwellings, including manufactured homes, was 294,350. The average number of occupied attached or detached single units and manufactured homes reported by the AHS for the specified years was 90,797,000. Thus, the frequency of fires per year was 0.0032.

The fraction of structural damage as a result of a fire event is not well documented; therefore, the fraction burned was estimated based on the reported dollar losses. The estimated average of total property damage per year was US$6.0 billion. This represents an average loss per fire of US$20,370. The average of the median house values reported by AHS [12, 25-28] for the same years was US$146,130, for an average loss due to fire of 14%.

It is important to recall the wide variation in fire behavior that is not represented by the average loss. The fire statistics for Prince George's County, Maryland, for the period of 1992 to 2007, in which sprinklers were mandated in newly constructed one- and two-family dwellings, provide a particularly clear example [14]. For the 15-year period, the average loss in 13,494 non-sprinklered fire incidences was US$9,983 while in 101 non-sprinklered fire incidences in which there was a fatality, the average loss was US$49,503, or an increase by a factor of five for these fires. The median value of a single-family home in Prince George's County was reported as US$145,600; therefore, the average loss due to fire is estimated to be between 7% and 34%.

Since the NFPA data indicate an average loss due to fire that is bounded by the Prince George's County data, in this analysis the fraction burned, F_b, will be assumed to be the two bounding values of 7% and 34%.

In addition to the fraction of material burned and the area of the home, estimating of the carbon emissions due to a fire event requires the total mass of combustible material per unit area, m''_f, and the carbon dioxide released per mass of material burned, e_{CO_2}. Davoodi [30] reports fuel loads of 19.0, 13.2, 21.0, 17.6, and 15.6 kg/m^2 for living rooms, family rooms, bedrooms, dining rooms, and kitchens respectively. For the present analysis the minimum, i.e., 13.2 kg/m^2, and maximum, i.e., 21.0 kg/m^2, values will be used as the bounding cases.

The carbon dioxide released per unit of material burned, e_{CO_2}, is taken as 3.0 kg/kg based upon combustion analysis and flammability data from Tewarson [31].

Finally, the replacement fraction needs to be determined. A conservative assumption is that the replacement fraction, F_r, is equal to the fraction burned, F_b; however, information indicates that after a fire event "the per-square-foot cost can increase by as much as 50 percent for readying a space for reconstruction" [32]. In this analysis, the replacement fraction is assumed to be 1.5 times the fraction burned; however, if the replacement fraction exceeds 50% it is assumed that a total constructive loss occurred and a value of 100% is used.

Based on these values, the contribution of fire risk to the total lifecycle carbon emissions of a home without sprinklers (Equation 8) is between 0.4% and 3.7%.

1.2.5 Improved Sustainability with Automatic Sprinklers

The installation of automatic sprinklers is expected to reduce LCE_{risk} (Equation 7) and the Risk Factor (Equation 8) through a reduction in the burn, and hence, replacement fractions. The reduction in burn fraction can be estimated from reduction in property loss with sprinklers. The fire statistics for Prince George's County [14] provide a significant record of the effect of residential sprinklers on fire fatalities and property damage.[†] Between 1992 and 2007, there were 13,494 fires in single-family dwellings or townhouses. There were 245 fires in such homes with residential sprinklers installed. No fatalities occurred in any of the sprinklered fires; however, there were 101 fatalities in the non-sprinklered fires. The average loss per event with a sprinkler system was US$4,883.83. Using the dollar loss values for events with and without sprinklers, the reduction in property loss achieved by automatic sprinklers is estimated to be between 51% and 90% in Prince George's County.

The contribution of a fire risk to the total lifecycle carbon emissions of a home is reduced to 0.2% when sprinklers are used, as all large fires are eliminated. In addition to saving lives, the presence of sprinklers ensures a reduction in carbon emissions and decreases the need for structural replacement as the fire will be limited to the housing contents initially ignited, and damage due to smoke and water will be minimized and limited to the room of fire origin.

[†] Hall [13] has analyzed the performance of automatic sprinklers in one- and two-family dwellings. He reports that, for the period of 2003 to 2006, fire damage was only reduced from an average of US$19,000 to US$14,000 as a result of automatic sprinklers. Hall comments that "only 1% of reported dwelling fires involve sprinklered properties, which means any loss estimate for sprinklered dwelling fires will tend to be statistically unstable" [13].

1.3 OBJECTIVES

The objective of the present study was to quantify the reduction in the environmental impact via the use of automatic fire sprinklers. To meet the objective, large-scale fire tests were conducted using identically constructed and furnished residential living rooms.[‡] In the non-sprinklered test, fire extinguishment was achieved only by fire service intervention, while in the sprinklered test a single residential sprinkler was used to control the fire until final extinguishment was achieved by the fire service. In the tests, the fire service initiated water application 10 minutes after the fire was detected.

Quantification of the environmental benefit of automatic fire sprinklers was based on comparisons between the sprinklered and non-sprinklered tests including total greenhouse gas production, quantity of water required to extinguish the fire, quality of water run-off, potential impact of wastewater runoff on groundwater and surface water, and mass of materials requiring disposal.

[‡] The primary analysis in this report is based on two fully instrumented tests, referred to as sprinklered and non-sprinklered. An additional, non-sprinklered test was conducted as a demonstration test. This test is referred to as non-sprinklered (b) and only used to supplement the water analysis.

2 FIRE TEST SETUP AND PROCEDURES

2.1 FACILITY

Testing was conducted under the 20-MW calorimeter in the Large Burn Laboratory (LBL) of the Fire Technology Laboratory located at the FM Global Research Campus in West Glocester, Rhode Island. The LBL measures 43 m (140 ft.) by 73 m (240 ft.) by 20.4 m (67 ft.) high and consists of three test locations: the north and south movable ceilings, and the 20-MW calorimeter. An illustration of the Large Burn Laboratory is shown in Figure 2. A separate air emission control system (AECS) is provided for each test location. The 20-MW calorimeter consists of a 10.7 m (35 ft.) diameter inlet that tapers down to a 3.05 m (10 ft.) diameter duct. The inlet to the calorimeter is at an elevation of 11.3 m (37 ft.) from the floor. Gas concentration, velocity, temperature, and moisture measurements are made within the duct downstream of an orifice. Beyond the measurement location, the exhaust duct connects to a wet electrostatic precipitator (WESP) prior to cleaned gases venting to the atmosphere. All tests were conducted with the ventilation rate set to 94.4 m^3/s (200,000 scfm).

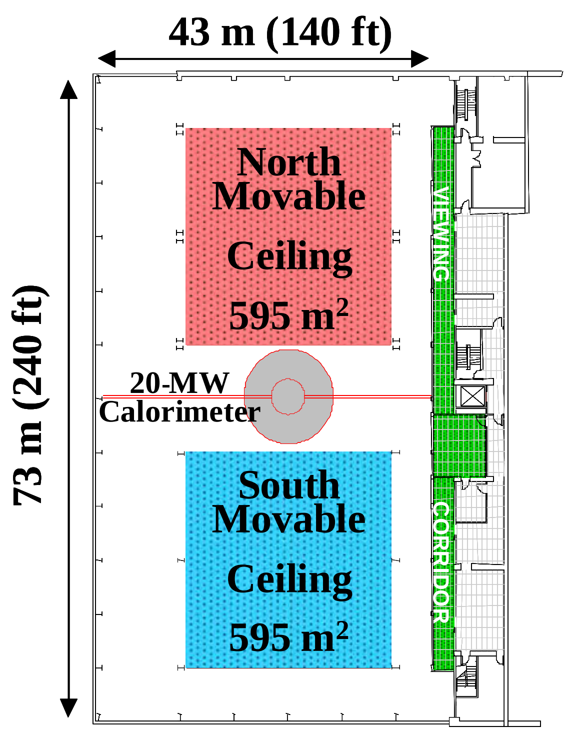

Figure 2: Illustrations of the large burn laboratory test sites.

The rooms, described in Section 2.2.1, were positioned under the 20-MW calorimeter as shown in Figure 3. The room centerline was offset relative to the calorimeter bell centerline by approximately 1.1 m (3.75 ft.) in the north-south direction to ensure that the gases exiting the room were collected within the calorimeter.

The demonstration test, non-sprinklered (b), was conducted with the room located under the north movable ceiling. The room was offset to the south-east corner of the ceiling and the movable ceiling was set to a height of 12.2 m (40 ft.).

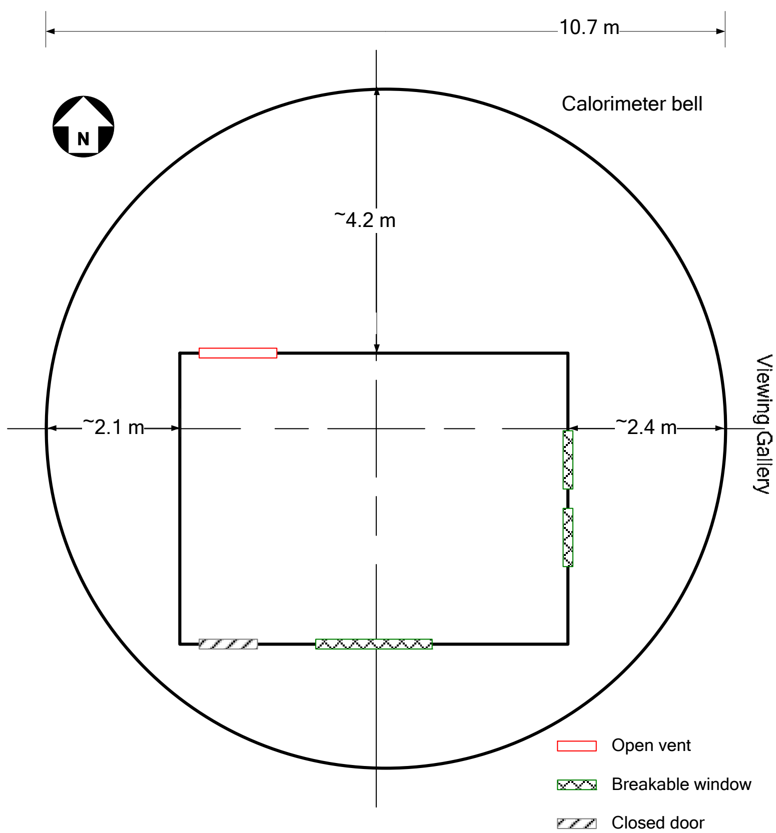

Figure 3: Room position relative to 20-MW calorimeter.

2.2 TEST CONFIGURATION

2.2.1 Living Room Construction

The living room was constructed by an outside contractor, R&R Wolf Construction, Inc. of North Attleboro, Massachusetts, using standard industry practices. The room measured 4.6 m (15 ft.) wide by 6.1 m (20 ft.) long, and had a 2.4 m (8 ft.) high ceiling. To simulate a single room of a larger house, two of the walls were considered exterior walls and included windows and an exterior door. The other two walls were considered interior house walls, with one being solid with no openings and the other having a 1.2 m wide x 2.1 m tall (4 ft. x 7 ft.) archway. Figure 4, Figure 5, and Figure 6 present illustrations of the room construction, location of the room penetrations, and a description of common construction terms.

The main deck of the enclosure had interior dimensions of 4.6 m x 6.1 m (15 ft. x 20 ft.) and was constructed with 50.8 mm x 203 mm (2 in. x 8 in.) lumber. The perimeter decking joist boards forming the box frame for the floor were constructed with 4.9 m and 6.7 m (16 ft. and 22 ft.) boards. These boards were doubled up along the perimeter and cut to provide exterior dimensions of 4.9 m x 6.4 m (16 ft. x 21 ft.). The frame was then filled with kiln dried #2 grade spruce boards spaced 406-mm (16-in.) on center, which were supported by joist hangers at each end. The framed deck was then covered with 19.1 mm (3/4 in.) CDX fir tongue-and-groove plywood flooring.

Figure 4: Room exterior walls (south and east walls).

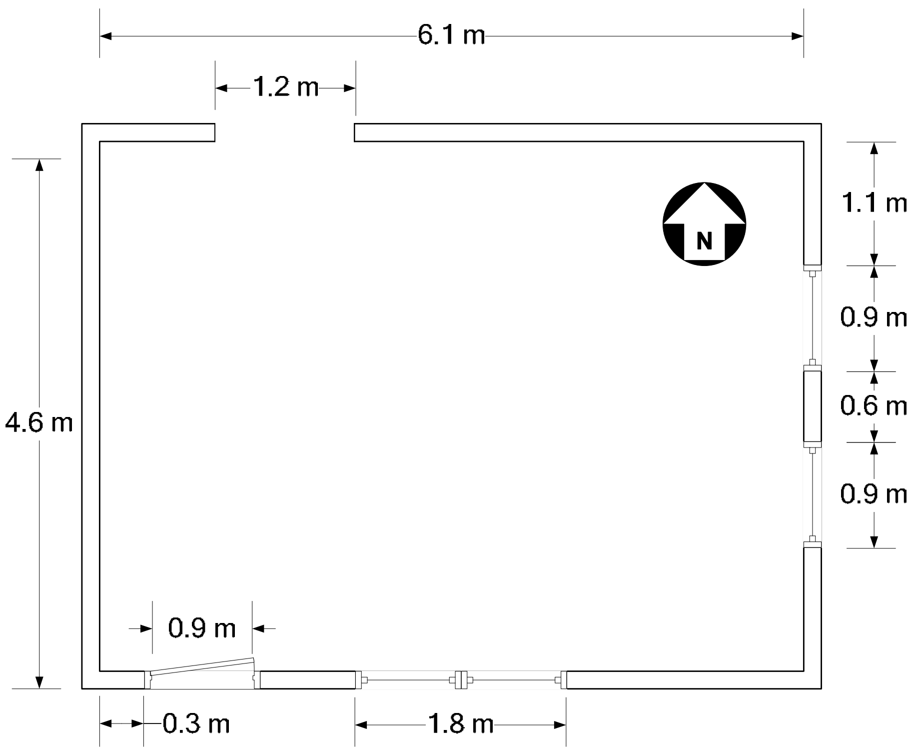

Figure 5: Location of room exterior door, archway, and windows.

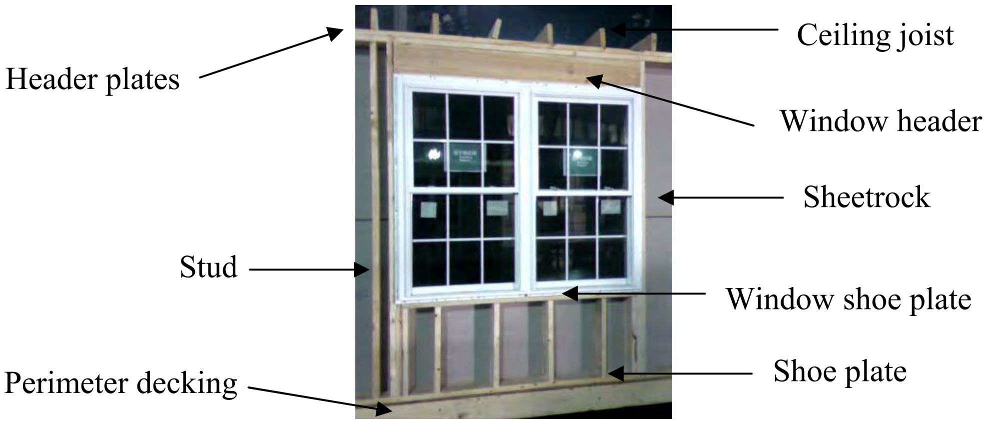

Figure 6: Room frame construction.

The enclosure sides consisted of two walls having interior dimensions of 4.6 m x 2.4 m (15 ft. x 8 ft.) and two walls with interior dimensions of 6.1 m x 2.4 m (20 ft. x 8 ft.) that were of consistent construction using 50.8 mm x 152.4 mm (2 in. x 6 in.) lumber. A shoe plate and two header plates constructed of 4.9 m (16 ft.) long boards were used for the shorter walls and 6.4 m (21 ft.) long boards for the longer walls. The walls were then filled with 2.4 m (7 ft. 8 in.) studs spaced 406-mm (16-in.) on center. The stud pattern was disrupted to allow for windows and door/archway openings. The window openings included a double shoe plate and single header, while the door and archway openings had only a single header. The inside walls were finished with 15.9 mm (5/8 in.) fire rated sheetrock that was taped, spackled, and painted a tan color.

The ceiling was constructed using 50.8 mm x 152.4 mm (2 in. x 6 in.) lumber spaced 406-mm (16-in.) on center. Since no perimeter boxing was necessary, the joists were towed-in to the wall header plates. To support the ceiling sheetrock, 25.4 mm x 76.2 mm x 4.9 m (1 in. x 3 in. x 16 ft.) spruce strapping, spaced 406-mm (16-in.) on center, was installed perpendicular to the ceiling joints. The ceiling was finished with 19.9 mm (5/8 in.) fire rated sheetrock that was taped, spackled, and painted bright white.

The two exterior walls and the ceiling were insulated using R13 and R19 fiberglass insulation respectively. The main deck also included *Alias* (Style 2760) carpeting with an Endure®Plus backing from J&J Industries. Carpet specifications taken from the manufacturer's website are provided in Table 3.

Table 3: Manufacturer's Carpet Specifications (J&J Industries' website)

Alias Style (2760)	
Yarn	100% Nylon: Encore® SD Ultima® (with recycled content) Bulked Continuous Filament
Dye Method	Solution Dyed
Surface Texture	Level Loop
Pattern Repeat	N/A
Gauge	1/8 (3.15 rows/cm)
Tufted Stitches Per Inch	8.5 (3.35 stitches/cm)
Yarn Weight	882 grams/m^2 (26 oz./yd^2)
Finished Pile Thickness	3.05 mm (0.120 in.) (ASTM D-418)
Density	7,800
Weight Density	202,800
Secondary Backing	Endure® PLUS
Special Treatments	ProTex® Fluorochemical
Width	3.66 m (12 ft.)
Flammability	Class 1
Smoke	Less Than 450 flaming
Static Generation	Less than 30 kV (AATCC-134)
ADA Compliance	Compliant For Accessible Routes

The windows installed in the room were Kasson & Keller, Inc., double hung, replacement windows measuring 0.9 m by 1.47 m (3 ft. by 4 ft. 10 in.). The windows were constructed of PVC frames with double-pane glass. The total weight of the windows was 23.6 kg (52 lb.) and the weight of the frame alone was 9.1 kg (20 lb.). The exterior door was steel clad with an insulated core and had dimensions of 0.9 m by 2.0 m (36 in. by 80 in.). The door had a 0.51 m wide by 0.9 m tall (20 in. by 36 in.) single pane window. The exact locations of the exterior door and windows are shown in Figure 4, and each was installed with a 203 mm (8 in.) sill.

2.2.2 Room Furnishings

Each of the rooms was furnished with the items listed in Table 4. The items are grouped into four categories: primary fuel items, secondary fuel items, decorative items, and ignition package. Each category of items will be discussed in detail in Sections 2.2.2.1 to 2.2.2.4. A schematic of the room with relative positions of the primary and secondary fuel items, and the ignition package is presented in Figure 7.

Table 4: Room Furnishings

Quantity	Item
Primary Fuel Items	
1	Recliner
1	Sofa
1	Loveseat
Secondary Fuel Items	
1	Coffee Table
1	Console Table
1	End Table
1	TV Stand with Shelves
2	Bookcase
1	37-inch LCD Television
Decorative Items	
1	Ceramic Table Lamp
1	Picture Frame (330 mm x 432 mm) (13 in. x 17 in.)
6	Picture Frame (127 mm x 178 mm) (5 in. x 7 in.)
1	Mirror (400 mm x 972 mm) (15 ¾ in. x 38 ¼ in.)
1	Poster Frame (610 mm x 914 mm) (24 in. x 36 in.)
1	Wall Clock (248 mm) (9 ¾ in. Diameter)
13.5 lbs	Magazines
1	Alarm Clock
8	CD Box with Lid
5	Hardcover Books
1	Plant Pot
6	Drapes
Ignition Package	
1	Magazine Rack
3	Newspapers

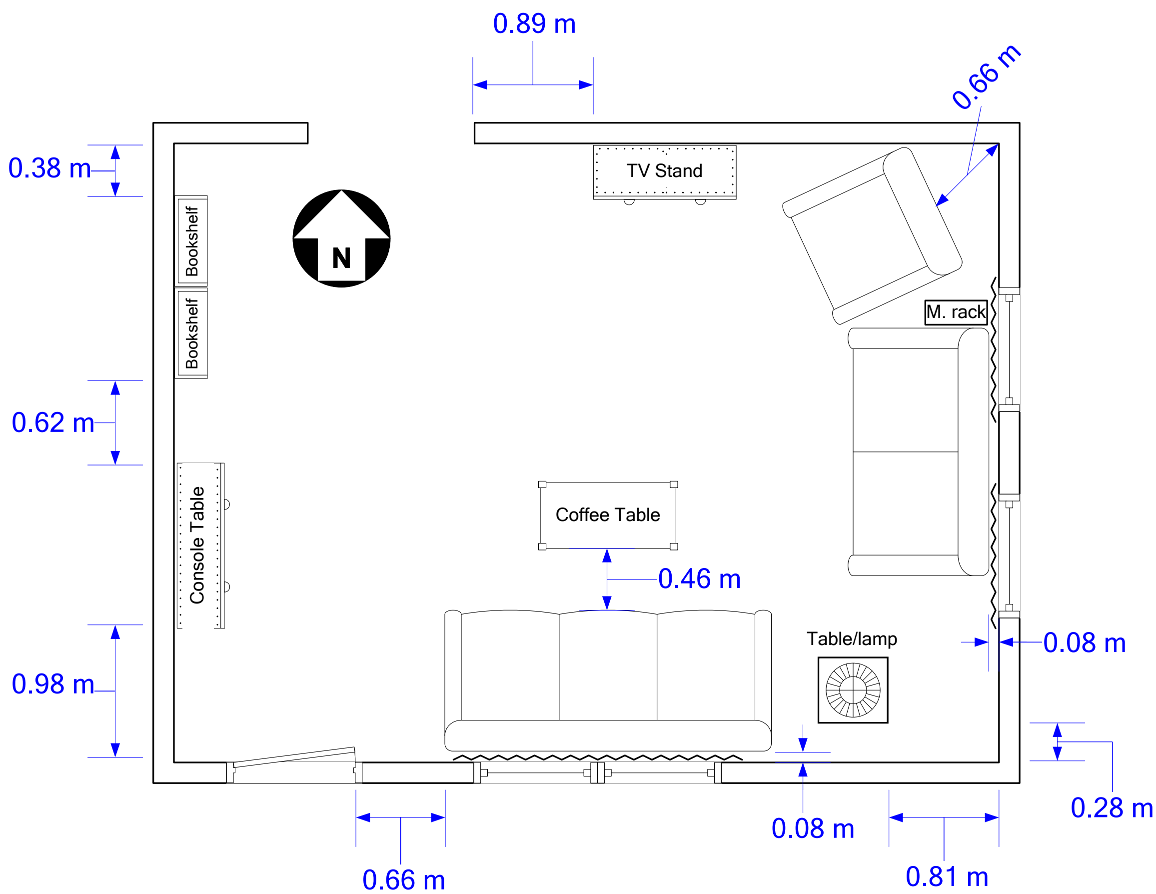

Figure 7: Furnishing positions and locations within the enclosure.

2.2.2.1 Primary Fuel Items

The primary fuel items consisted of a “Big Easy” Recliner and a “Kick Back” Sofa and Loveseat. The loveseat and sofa came with eight decorative throw pillows that are considered part of the package as shown in Figure 8. The dimensions, total weight, and major combustible materials for each item are listed in Table 5. The weights of the sofa and loveseat include four throw pillows.

Table 5: Primary Fuel Items

Item	Dimensions (L x D x H) m x m x m (in. x in. x in.)	Total Weight kg (lb.)	Principle Combustible Material
Big Easy Recliner	0.99 x 1.12 x 1.04 (39 x 44 x 41)	44.5 (98.1)	Urethane foam, wood frame
Kick Back Sofa	2.41 x 1.04 x 0.97 (95 x 41 x 38)	69.9 (154.1)	Polyurethane foam, wood frame
Kick Back Loveseat	1.83 x 1.04 x 0.97 (72 x 41 x 38)	56.9 (125.5)	Polyurethane foam, wood frame

Figure 8: Images of the "Big Easy" recliner and "Kick Back" sofa and loveseat combination (from store website, not to scale).

2.2.2.2 Secondary Fuel Items

The total mass, dimensions, and combustible material for each of the secondary fuel items are listed in Table 6. Images of each item, taken from the retail store websites, are shown in Figure 9 and Figure 10.

Table 6: Secondary Fuel Items

Item	**Dimensions (L x D x H) m x m x m (in. x in. x in.)**	**Total Weight kg (lb.)**	**Principle Combustible Material**
Mission Natural Coffee Table	1.0 x 0.5 x 0.4 (40.5 x 20 x 16.5)	15.1 (33.3)	Rubberwood
Mission Natural Console Table	1.2 x 0.4 x 0.8 (48 x 15.25 x 30)	15.6 (34.4)	Rubberwood
Mission Natural End Table	0.5 x 0.48 x 0.5 (20.1 x 19 x 20.1)	8.3 (18.3)	Rubberwood
TV Stand with Shelves	1.1 x 0.44 x 0.5 (41.5 x 17.25 x 20)	21.2 (46.7)	Laminated composite wood
Kilby Bookcase	0.67 x 0.24 x 1.9 (26.4 x 9.5 x 76.4)	18.5 (40.8)	Laminated composite wood
37-inch LCD Television	0.9 x 0.2 x 0.67 (36.75 x 9.5 x 26.5)	16.7 (36.8)	Unexpanded plastic

Figure 9: Images of secondary fuel items: coffee, console, end tables, and bookcase (from store website, not to scale).

Figure 10: Images of secondary fuel items: 37-inch LCD TV and TV stand (from store website, not to scale).

2.2.2.3 Decorative Items

The decorative items listed in Table 4 were arranged throughout the room as shown in Figure 11. Due to the low fire load contribution of these items to the overall heat release rate, a detailed breakdown of the individual components has not been made. The primary combustible materials were cotton, soft woods, polystyrene and polypropylene plastic, cardboard, and paper. The total weight of all of the decorative materials was 26.7 kg (59 lb.) and is based on the listed shipping weights.

Figure 11: Orientation of decorative items on console table, bookcases, and coffee table.

2.2.2.4 Ignition Package

The fire was initiated in a magazine rack filled with three rolled up newspapers (see Figure 12a), which was positioned adjacent to the loveseat as shown in Figure 12b. The dimensions of the magazine rack were 338 mm x 152 mm x 279 mm (13.3 in. x 6 in. x 11 in.). The magazine rack was constructed of medium density fiberboard and weighed 1.7 kg (3.75 lb.). The newspapers were ignited using a propane torch.

(a) (b)

Figure 12: (a) Ignition source and (b) Magazine rack relative to loveseat and curtain.

2.3 FIREFIGHTING

Fire control and suppression was achieved in the non-sprinklered test by manual fire service intervention only; in the sprinklered test, a single residential sprinkler was used to control the fire until final extinguishment was achieved by the fire service.

2.3.1 Sprinkler Protection

A single FM Approved Tyco Fire Suppression & Building Products recessed residential sprinkler (TY4234), Figure 13, was installed at the ceiling center within the living room. The sprinkler was equipped with a fast-response fusible link, which had a temperature rating of 68°C (155°F). A nominal operating pressure of 1.3 bar (19.0 psig) was used, resulting in a 4.1 mm/min (0.1 gpm/ft^2) water density, in accordance with FM Global Property Loss Prevention Data Sheet 2-5, *Installation Guidelines for Automatic Sprinklers in Residential Occupancies* [10].

Figure 13: Tyco Fire Suppression & Building Products Residential Sprinkler (TY4234).

2.3.2 Fire Service Response Tactics

In all of the tests, the fire service response was initiated via smoke detector activation. Upon activation a 10-minute response clock was started. The 10-minute delay accounted for fire service notification, dispatch, arrival, and setup and was based on nationally accepted standards, including NFPA 1710 [33], NFPA 1720 [34], and other published literature [35]. NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, Section 5.2.4.1.1 states that "The fire department's fire suppression resources shall be deployed to provide for the arrival of an engine company within a 240-second travel time to 90 percent of the incidents" [33]. For volunteer fire departments, NFPA 1720, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments*, states that for structural firefighting of a "low-hazard occupancy such as a 2000 ft^2 (186 m^2), two-story, single-family home without a basement" [34] in urban areas shall be 9 minutes, 90% of the time, and in rural areas the response time increases to 14 minutes, 80% of the time (see Table 7). Furthermore, Section 4.3.3 states "Upon assembling the necessary resources at the emergency scene, the fire department shall have the capability to safely commence an initial attack within 2 minutes 90 percent of the time" [34].

Table 7: Table 4.3.2 Staffing and Response Time taken from NFPA 1720

Table 4.3.2 Staffing and Response Time

Demand Zone[a]	Demographics	Minimum Staff to Respond[b]	Response Time (minutes)[c]	Meets Objective (%)
Urban area	>1000 people/mi^2	15	9	90
Suburban area	500–1000 people/mi^2	10	10	80
Rural area	<500 people/mi^2	6	14	80
Remote area	Travel distance ≥ 8 mi	4	Directly dependent on travel distance	90
Special risks	Determined by AHJ	Determined by AHJ based on risk	Determined by AHJ	90

[a] A jurisdiction can have more than one demand zone.
[b] Minimum staffing includes members responding from the AHJs department and automatic aid
[c] Response time begins upon completion of the dispatch notification and ends at the time interval shown in the table.

A publication by the Illinois Fire Inspectors Association states that the average time for firefighters to open hose nozzles after a fire is detected is 10 minutes (see Figure 14).

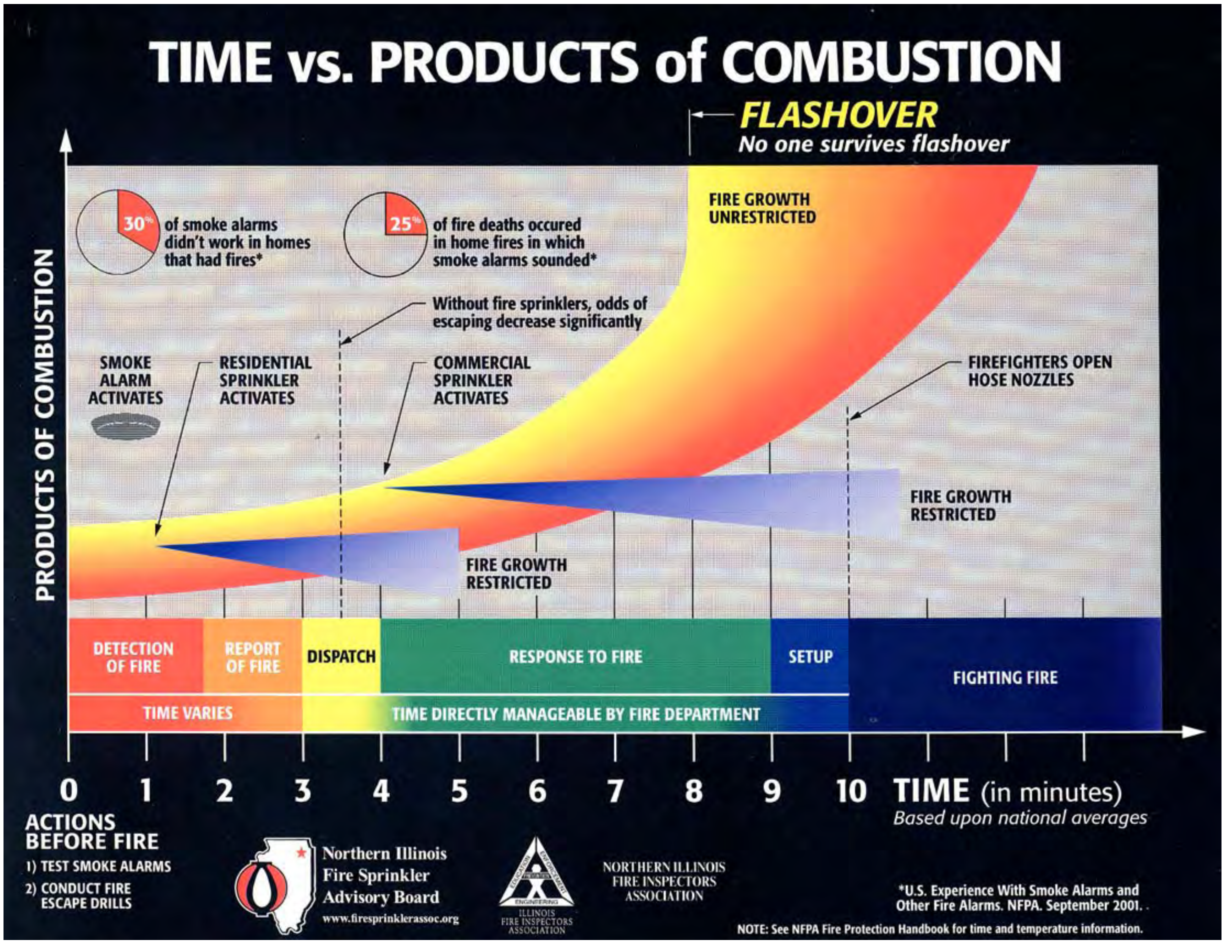

Figure 14: Timeline of fire development versus typical fire service response (taken from http://www.illinoisfireinspectors.org/ifia.htm).

Firefighting activities were in compliance with recognized fire service attack standards including NFPA and Oklahoma State University's "*Essentials of Fire Fighting and Fire Department Operations*" [35].

NFPA 1710, Section 5.2.4.2.2 recommends "establishment of an effective water flow application rate of 300 gpm from two handlines, each of which has a minimum flow rate of 100 gpm" [33]. This is for an "initial full alarm assignment to a structure fire in a typical 2000 ft^2 two story single-family dwelling" [33].

To comply, two 30.5-m (100-ft.) long, 1 ¾ in. attack handlines with Task Force Tip Thunder Fog Nozzles, model #FTS200, set at 360 lpm (95 gpm), were staffed with two trained firefighters each. A constant 6.9 bar (100 psi) nozzle pressure was supplied. For safety reasons, a third identical attack line was staffed and supported but not utilized.

During the non-sprinklered test, firefighting tactics as recommended by Reference 35 were closely followed. A realistic and aggressive interior attack occurred once deemed practical as a result of a direct exterior attack. This was executed by straight stream water application to obtain maximum cooling and darkening down of visible fire immediately at the 10-minute fire interval.

Interior entry was gained as soon as possible and a short period of 40-60 degree fog spray was applied to obtain maximum cooling and fire extinguishment. Proper ventilation had occurred as the windows and door had already burned out and fallen out of the structure. A straight stream was then applied to conduct and pursue final extinguishment.

In the sprinklered test, only an interior attack was required because of the sprinkler activation and subsequent fire control. At the 10-minute mark, firefighters approached the room, pried open the exterior door and used a single fire hose line to attack the fire. The second attack line provided backup only. A short period of 40-60 degree fog spray was applied to obtain maximum cooling and fire extinguishment. Final extinguishment occurred through direct application of a straight stream.

2.4 INSTRUMENTATION

Scientific measurements internal and external to the room were made in each test. Each room was instrumented with ceiling and elevation thermocouples, heat flux gages, and gas measurements. All instrumentation was calibrated in accordance with ISO/IEC 17025-2005 [36]. The instrumentation layout within the room is shown in Figure 15. The following sections describe each of the instruments used in the tests.

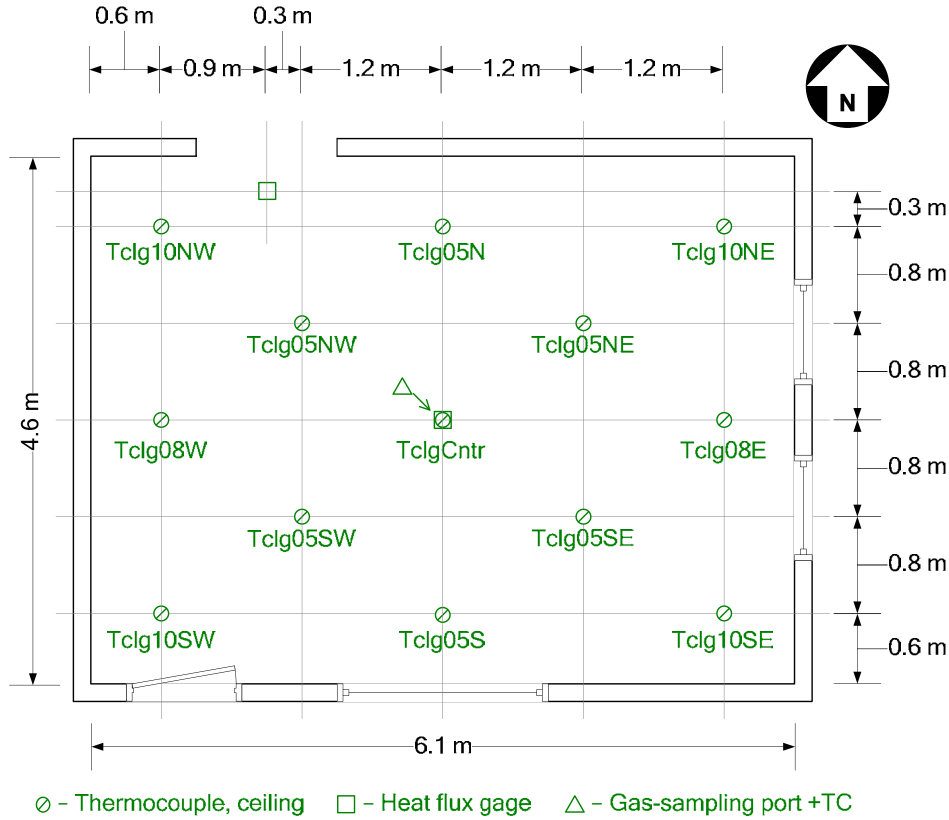

Figure 15: Instrumentation layout within the room.

2.4.1 Gas Analysis Measurements within the Duct

Multiple gas measurements were made, within the 20-MW calorimeter duct, to evaluate the products of combustion generated during the fire tests. The data was used to quantify the reduction in greenhouse gases and pollutants between the sprinklered and non-sprinklered tests, and to determine the chemical heat release rate and total energy released.

2.4.1.1 FM Global Instrumentation

Continuous real-time gas measurements within the 20-MW calorimeter duct include oxygen, carbon monoxide, carbon dioxide, and total hydrocarbons. A Rosemount Analytical MLT series analyzer, model MLT-4T-IR-IR-PO2, was used to measure carbon monoxide, carbon dioxide and oxygen. The analyzer comprises infrared sensors to measure carbon monoxide and carbon dioxide, and a paramagnetic sensor to measure oxygen. Total hydrocarbons were measured, as equivalent methane, using a Rosemount Analytical analyzer, model NGA2000 FID2. The analyzers were set to operate with ranges indicated in Table 8.

Table 8: FM Global Gas Analyzer Measurement Ranges (Duct)

Species	Range
Carbon Dioxide (ppm)	0 - 25,000
Carbon Monoxide (ppm)	0 - 5,000
Oxygen (%)	0 - 21
Total Hydrocarbons (ppm)	0 - 5,000

2.4.1.2 External Instrumentation

Standard FM Global measurements within the duct were supplemented by an outside contractor, Air Pollution Characterization and Control, Ltd. (APCC), retained by Woodard & Curran. Measurements included the following:

- Criteria Pollutants
- Volatile Organic Compounds (VOCs)
- Greenhouse Gas Pollutants
- Particulate Matter
- Heavy Metals
- Semi-Volatile Organic Compounds (SVOCs)
- Other Organic and Inorganic compounds
- Total Hydrocarbons
- Oxygen

Full details on the measurement techniques and instrumentation are reported in Reference 37.

2.4.2 Gas Analysis Measurements within the Room

Continuous real-time gas samples for measurement of carbon monoxide, carbon dioxide, oxygen, and total hydrocarbons were obtained at the center of the room at a 1.5 m (5 ft.) elevation. For the sprinklered test a Rosemount Analytical MLT series analyzer, model MLT-4T-IR-IR-PO2, was used to measure carbon monoxide, carbon dioxide, and oxygen. The analyzer comprises infrared sensors to measure carbon monoxide and carbon dioxide, and a paramagnetic sensor to measure oxygen. Total hydrocarbons were measured as equivalent methane, using a Rosemount

Analytical analyzer, model NGA2000 FID2. The analyzers were set to operate with ranges indicated in Table 9. For the non-sprinklered test, units were rented from Clean Air Instrument Rental of Palatine, Illinois. The analyzers used were Fuji Electric Systems Co., Ltd. model ZRH carbon monoxide analyzer, Horiba, Ltd. model VIA-510 carbon dioxide analyzer, J.U.M. Engineering GmbH model 3-300A total hydrocarbon analyzer, and a Servomex Ltd. model 1420C oxygen analyzer. The analyzers operated within the ranges indicated in Table 9.

Table 9: Gas Analyzer Measurement Ranges (Room)

Species	Sprinklered	Non-Sprinklered
Carbon Dioxide (ppm)	0 - 50,000	0 - 250,000
Carbon Monoxide (ppm)	0 - 10,000	0 - 100,000
Oxygen (%)	0 - 21	0 - 25
Total Hydrocarbons (ppm)	0 - 5,000	0 - 100,000

2.4.3 Ceiling and Room Thermocouples

Temperatures under the ceiling were monitored during each test using 13 20-gage Type K bare-bead thermocouples. These thermocouples have a 19-mm (0.75-in.) exposed length of wire. The time response of these thermocouples has been measured[§] and is characterized by an RTI value of 8 ±1 $(m\cdot s)^{1/2}$ (14.5 ±1.8 $(ft\cdot s)^{1/2}$). The thermocouples were positioned as shown in Figure 15 and the beads were located approximately 76 mm (3 in.) below the ceiling. The 13 thermocouple labels are identified in Figure 15.

An additional thermocouple with the same characteristics as those described above was installed adjacent to the gas sampling location at the center of the room described in Section 2.4.2.

2.4.4 Heat Flux Measurements

Heat flux gages were used to evaluate the heat transfer from the gases near the ceiling to the floor and ceiling. The gages were water cooled Schmidt-Boelter sensors. Three gages were used in each test; two were located on the floor—one at the center of the room and one at the

§ H-Z Yu, “Sensitivity of the certified Omega 20-gage thermocouple used at LBL,” Email dated June 2, 2008. Also: “RE: Sensitivity of 20-gage TCs,” Email dated August 27, 2008.

archway; a third gage was located at the ceiling directly above the one installed on the floor at the archway. The floor mounted gages were installed with the top surface flush with the top of the carpet as shown in Figure 16. The model and maximum measurement value of each gage, at each location, are listed in Table 10.

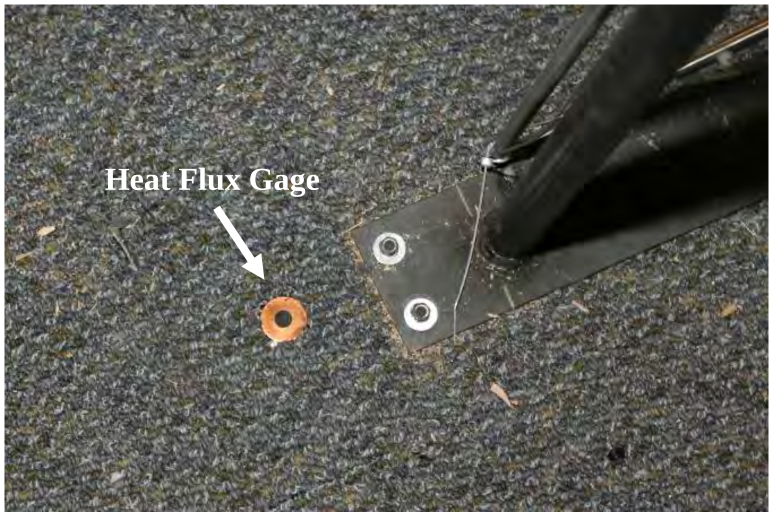

Figure 16: Heat flux gage installation at the floor.

Table 10: Heat Flux Gage Information

Location	Model	Maximum Value
Non-Sprinklered Test		
Floor (center)	64-5SB-20KS	57 kW/m^2 (5 BTU/ft^2s)
Floor (archway)	64-5SB-20KS	57 kW/m^2 (5 BTU/ft^2s)
Ceiling (archway)	64-15SB-20KS	170 kW/m^2 (15 BTU/ft^2s)
Sprinklered Test		
Floor (center)	64-5SB-20KS	57 kW/m^2 (5 BTU/ft^2s)
Floor (archway)	64-5SB-20KS	57 kW/m^2 (5 BTU/ft^2s)
Ceiling (archway)	64-5SB-20KS	57 kW/m^2 (5 BTU/ft^2s)

2.4.5 Smoke Detectors

Each room was instrumented with two smoke detectors, one ionization detector and one photoelectric detector. The ionization detector was a Kidde, Model 0916 (Part Number 440375) and the photoelectric detector was a Kidde, Model PE9 (Part Number 440378).[**] Detector operation was monitored and recorded by connecting the speaker signal to the data acquisition system.

The detectors were installed on the interior wall with the centerline of the detectors 22.9 cm (9 in.) below the ceiling. The photoelectric detector was 20.3 cm (8 in.) inward from the edge of the archway and the ionization detector was 35.6 cm (14 in.) from the edge.

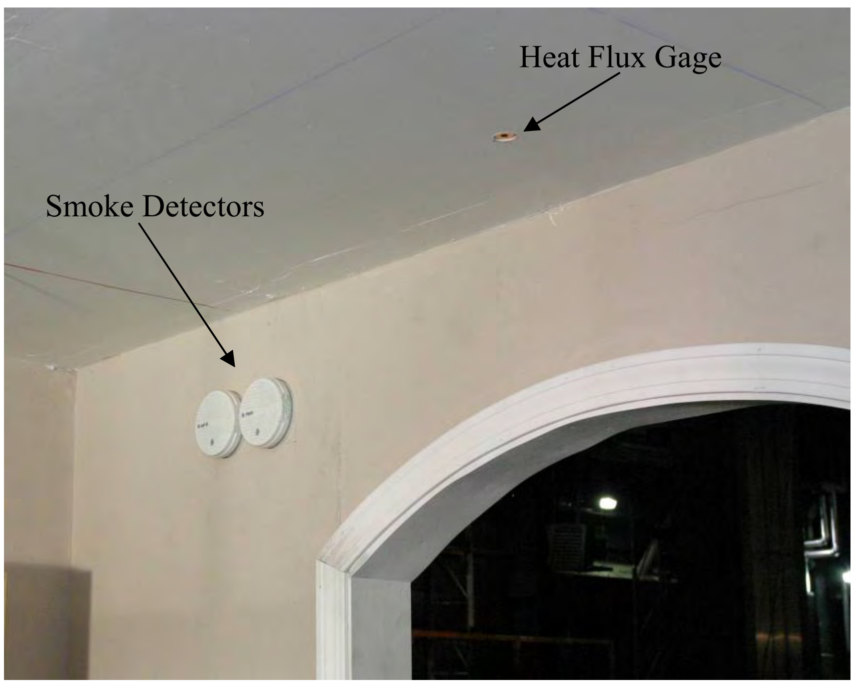

Figure 17: Smoke detector and ceiling heat flux gage locations.

2.4.6 Water Collection System

A special water collection system was constructed to collect the portion of the water exiting the living room via the archway. The system generally consisted of a stainless steel collection pan fastened to the base of the archway. Two sump pumps were located within the pan to transfer

[**] FM Approved units were not used for these tests since battery operated residential detectors were required and FM Approvals does not approve these types of detectors.

the water to a 1040 L (275 gal.) intermediate bulk container (IBC). Depending on the volume of water flowing through the archway, either a ⅓ HP Goulds model SP035M or 1/16 HP Simer model 2310-03 sump pump was turned on to keep the collection pan from overflowing. Each test used a new IBC, and the stainless steel collection pan was scrubbed and triple rinsed with distilled water between tests to ensure there was no cross contamination. The collection pan was also covered in plastic wrap until immediately before the start of each test.

For the non-sprinklered test this system consisted of a 1.85 m long x 0.3 m wide x 0.36 m tall (6 ft. 1 in. x 1 ft. x 1 ft. 2 in.) stainless steel pan connected to the IBC with plastic tubing. However, the heat output from the fire exiting the archway was sufficient to damage the pumps and burn the plastic tubing. This resulted in an unknown amount of contamination to the collected water. Consequently, the collection system was redesigned to minimize the heat flux to the pumping system for the sprinklered test and the demonstration test (referred to as non-sprinklered test (b)). The revisions to the system included increasing the length of the collection pan to 2.46 m (8 ft. 1 in.) and moving the pumps to the pan edge away from the archway, Figure 18. Additional revisions to the system for non-sprinklered test (b) included changing all tubing to stainless steel and surrounding the pumps with a stainless steel baffle, Figure 19.

Figure 18: Revised water collection pan setup for sprinklered test.

Figure 19: Baffled water collection pan setup for non-sprinklered test (b).

2.4.7 Water Quality Analysis

The services of Woodard and Curran were retained to evaluate the quality of the wastewater generated in each test and to determine the potential environmental impacts on groundwater and surface water. Analysis of the water samples included general chemistry parameters, heavy metals, cyanide, volatile organic compounds, and semi-volatile organic compounds. The complete list of analysis and appropriate test methods is provided in Table 11. Full details of the water analysis are reported in Reference 38.

Table 11: Wastewater Analysis Taken from Reference 38

Analysis	Test Method
Volatile Organic Compounds (VOCs)	USEPA 624
Semi-Volatile Organic Compounds (SVOCs)	USEPA 625
pH	USEPA 150.1
Chemical Oxygen Demand – COD	SM 5220
Specific Conductance	SM 2510
Ammonia Nitrogen	SM 4500
Nitrate Nitrogen	SM 4500
Total Cyanide	SM 4500
Total Suspended and Dissolved Solids	SM 2540
Total Organic Carbon (TOC)	SM 5310
Total Phosphorous	SM-4500P-E(M)
Total and Dissolved Priority Pollutant 13 Metals*	USEPA 6010B/7470

*Antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc.

2.4.8 Solid Waste Analysis

The services of Woodard and Curran were retained to evaluate the solid waste generated in each test to determine if the debris exhibited the hazardous waste characteristics of toxicity. Samples of ash and/or charred materials were collected after each test and analyzed per the United States Environmental Protection Agency's (USEPA) Toxicity Characteristic Leaching Procedure (TCLP), Method 1311. Details of the solid waste analysis are reported in Reference 38.

2.4.9 Video and Photography Details

Each test was documented via video and still photography. Video documentation consisted of five cameras in total: two cameras viewing inside the living room (Panasonic Color CCTV, Model # WV-CP504) and three cameras, including a standard definition (Sony DSR-PD170) and two high definition (Sony HVR-Z1U), positioned around the exterior of the room. The standard definition camera was positioned to view the east wall of the room, while the two high definition cameras were positioned to look at the north-west and south-west corners of the room. The cameras viewing the interior of the room were installed in the west and north walls. The camera positions relative to the room are shown in Figure 20. In addition to the video images, still photography was taken before, during, and after each test, via two digital 35-mm cameras.

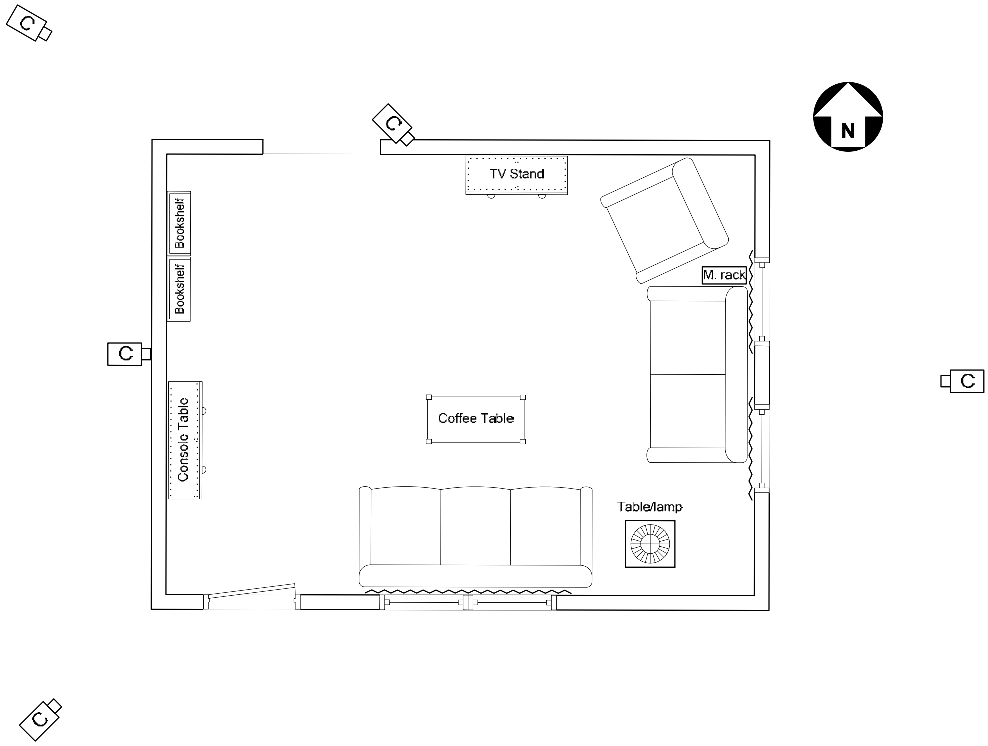

Figure 20: Video camera positions relative to the room.

3 EXPERIMENTAL RESULTS

3.1 FIRE TEST CHRONOLOGIES

On September 17, 2009, the first fully instrumented, non-sprinklered test was conducted. The comparison burn, a fully instrumented sprinklered test was conducted on October 1, 2009; in addition, a second non-sprinklered test was conducted as a demonstration test for the visitors present on that day. The test setup and conditions for the demonstration test were identical to the previous two tests. Very limited data was collected during the demonstration test and it is not included in the main analysis. The fire test chronologies for the two fully instrumented tests are provided in Table 12.

Table 12: Fire Test Chronologies

Event	Sprinklered Test (min:s)	Non-Sprinklered Test (min:s)
Ignition	0	0
Smoke Detector Activation (Ionization)	0:25	0:25
Flames Reach the Ceiling 2.4 m (8 ft.)	0:35	1:55
Sprinkler Activation	0:44	---
Smoke Detector Activation (Photoelectric)	1:10	0:33
Window 1 Breaks	---	4:00
Window 2 Breaks	---	4:42
Flames Extend Out of Archway	---	4:48
Window 4 Breaks	---	5:12
Window 3 Breaks	---	5:32
Flames Exit Around Exterior Door Seam	---	5:42
Window in Exterior Door Falls Out	---	6:18
Fire Service Pries Open Door	10:30	---
Fire Service Applies Hose Stream	10:38	10:30
Fire Service Enters Room	10:58	11:42
Fire Out	13:40	24:44

Note: Windows are numbered as East Wall, North (#1), East Wall, South (#2), South Wall, East (#3), and South Wall, West (#4).

In the non-sprinklered test, fire spread from the magazine rack to the curtains and loveseat and was noticeably slower compared to the sprinklered test, as seen in the time for the flames to reach the ceiling. This longer incipient period is reflected in the ceiling thermocouple measurements reported in Section 3.5; however, the slower fire development does not impact any of the final results and conclusions. It should be noted that in the demonstration test, non-sprinklered (b), the fire development from ignition until 44 seconds was very similar to the sprinklered test. The difference between the two non-sprinklered tests reflects the inherent variability of large-scale fires.

3.2 SPECIES MEASUREMENTS WITHIN THE DUCT

A limited number of species was measured by both FM Global and APCC within the 20-MW exhaust duct. The time resolved concentrations of carbon monoxide, carbon dioxide, and unburned hydrocarbons are presented for the non-sprinklered and sprinklered tests in Figure 21 and Figure 22, respectively. In Figure 21 and Figure 22 the FM Global data are one-second samples and the APCC data are 30-second grab samples.

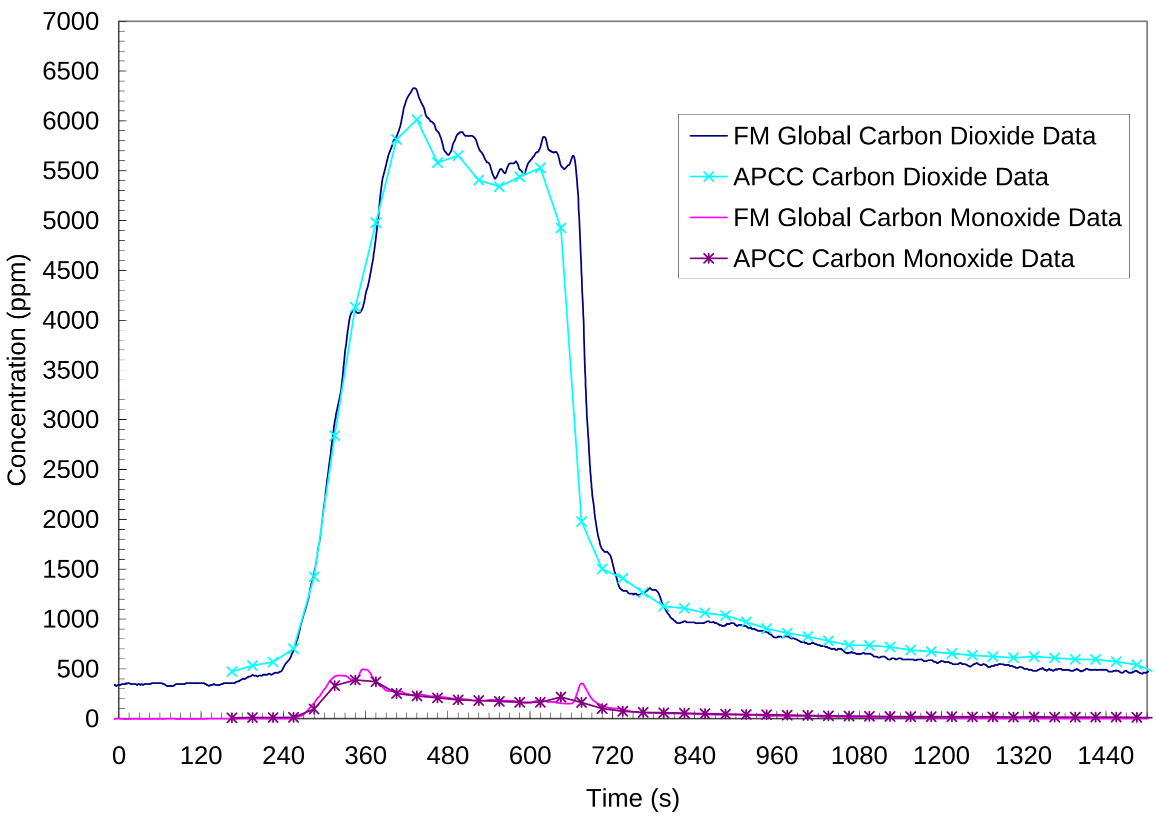

Figure 21: Duct concentrations of CO_2 and CO for the non-sprinklered test.

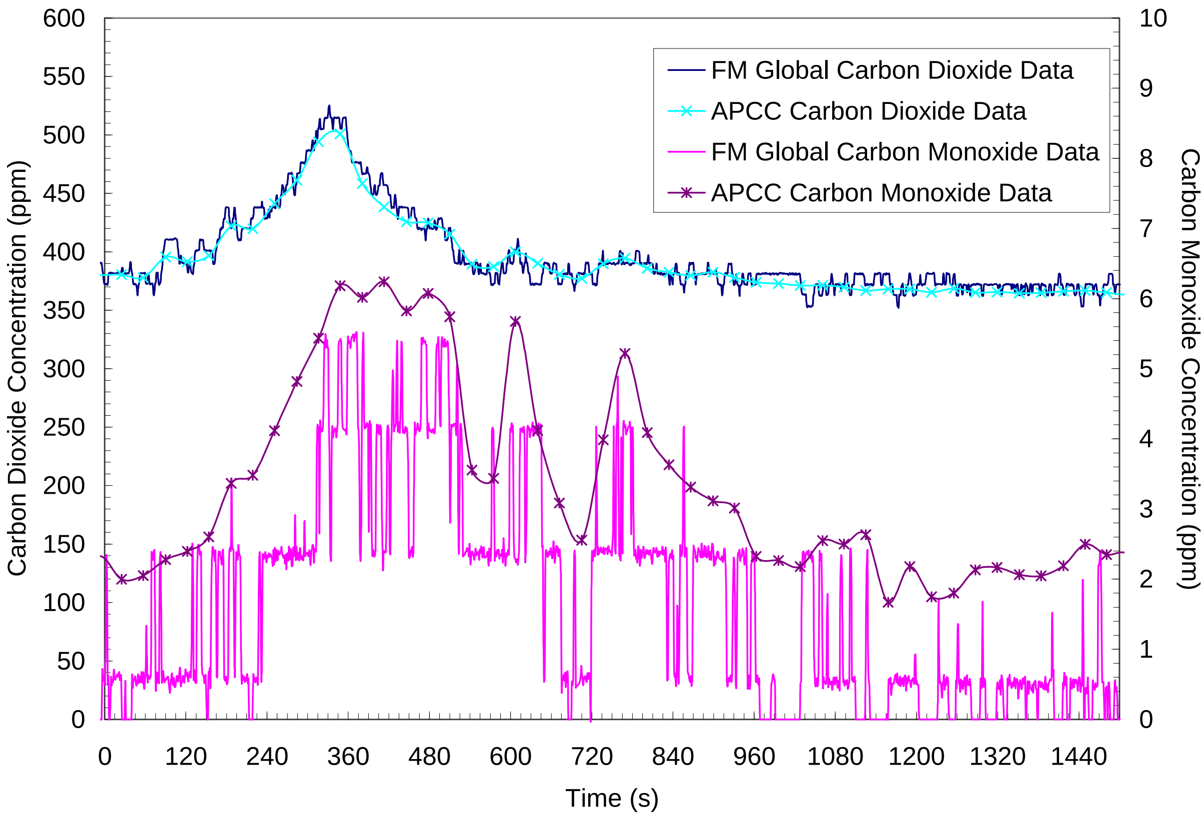

Figure 22: Duct concentrations of CO_2 and CO for the sprinklered test.

Excellent agreement is seen between the two independent data sets. The slight deviation between the FM Global data and the APCC data for the carbon monoxide levels in the sprinklered test is attributed to the very low concentrations, i.e., less than 7 ppm, and the dynamic range of the FM Global analyzer. In the following sections, the FM Global data are used to calculate the heat release rate and the total energy generated during each test, and the APCC data are used to evaluate the environmental impact.

3.3 HEAT RELEASE RATE AND TOTAL ENERGY

The chemical heat release rate (HRR) of each fire was calculated from calorimetry techniques based on carbon monoxide and carbon dioxide generation. The total chemical energy released during each fire was determined by integrating the time-resolved heat release rate data.

The chemical heat release rates as a function of time for the sprinklered and non-sprinklered tests are shown in Figure 23; the peak heat release rates were 300 kW and 13,200 kW respectively. The total energy released in the non-sprinklered test was 5,169 MJ, 76 times greater than that of the sprinklered test, which was 68 MJ. The calculated total energy released as a function of time is shown in Figure 24.

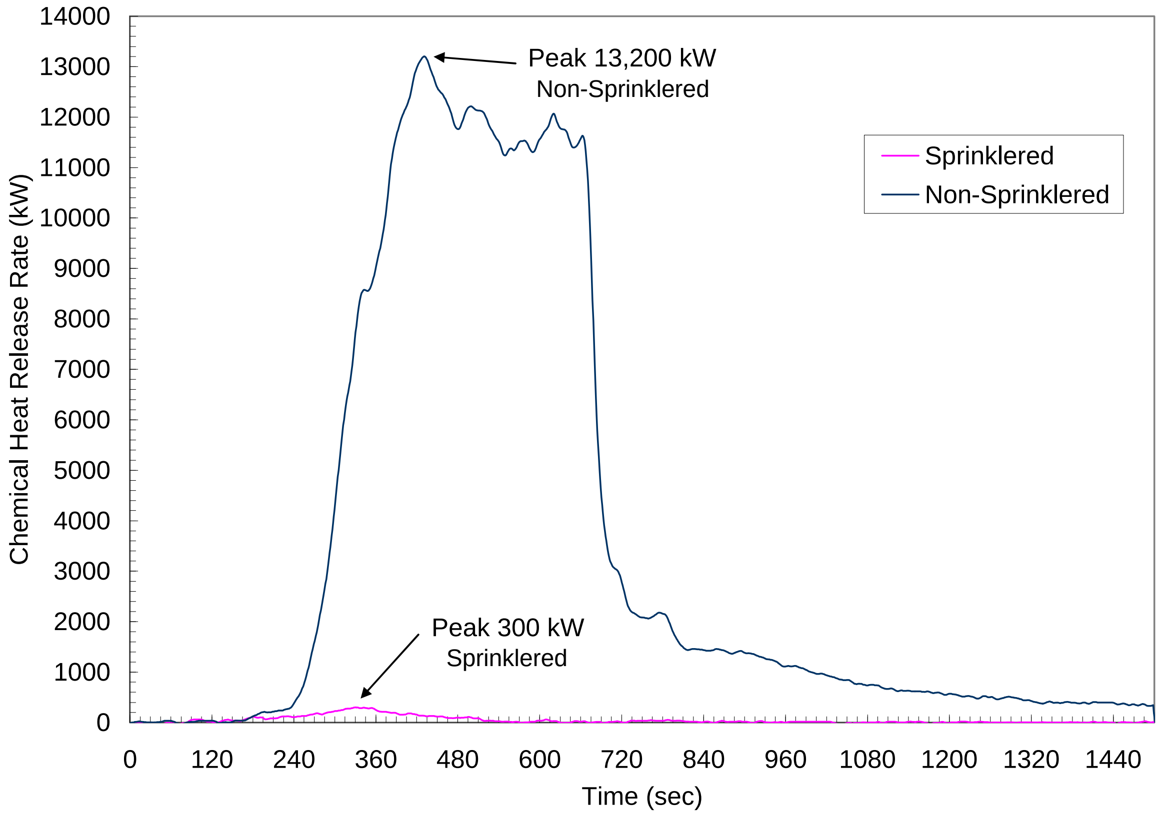

Figure 23: Chemical heat release rate as a function of time for the sprinklered and non-sprinklered tests.

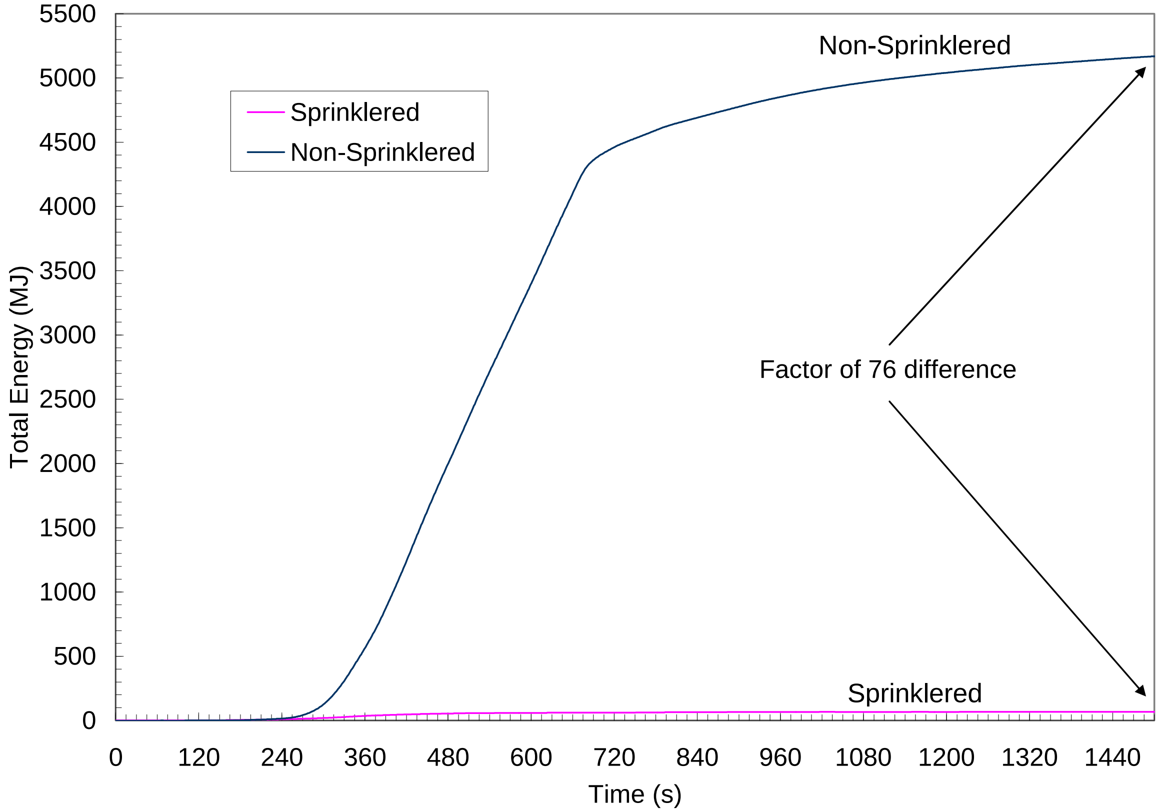

Figure 24: Total chemical energy as a function of time for the sprinklered and non-sprinklered tests.

3.4 ROOM GAS MEASUREMENTS

Gas measurements including the generated carbon dioxide, carbon monoxide, and total hydrocarbons, and the depleted oxygen levels within the rooms were monitored at a 1.5 m (5 ft.) elevation in the center of the room as described in Section 2.4.2. The generated species are plotted as a function of time in Figure 25 and Figure 26, for the non-sprinklered and sprinklered tests respectively.

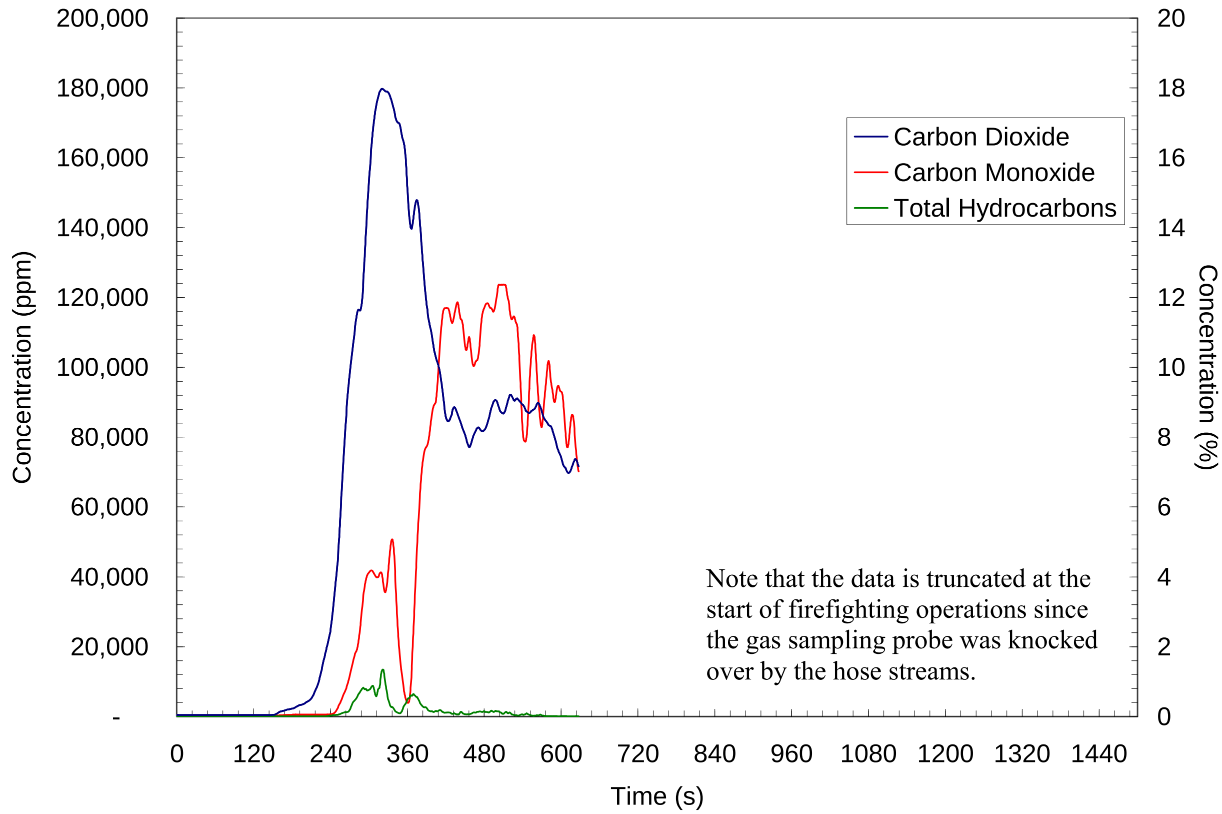

Figure 25: Carbon dioxide, carbon monoxide, and unburned hydrocarbon concentrations as a function of time within the room for the non-sprinklered test.

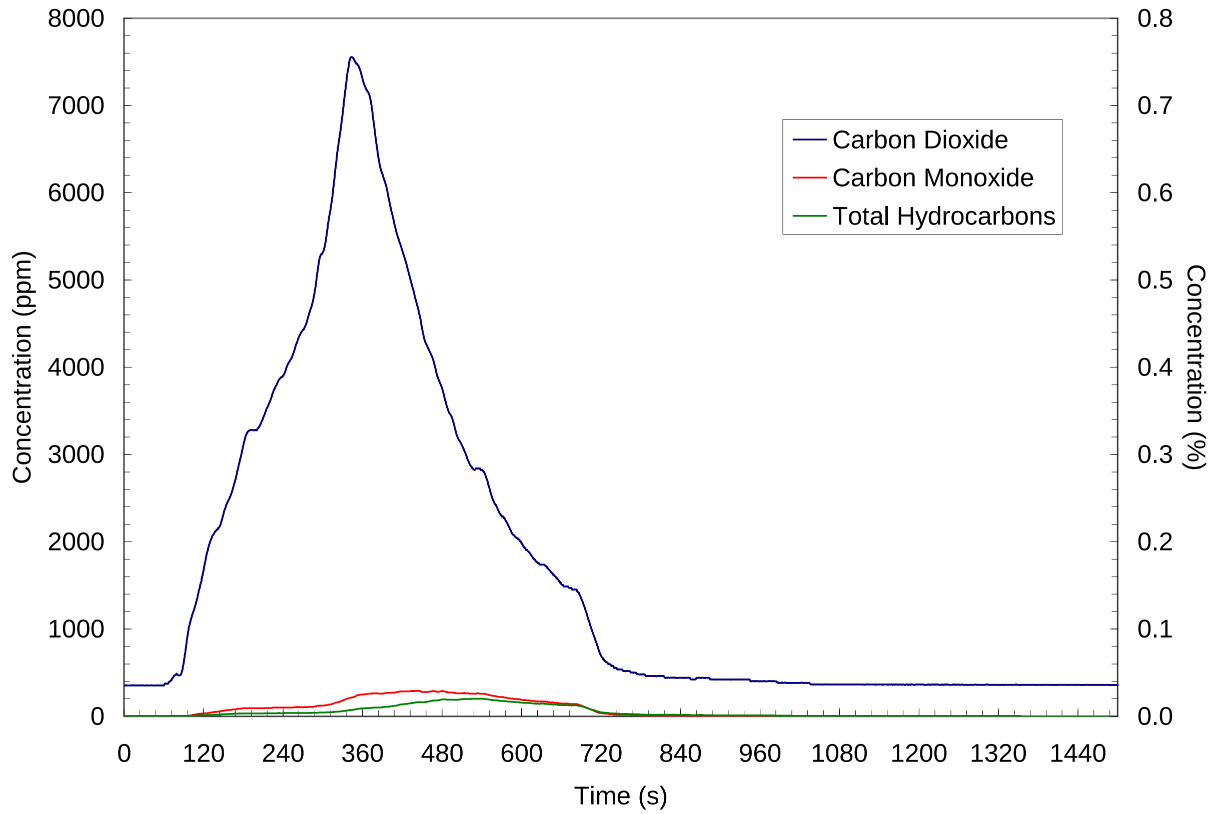

Figure 26: Carbon dioxide, carbon monoxide, and unburned hydrocarbon concentrations as a function of time within the room for the sprinklered test.

It should be noted that the maximum calibrated gas analyzer range for the carbon monoxide, in the non-sprinklered test, was 100,000 ppm (10%); measured concentrations above the maximum range should be viewed with caution. Furthermore, in the non-sprinklered test, at some point after the initiation of firefighting activities the gas sampling probe was knocked over by the hose streams; therefore, all of the data is truncated at the initiation of firefighting activities for this test.

Significantly higher levels of carbon dioxide, carbon monoxide, and total hydrocarbons were measured in the non-sprinklered test than in the sprinklered test. Maximum carbon monoxide levels differed by a factor of 420, while maximum carbon dioxide and total hydrocarbons levels differed by a factor of 24 and 67 respectively.

The oxygen concentrations as a function of time for the sprinklered and non-sprinklered tests are plotted in Figure 27. In the sprinklered test the oxygen level did not decrease below 18.8%; however, in the non-sprinklered test the oxygen level decreased to zero.

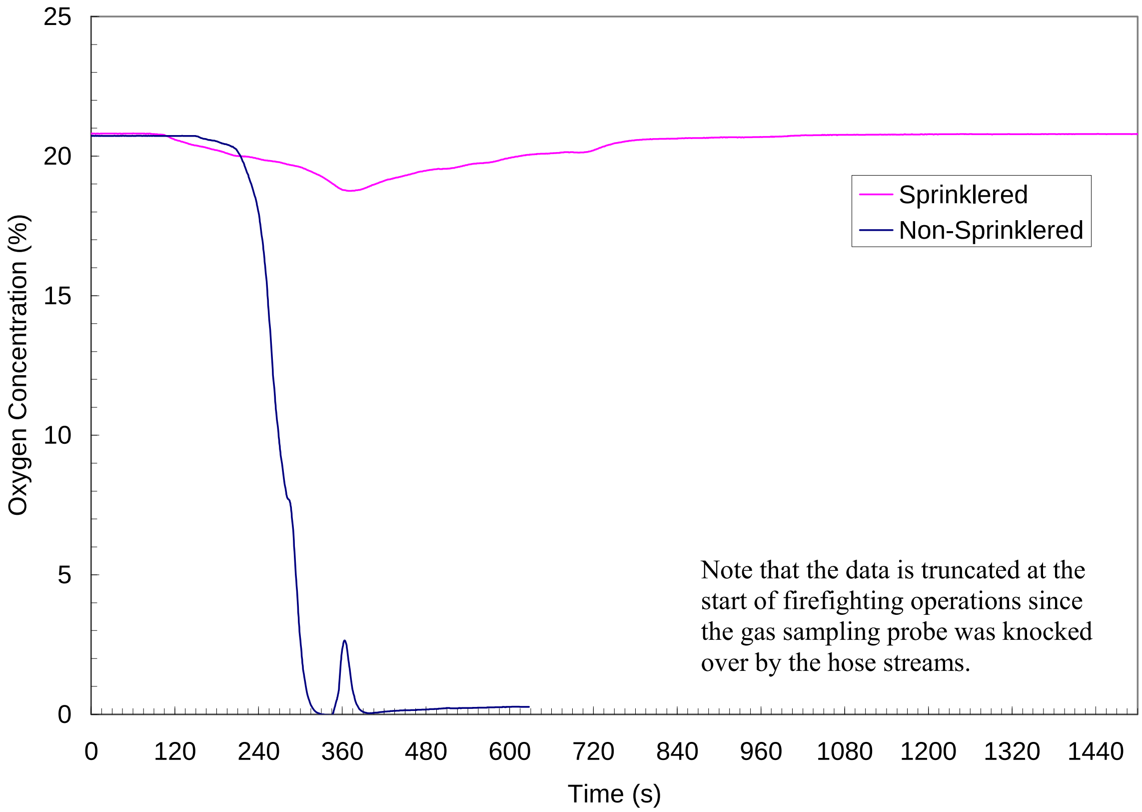

Figure 27: Oxygen concentrations as a function of time within the room for the sprinklered and non-sprinklered tests.

3.5 CEILING TEMPERATURES

Thermocouple measurements near the ceiling were taken at 13 locations as described in Section 2.4.3. The time resolved temperature measurements for the non-sprinklered and sprinklered tests are plotted in Figure 28 and Figure 29 respectively. In the non-sprinklered test a temperature rise across the ceiling is observed at approximately 120 s. The thermocouple reading directly over ignition, i.e., Tclg10NE, reached 530°C (986°F) as the flames spread up the curtain and reached the ceiling. The decrease in temperatures observed at 150 s is attributed to the curtain burning and falling to the floor, thus momentarily decreasing the flame height. As the fire developed and spread, the temperatures near the ceiling rose rapidly and thermocouple readings in excess of 900°C (1650°F) were recorded throughout the room up to the initiation of firefighting activities at 630 s. The maximum readings at several locations approached the upper calibrated limit of a Type K thermocouple, i.e., 1250°C (2282°F) and should be viewed with caution.

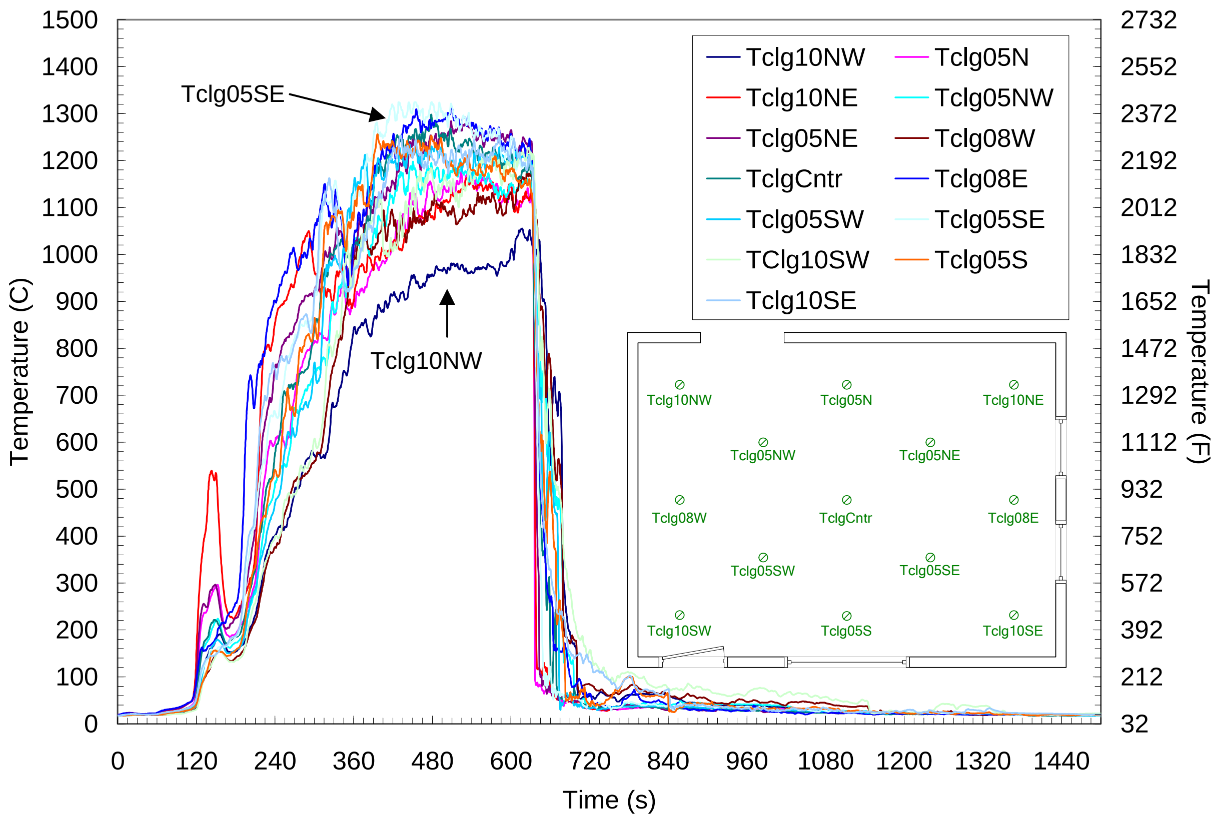

Figure 28: Near-ceiling thermocouple measurements for the non-sprinklered test.

In the sprinklered test, fire propagation from the magazine rack to the curtain and loveseat was more rapid and is reflected in the rapid temperature rise recorded directly over ignition. Upon sprinkler operation, at 44 seconds, the temperatures decrease and for the remaining duration of the test the temperatures near the ceiling do not exceed 260°C (500°F).

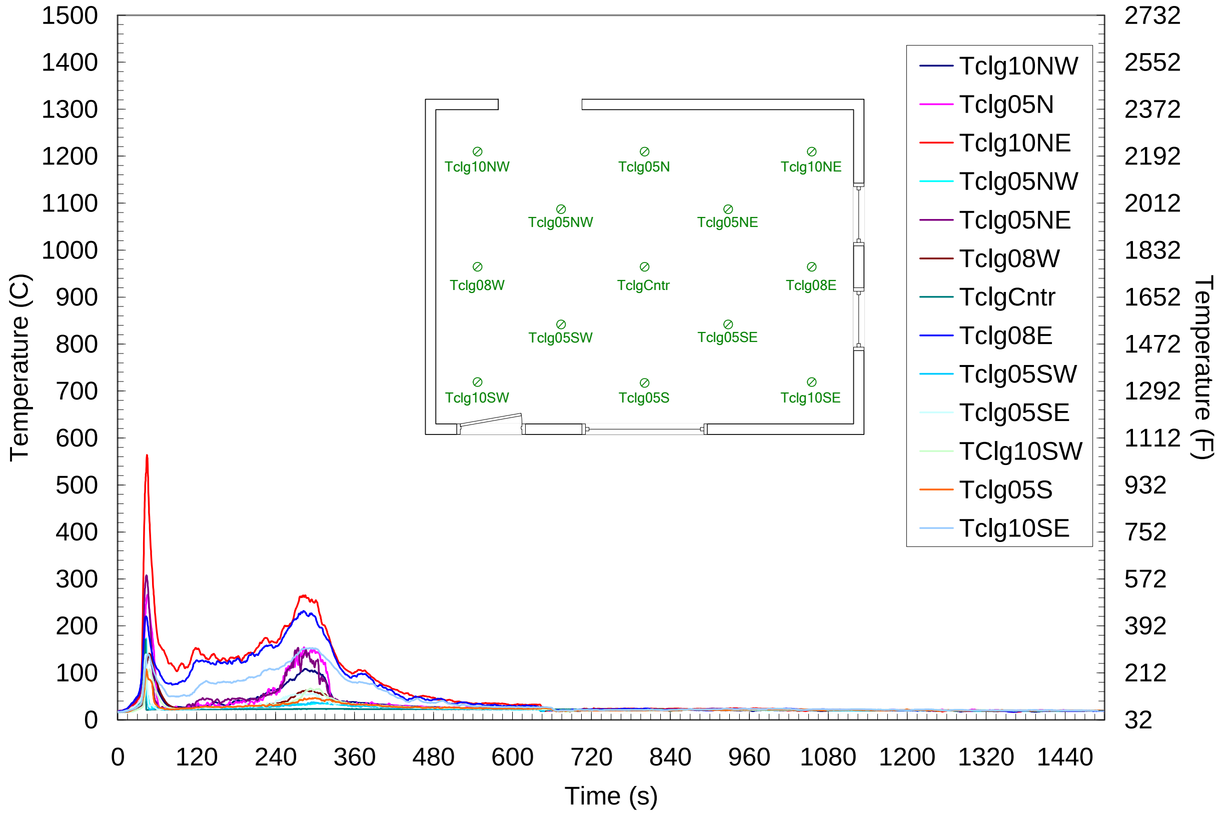

Figure 29: Near-ceiling thermocouple measurements for the sprinklered test.

3.6 FLASHOVER

Flashover is defined by the International Standards Organization as "the rapid transition to a state of total surface involvement in a fire of combustible material within an enclosure" [39]. Although not precise, the typical quantitative criteria for flashover are room temperatures between 500°C (932°F) and 600°C (1112°F), or radiation to the floor of the compartment from the gas layer between 15 and 20 kW/m^2 (1.3 to 1.8 BTU/ft^{2}s). A more subjective demarcation of flashover is the visual observation of flames external to the enclosure.

Using these criteria, the time to flashover in the non-sprinklered test was determined to be between 271 seconds and 327 seconds (see Figure 30). The embedded images in Figure 30 are of the archway taken at the two defining boundaries, i.e., ceiling temperature of 500°C (932°F) and a floor heat flux of 20 kW/m^2 (1.8 BTU/ft^{2}s). The dashed line indicates the visual observation of flames extending to the floor within the enclosure and extending out of the archway.

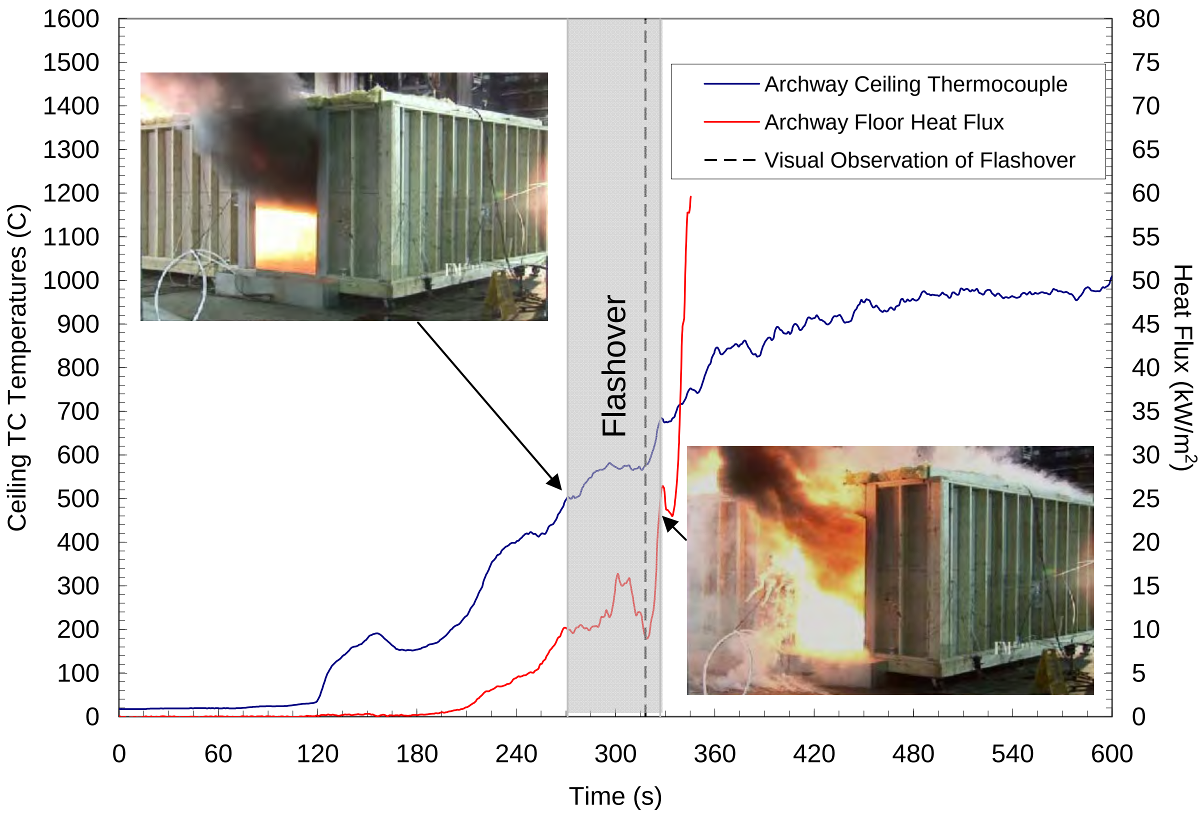

Figure 30: Flashover analysis of non-sprinklered test.

The occurrence of flashover prior to fire service response is an indication that the fire would have progressed to adjoining rooms, thus increasing the volume of materials consumed by the fire and the quantity of water required to extinguish the fire. In the sprinklered test the temperature near the ceiling at the archway did not exceed 136°C (277°F), the heat flux at the floor did not exceed 0.3 kW/m^2 (0.03 BTU/ft^2s), and no flames were observed exiting the enclosure. All of the data indicate that flashover did not occur in this case and the fire was contained completely to the room of origin.

3.7 WATER USAGE

As noted previously, the water sample from the first non-sprinklered test was potentially contaminated due to the melted plastic tubing and sump pumps within the water collection pan; therefore, water flow measurements and water samples for quality analysis were also taken during the demonstration test. Data from the demonstration test are labeled non-sprinklered (b). It should be noted that a more aggressive firefighting approach was also implemented in the demonstration test to better represent typical fire service response.

The volume of water discharged as a function of time in each of the three tests is plotted in Figure 31 and the results are tabulated in Table 13.

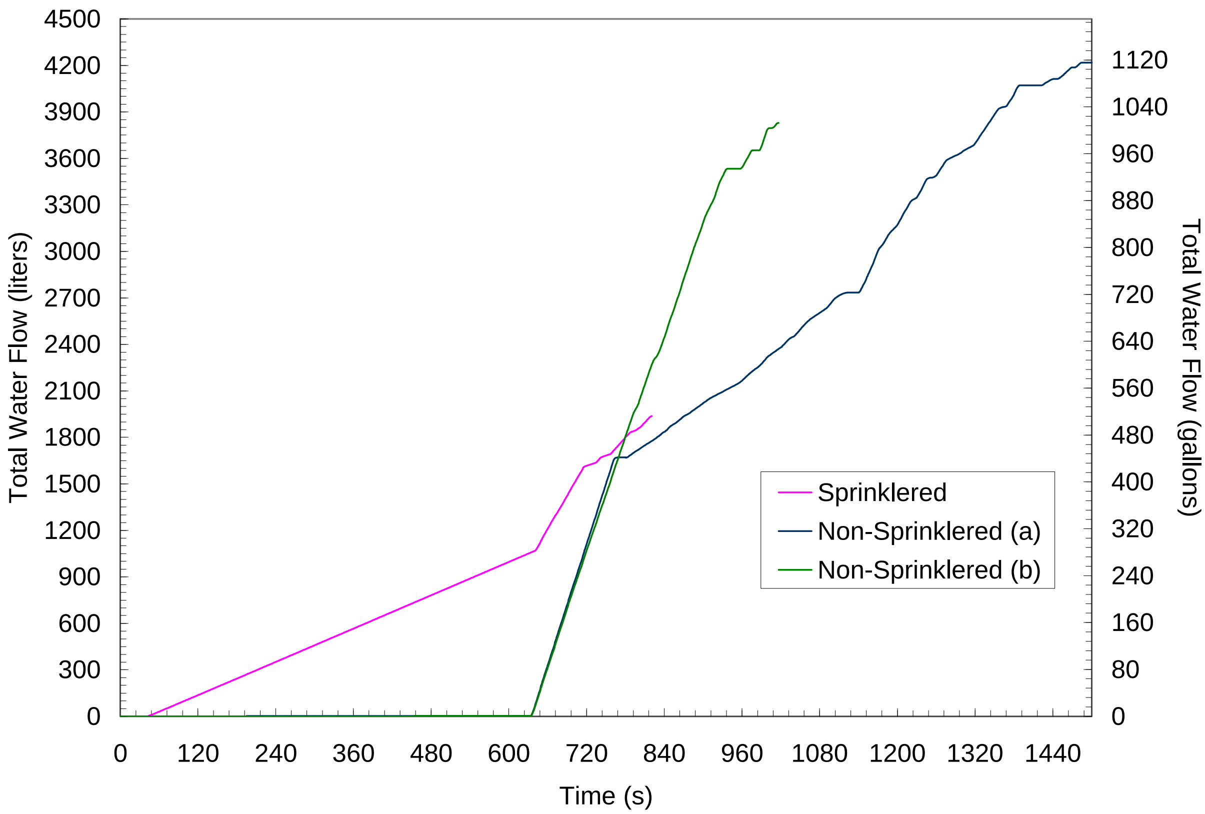

Figure 31: Total volume of water used as a function of time.

Comparing the water usage between non-sprinklered test (a) and (b), the difference in the total quantity of water discharged was not significant, i.e., ~379 L (100 gal.); however, the more aggressive firefighting tactic resulted in extinguishment of the fire 7 minutes and 46 seconds faster. Taking the lower water discharge volume as the representative volume of water for the non-sprinklered tests and comparing it to the total combined sprinkler and hose stream volume, for the sprinklered test, it is seen that 50% less water was used in the sprinklered test compared to the non-sprinklered test. Furthermore, the fire with the sprinkler was extinguished 3 minutes and 17 seconds faster than the non-sprinklered fire. This comparison is conservative, i.e., expected values for the non-sprinklered case will be larger, for two reasons, 1) the time to extinguishment and the volume of water used with the more aggressive firefighting tactics was used for the calculations; and more importantly, 2) in the non-sprinklered tests the fire would have propagated to adjacent rooms, if not the entire house, requiring more time and water to extinguish the fire. Conversely, the fire was contained to the ignition area in the sprinklered room making the results independent of any additional rooms. Extrapolation of the water usage data to larger occupancies will be made in Section 4.2.

Table 13: Water Usage Results

	Sprinklered	**Non-Sprinklered (a)**	**Non-Sprinklered (b)**
Sprinkler [L (gal.)]	1393 (368)	0	0
Hose Stream [L (gal.)]	545 (144)	4221 (1115)	3835 (1013)
Total [L (gal.)]	1938 (512)	4221 (1115)	3835 (1013)
Time to Extinguishment [s]	820	1484	1017

3.8 AIR EMISSION RESULTS

The following table, labeled Table 14, has been extracted directly from Reference 38. In the original report the table is labeled *Table 3-1: Controlled Burn Air Emissions* and the results are reported in pounds.[††] In addition to the mass of each species, the ratio between the non-sprinklered and sprinklered values is reported for each species. Of the 123 species analyzed, only 76 were detected in either the sprinklered or non-sprinklered test. There were 24 species detected at ratios in excess of 10:1, of which 11 were detected at ratios in excess of 50:1, and of those six were detected at ratios in excess of 100:1. Four species, NH_3, 1,2,3-trichloropropane, carbon tetrachloride, and o(rtho)-xylene, were detected in the non-sprinklered test but not in the sprinklered test. Similarly, four species, ethanol, hydrogen chloride (HCl), isopropyl alcohol (IPA), and bromoform, were detected in the sprinklered test but not the non-sprinklered test. The data indicate that "The total emissions from the Sprinkler controlled burn were lower than the emissions from the No Sprinkler controlled burn" [38].

[††] Note: Woodard and Curran used the terms "No Sprinkler" for the non-sprinklered test, and "Sprinkler" for the sprinklered test.

Table 14: Controlled Burn Air Emissions (Table 3-1 extracted from Reference 38)

Criteria Pollutants	Emissions (lbs/burn) 17 September No Sprinkler	1 October Sprinkler	Ratio of Emissions, No Sprinkler vs. Sprinkler
CO	26.42	0.23	113
NO_2	0.14	0.14	1
SO_2	0.48	0.20	2.4
Total VOC - THC (as CH_4)	3.77	0.02	184
Particulate	17.76	1.39	13
Greenhouse Gases	**Emissions (lbs/burn) 17 September No Sprinkler**	**1 October Sprinkler**	**Ratio of Emissions, No Sprinkler vs. Sprinkler**
CO_2	793.95	12.98	61
Methane	1.80	0.01	130
Nitrous Oxide (N_2O)	0.17	0.02	7
Metals	**Emissions (lbs/burn) 17 September No Sprinkler**	**1 October Sprinkler**	**Ratio of Emissions, No Sprinkler vs. Sprinkler**
Antimony (Sb)	0.017	0.00056	30
Arsenic (As)	0.00056	0.00023	2.5
Barium (Ba)	0.012	0.012	1
Beryllium (Be)	0.0014	0.000056	25
Cadmium (Cd)	0.0014	0.00012	12
Total chromium (Cr)	0.050	0.015	3.3
Copper (Cu)	0.016	0.0091	1.8
Mercury (Hg)	0.0082	0.0048	1.7
Lead (Pb)	0.013	0.0087	1.5
Manganese (Mn)	0.081	0.010	8.3
Nickel (Ni)	0.043	0.0095	4.6
Phosphorous (P)	0.012	0.0084	1.5
Selenium (Se)	0.012	0.00063	19
Silver (Ag)	0.00052	0.00026	2
Thallium (Tl)	0.00070	0.00028	2.5
Zinc (Zn	0.147	0.018	8.4

Table 14: Controlled Burn Air Emissions (Table 3-1 extracted from Reference 38) (cont'd)

Air Toxics and Other Pollutants	Emissions (lbs/burn)		Ratio of Emissions, No Sprinkler vs. Sprinkler
	17 September No Sprinkler	1 October Sprinkler	
Acetaldehyde	0.32	0.0016	200
Acrolein	0.21	0.35	0.6
Benzene	0.69	2.06	0.3
Ethanol	0	1.44	0
Ethylene	0.51	0.012	43
Formaldehyde	0.15	0.0092	17
Hydrogen Fluoride (HF)	0.0026	0.0045	0.6
Hydrogen Chloride (HCl)	0	0.016	0
Isopropyl Alcohol (IPA)	0	0.35	0
Methanol	0.20	0.037	5.5
NH_3	0.0026	0	---
NO	0.91	0.021	44
Toluene	0.58	0.084	6.9
Hydrogen Cyanide (HCN)	0.07	0.013	5.4
1,1,1-Trichloroethane	0.46	0.56	0.8
Bromoform	0	0.0011	0
Carbon Disulfide	25.15	0.037	678
Chloroform	0.046	0.012	3.8
Methyl Ethyl Ketone (MEK)	3.52	0.053	67
Iodo-methane	1.042	0.077	14
1,2,3-Trichloropropane	28.31	0	---
Carbon Tetrachloride	0.13	0	---
m(eta)-Xylene	0.057	0.016	3.5
o(rtho)-Xylene	2.97	0	---
p(ara)-Xylene	7.22	0.90	8
Total Xylenes	10.24	0.91	11
Methyl Isobutyl Ketone (MIBK)	3.16	0.032	98

Table 14: Controlled Burn Air Emissions (Table 3-1 extracted from Reference 38) (cont'd)

Semi-Volatile Organic Air Toxics	Emissions (lbs/burn) 17 September No Sprinkler	1 October Sprinkler	Ratio of Emissions, No Sprinkler vs. Sprinkler
1,2,4-Trichlorobenzene	0	0	---
1,2-Dichlorobenzene	0	0	---
1,3-Dichlorobenzene	0	0	---
1,4-Dichlorobenzene	0	0	---
1-Chloronaphthalene	0	0	---
1-Methylnaphthalene	0.0056	0.0017	3.3
2,4,5-Trichlorophenol	0	0	---
2,4,6-Trichlorophenol	0	0	---
2,4-Dichlorophenol	0	0	---
2,4-Dimethylphenol	0	0	---
2,4-Dinitrophenol	0	0	---
2,4-Dinitrotoluene	0	0	---
2,6-Dinitrotoluene	0	0	---
2-Chloronaphthalene	0	0	---
2-Chlorophenol	0	0	---
2-Methylnaphthalene	0.0065	0.0011	5.7
2-Methylphenol	0.0095	0.0017	5.5
2-Nitroaniline	0	0	---
2-Nitrophenol	0	0	---
3 & 4-methylphenol	0.015	0.0020	7.6
3,3'-Dichlorobenzidine	0	0	---
3-Nitroaniline	0	0	---
4,6-Dinitro-2-methylphenol	0	0	---
4-Bromophenyl phenyl ether	0	0	---
4-Chloro-3-Methylphenol	0	0	---
4-Chloroaniline	0	0	---
4-Chlorophenyl phenyl ether	0	0	---
4-Nitroaniline	0	0	---

Table 14: Controlled Burn Air Emissions (Table 3-1 extracted from Reference 38) (cont'd)

Semi-Volatile Organic Air Toxics (con't)	Emissions (lbs/burn) 17 September No Sprinkler	Emissions (lbs/burn) 1 October Sprinkler	Ratio of Emissions, No Sprinkler vs. Sprinkler
4-Nitrophenol	0	0	---
Acenaphthene	0	0	---
Acenaphthylene	0.021	0.00029	75
Aniline	0	0	---
Anthracene	0.0032	0.00023	14
Benzidine	0	0	---
Benzo(a)anthracene	0.0017	0.00023	7.4
Benzo(a)pyrene	0.0018	0.00029	6.1
Benzo(b)fluoranthene	0.0029	0.00023	13
Benzo(g,h,i)perylene	0.0021	0.00023	9
Benzo(k)fluoranthene	0.00088	0.00029	3.1
Benzoic Acid	0.15	0.0011	130
Benzyl Alcohol	0.0011	0.00029	3.7
Benzyl butyl phthalate	0.00026	0.0044	0.1
Biphenyl	0.013	0.0011	12
Bis(2-chloroethoxy)methane	0	0	---
Bis(2-chloroethyl)ether	0	0	---
Bis(2-chloroisopropyl)ether	0	0	---
Bis(2-ethylhexyl)phthalate	0.15	0.061	2.5
Carbazole	0	0	---
Chrysene	0.0013	0.00023	5.5
Dibenz(a,h)anthracene	0.00042	0.00023	1.8
Dibenzofuran	0	0	---
Diethyl phthalate	0	0	---
Dimethyl phthalate	0	0	---
Di-N-butyl phthalate	0	0	---
Di-N-octyl phthalate	0	0	---
Fluoranthene	0.0085	0.00061	14
Fluorene	0.0035	0.00023	15
Hexachlorobenzene	0	0	---
Hexachlorobutadiene	0	0	---
Hexachlorocyclopentadiene	0	0	---
Hexachloroethane	0	0	---
Indeno(1,2,3-cd)pyrene	0.0019	0.00029	6.7
Isophorone	0	0	---
Naphthalene	0.092	0.0012	78
Nitrobenzene	0	0	---
N-Nitrosodimethylamine	0	0	---
N-Nitroso-di-n-propylamine	0	0	---

Table 14: Controlled Burn Air Emissions (Table 3-1 extracted from Reference 38) (cont'd)

Semi-Volatile Organic Air Toxics (con't)	Emissions (lbs/burn) 17 September No Sprinkler	1 October Sprinkler	Ratio of Emissions, No Sprinkler vs. Sprinkler
N-Nitrosodiphenylamine	0	0	---
Pentachlorophenol	0	0	---
Phenanthrene	0.024	0.00055	44
Phenol	0.075	0.00085	88
Pyrene	0.0067	0.00029	23

Note: Carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) are greenhouse gases that were measured during the controlled burns. A result of zero indicates that the constituent was either not detected or controlled burn test results were below the detection limit of the analysis. A dash (---) indicates that ratio was not calculated, because a constituent was not detected in the analysis.

3.9 WATER QUALITY RESULTS

The following results and discussion related to the wastewater analysis have been extracted directly from Reference 38. The section and table numbering of the original report have been maintained. The water analysis includes water samples from each of the fire tests. In addition, since FM Global uses a closed-loop recycled water system for firefighting purposes, samples of the recycled water on each day were also analyzed to establish a baseline.

4.2.1 Analytical Results

As discussed, one composite wastewater sample was collected from each controlled burn (i.e., with and without sprinkler) immediately following fire response activities. Samples were analyzed for general chemistry parameters, dissolved and total metals, VOCs, and SVOCs. Additionally, one recycled water sample was collected per controlled burn and analyzed for the same suite of parameters. Analytical results for all constituents detected at least once in wastewater samples are summarized in Table 4-2a and 4-2b. Recycled fire fighting water sample results are also reported on these tables. The laboratory analytical reports for these samples are provided in Appendix B. As discussed, there were potential sample contamination issues associated with the September 17, 2009 sampling event for the No sprinkler controlled burn. However, for comparative purposes, the analytical results for this wastewater sample and recycled water samples collected on this date are presented on Table 4-2a.

The values presented in the analytical results table show either a detected concentration, or a "non-detect" concentration, indicated by a qualifier of "U". The "U"-qualified value is the reporting limit (RL), which is the lowest concentration that an analytical instrument can accurately measure, within specified limits of precision and accuracy. The constituent may potentially be present at a level below the RL, but the instrument is not able to detect it at a concentration lower than the RL. Note that RLs are, in part, dependent on sample-specific *characteristics, such as the level of contaminant present or the sample dilution required for analysis, and thus, the RL for one analyte in one sample may vary considerably from the RL reported for the same constituent in another sample.*

Because various constituents were detected in the recycled fire fighting water samples, the tables below provide adjusted concentrations of constituents in each wastewater sample. This adjusted, or net, concentration represents the difference between the detected level of a constituent in wastewater and the corresponding detected level in the recycled water sample. Non-detect results were not included in calculation of the adjusted concentration. A positive net value indicates that the concentration of constituent in the wastewater sample was greater than that of the recycled water sample; conversely, a negative value indicates that the concentration in the recycled water sample was greater than that of the wastewater sample.

Table 4-2a: Summary of Analytical Results – Wastewater Samples, September 17, 2009

LOCATION SAMPLING DATE	Units	September 17, 2009 Sampling Event RW - 1 Recycled Water 9/17/2009 Result	Qual	WW-1 No Sprinkler 9/17/2009 Result	Qual	WW-1 No Sprinkler 9/17/2009 Net Result*
General Chemistry						
pH (H)	SU	7.8		11.6		3.8
Specific Conductance	umhos/cm	2,100		5,100		3,000
Solids, Total Dissolved	ug/l	1,200,000		4,000,000		2,800,000
Solids, Total Suspended	ug/l	5,000	U	2,000,000		2,000,000
Cyanide, Total	ug/l	5	U	96		96
Nitrogen, Ammonia	ug/l	75	U	7,200		7,200
Nitrogen, Nitrate	ug/l	100	U	1,900		1,900
Phosphorus, Total	ug/l	19		337		318
Chemical Oxygen Demand	ug/l	220,000		850,000		630,000
Total Organic Carbon	ug/l	71,000		240,000		169,000
Volatile Organic Compounds						
Chloroform	ug/l	150		160		10
Benzene	ug/l	50	U	50	U	ND
Styrene	ug/l	50	U	50	U	ND
Acetone	ug/l	5,900		6,400		500
Semivolatile Organic Compounds						
Phenol	ug/l	7	U	230		230
2-Methylphenol	ug/l	6	U	100		100
3-Methylphenol/ 4-Methylphenol	ug/l	6	U	200		200
Benzoic Acid	ug/l	86		1,300		1,214
Total Metals						
Antimony, Total	ug/l	50	U	208		208
Arsenic, Total	ug/l	5	U	5	U	ND
Chromium, Total	ug/l	10	U	10	U	ND
Copper, Total	ug/l	45		35		-10
Lead, Total	ug/l	2	U	12		12
Mercury, Total	ug/l	0.2	U	1.3		1.3
Silver, Total	ug/l	0.8	U	0.8	U	ND
Zinc, Total	ug/l	82		188		106
Dissolved Metals						
Antimony, Dissolved	ug/l	50	U	210		210
Copper, Dissolved	ug/l	10	U	10	U	ND
Mercury, Dissolved	ug/l	0.2	U	1.5		1.5
Zinc, Dissolved	ug/l	50	U	50	U	ND

U = Constituent not detected at laboratory reporting limit
ug/L = micrograms per liter
SU = standard units
umhos/cm = micromhos per centimeter
Free CN- = Cyanide (CN-) criteria are available for free, or bioavailable, cyanide. Wastewater results are reported for total cyanide. Total cyanide concentrations are not necessarily indicative of free cyanide concentrations.

*Wastewater concentrations were corrected to account for the contribution of contamination from the recycled firefighting water used to extinguish the test burns. The net result shown above is the difference between the measured level of a constituent in the test burn sample and the corresponding recycled water sample.
Non-detect (ND) results were not included in calculating the difference (i.e., these results were assumed equivalent to zero).
A negative result indicates that the test burn sample level was lower than the recycled water concentration.

Table 4-2b: Summary of Analytical Results – Wastewater Samples, October 1, 2009

LOCATION / SAMPLING DATE	Units	October 1, 2009 Sampling Event							
		RW-1 Recycled Water 10/1/2009		WW-1 Sprinkler 10/1/2009		WW-1 Sprinkler 10/1/2009	WW-2 No Sprinkler 10/1/2009		WW-2 No Sprinkler 10/1/2009
		Result	Qual	Result	Qual	Net Result*	Result	Qual	Net Result*
General Chemistry									
pH (H)	SU	8.1		7.9		-0.2	12.1		4
Specific Conductance	umhos/cm	2,200		2,300		100	7,300		5,100
Solids, Total Dissolved	ug/l	1,200,000		1,300,000		100,000	5,500,000		4,300,000
Solids, Total Suspended	ug/l	5,000	U	36,000		36,000	640,000		640,000
Cyanide, Total	ug/l	5	U	639		639	55		55
Nitrogen, Ammonia	ug/l	75	U	1,470		1,470	4,850		4,850
Nitrogen, Nitrate	ug/l	100	U	130		130	440		440
Phosphorus, Total	ug/l	16		500		484	401		385
Chemical Oxygen Demand	ug/l	160,000		420,000		260,000	810,000		650,000
Total Organic Carbon	ug/l	54,000		110,000		56,000	190,000		136,000
Volatile Organic Compounds									
Chloroform	ug/l	290		84		-206	82		-208
Benzene	ug/l	100	U	62		62	50	U	ND
Styrene	ug/l	100	U	50	U	ND	63		63
Acetone	ug/l	13,000		11,000		-2,000	8,000		-5,000
Semivolatile Organic Compounds									
Phenol	ug/l	6.8	U	280	U	ND	370		370
2-Methylphenol	ug/l	5.8	U	240	U	ND	180		180
3-Methylphenol/ 4-Methylphenol	ug/l	5.8	U	240	U	ND	290		290
Benzoic Acid	ug/l	80		2,000	U	ND	960	U	ND
Total Metals									
Antimony, Total	ug/l	50	U	50	U	ND	272		272
Arsenic, Total	ug/l	5	U	5	U	ND	7		7
Chromium, Total	ug/l	10	U	10	U	ND	10		10
Copper, Total	ug/l	40		61		21	46		6
Lead, Total	ug/l	2	U	2		2	18		18
Mercury, Total	ug/l	0.2	U	2.5		2.5	0.8		0.8
Silver, Total	ug/l	0.8	U	0.8	U	ND	1.8		1.8
Zinc, Total	ug/l	165		337		172	350		185
Dissolved Metals									
Antimony, Dissolved	ug/l	50	U	50	U	ND	150		150
Copper, Dissolved	ug/l	10	U	30		30	10	U	ND
Mercury, Dissolved	ug/l	0.2	U	1.1		1.1	0.6		0.6
Zinc, Dissolved	ug/l	128		182		54	50	U	ND

U = Constituent not detected at laboratory reporting limit
ug/L = micrograms per liter
SU = standard units
umhos/cm = micromhos per centimeter
Free CN- = Cyanide (CN-) criteria are available for free, or bioavailable, cyanide. Wastewater results are reported for total cyanide. Total cyanide concentrations are not necessarily indicative of free cyanide concentrations.

*Wastewater concentrations were corrected to account for the contribution of contamination from the recycled firefighting water used to extinguish the test burns. The net result shown above is the difference between the measured level of a constituent in the test burn sample and the corresponding recycled water sample.
Non-detect (ND) results were not included in calculating the difference (i.e., these results were assumed equivalent to zero).
A negative result indicates that the test burn sample level was lower than the recycled water concentration.

4.2.1.2 Pollutant Concentrations in Wastewater

Recycled Water Samples: Analytical results for both of the recycled water samples indicate that total copper, total zinc, two VOCs (acetone and chloroform), and benzoic acid, a SVOC, are present at a level above the laboratory reporting limits. In general, the types of constituents detected in both September 17 and October 1 samples were similar, although concentrations of these constituents were variable. Of the metals, only zinc was detected in dissolved form, and only in the October 1, 2009 sample. General chemistry results showed that organic solids were also present in the water samples. These results indicate that a baseline level of chemical constituents is present in the recycled water system.

Sprinkler controlled burn: Acetone, benzene, and chloroform were detected in the sample obtained from the Sprinkler controlled burn, WW-1, on October 1, 2009. Both chloroform and acetone levels in the Sprinkler controlled burn sample were lower than those of the recycled water sample collected on the same sample date. No SVOCs were detected in the Sprinkler sample; however, reporting limits for several of the constituents were elevated in this sample compared to those in the recycled water sample (due to the high concentrations of several analytes present in the sample), thereby potentially "masking" the presence of these constituents. Total and dissolved copper, mercury, and zinc were detected in sample WW-1; lead was detected only in total form in this sample.

No Sprinkler controlled burn: Similar types of constituents were detected in the samples obtained from the No Sprinkler controlled burn (samples WW-1, on September 17, 2009 and WW-2, on October 1, 2009). Chloroform, styrene, acetone, and several phenolic compounds were detected; both acetone and chloroform levels were lower than those detected in the recycled water sample. Heavy metals, including antimony, arsenic, chromium, lead, mercury, and silver, were also detected. Of the metals, only antimony and mercury were detected in dissolved form, and in both samples, implying that most of the detected metals are likely associated with suspended particulate matter.

During the October 1, 2009 event, both chloroform and acetone concentrations were highest in the recycled water sample compared to concentrations detected in the Sprinkler and No Sprinkler samples. Because both of these compounds are volatile, one would expect a higher degree of volatilization resulting from either controlled burn (because recycled fire fighting water is spread over a larger area and because the heat from the fire would increase volatilization), which may, in part, explain the difference in concentration for these contaminants.

Three SVOCs were detected in the No Sprinkler sample, whereas none was detected in the Sprinkler sample; however, the reporting limits for SVOCs in the Sprinkler sample were similar to or higher than those of the No Sprinkler sample. It is therefore unclear whether SVOCs in the Sprinkler sample are not actually present or are present but at levels below the reporting limits.

Relative to the recycled water samples, the Sprinkler and No Sprinkler samples contained higher levels of both total suspended and dissolved solids, organic carbon, and nutrients (nitrogen and phosphorous). In general, the No Sprinkler water samples contained the highest levels of solids and TOC, and a higher pH. This is expected, considering the high generation of ash resulting *from the No Sprinkler controlled burn compared to the Sprinkler controlled burn. Of all of the wastewater samples, the total cyanide concentration was highest in the October 1, 2009 Sprinkler sample. Cyanide gas can be generated from burning synthetic polymers in building materials and furnishings, as well as natural materials such as wood.*

Metals concentrations were variable between the Sprinkler and No-Sprinkler controlled burn samples, with no clear bias shown by either sample. In general, however, the differences in concentration between the two controlled burns were less than an order of magnitude. Of the eight metals analyzed (as total metals), six metals were detected in the No Sprinkler sample at concentrations higher than that of the Sprinkler sample. However, dissolved copper, mercury, and zinc concentrations were highest in the Sprinkler controlled burn. Dissolved antimony concentrations were highest in the No Sprinkler sample.

The pH of the composite wastewater samples from the two No Sprinkler controlled burns were 11.6 and 12.1 vs. pH of 7.9 for the wastewater sample from the Sprinkler controlled burn. Thus, the wastewater from the No Sprinkler controlled burns was approximately four orders of magnitude higher in alkalinity than the wastewater from the Sprinkler controlled burn. The discharge of any wastewater with pH values of higher than 10 would be a serious environmental concern. Wastewaters exhibiting pH values of greater than 9.0 would be exceeding the allowable discharge range of pH 5.5-9.0 required by most environmental regulatory agencies.

3.10 SOLID WASTE ANALYSIS

Solid waste from each of the tests, including non-sprinklered test (b) was analyzed as described in Section 2.4.8. The results of the analysis indicate that all three samples "would not be considered 'hazardous waste' under USEPA regulations". Furthermore, "the wastes are not anticipated to significantly leach once landfilled" [38].

4 DISCUSSION

In the following sections, the reduction in the environmental impact due to the use of automatic fire sprinklers in a fire will be discussed. Quantification of the environmental impact will be based on analysis of greenhouse gases, water usage, potential environmental impacts of wastewater runoff, fire damage, and solid waste material disposed in landfills. In addition, the benefits of automatic fire sprinklers from a life safety perspective will be presented.

4.1 IMPACT ON GREENHOUSE GASES

This section discusses the impact of sprinkler protection on the generation of greenhouse gases. The measured greenhouse gases reported in Section 3.8 can be converted to an equivalent mass of carbon dioxide:

$$CO_{2,equivalent} = GWP_{gas} \cdot m_{gas} \tag{9}$$

Where:

$CO_{2,equivalent}$ - equivalent mass of carbon dioxide for a gas

m_{gas} - mass of the greenhouse gas

GWP_{gas} - global warming potential of the gas

The global warming potentials (GWP) "are a measure of the relative radiative effect of a given substance compared to another, integrated over a chosen time horizon. [40]" A common time horizon used by regulators is 100 years.

The global warming potential, measured masses of greenhouse gases, and calculated equivalent carbon dioxide levels are listed in Table 15. The equivalent mass of CO_2 generated in the non-sprinklered test was 404.4 kg (890.7 lb.) versus 8.7 kg (19.2 lb.) generated in the sprinklered test. This indicates that in the event of a fire, the use of sprinklers can reduce the greenhouse gas emissions by 97.8%. It should be noted that this is a conservative value, i.e., the expected values will be larger, since in the non-sprinklered test the fire would have propagated to adjacent rooms, if not the entire house, before firefighting intervention commenced.

Table 15: Equivalent Carbon Dioxide Values for Measured Greenhouse Gases

Gas	GWP*	Measured Mass		Equivalent CO_2	
		(Non-Sprinklered) kg (lb.)	(Sprinklered) kg (lb.)	(Non-Sprinklered) kg (lb.)	(Sprinklered) kg (lb.)
CO_2	1	360.1 (794)	5.9 (13.0)	360.1 (794)	5.9 (13.0)
CH_4	25	0.82 (1.8)	0.004 (0.019)	20.5 (45.2)	0.1 (0.22)
N_2O	298	0.08 (0.17)	0.009 (0.02)	23.8 (52.5)	2.7 (6.0)
			Total	**404.4 (890.7)**	**8.7 (19.2)**

* Based on a 100-year time interval

These results can be extrapolated to estimate the total greenhouse gas production resulting for all residential fires within the U.S. between 1999 and 2008. As discussed previously in Sections 1.2.3 and 1.2.4, the average size of a single-family home during that time period was 164 m^2 (1,765 ft^2) and the estimated average damage, per NFPA statistics, was 14%. Furthermore, data from NFPA indicate that the total number of residential fires in one- and two-family homes (including manufactured homes) between 1999 and 2008 was 2,943,500. Assuming a direct proportionality between the greenhouse gas emissions and the area of the room, it is estimated that 14.5 kg/m^2 (3.0 lbs/ft^2) of equivalent carbon dioxide was generated. Based on these values, the total amount of greenhouse gases generated between 1999 and 2008, as a result of residential fires, was 979,950,020 kg (2,160,419,982 lb.) If sprinklers had been used, the total mass of greenhouse gases, over the 10-year period, would have been reduced by 97.8% to 21,558,900 kg (47,529,240 lb.) On a yearly basis the values are reduced by a factor of 10.

As a reference, the EPA reports that “In the United States, approximately 4 metric tons of carbon dioxide (CO_2) equivalent (almost 9,000 pounds) per person per year (about 17% of total U.S. emissions) are emitted from people's homes. The three main sources of greenhouse gas emissions from homes are electricity use, heating and waste.”

4.2 WATER USE EXTRAPOLATION

In this section, the quantity of water needed to extinguish a fire in structures larger than the one used in this study will be estimated. The key assumption in this analysis is that the quantity of water needed to extinguish the fire is directly proportional to the area of the room. It is reported in Section 3.7 that the quantity of water used in non-sprinklered test (b) was 3,835 L (1,013 gal.). Based on the area of the room used in this study the quantity of water per unit area needed to extinguish the fire without a sprinkler was 138 L/m^2 (3.4 gal/ft^2).

Assuming various percentages of damage to a typical sized residence, the projected quantity of water required by firefighters can be determined and the percent reduction achieved by using a sprinkler can be estimated. The experimental data reported in Section 3.7 and the estimates in Table 16 indicate that, in the event of a fire, for an average sized home of 164 m^2 (1,765 ft^2) using sprinklers can reduce the water usage between 50% and 91%.

Table 16: Water Usage Estimates

Percentage Damaged	Area Damaged m^2 (ft^2)	Estimated Water Usage by Firefighters L (gal.)	Reduction Achieved by Using Sprinklers (%)
25	41 (441)	5,644 (1,491)	66
50	82 (883)	11,292 (2,983)	83
75	123 (1,324)	16,936 (4,474)	89
100	164 (1,765)	22,584 (5,966)	91

4.3 FIRE DAMAGE

The combustible loading within each living room consisted of the primary and secondary fuel items, decorative items, and ignition package comprising a combined mass of 309.8 kg (683.0 lb.). The carpet, carpet padding, and plastic window frames are also considered part of the combustible loading, adding an additional 130 kg (287 lb.) of combustible material. Therefore, the total mass of combustible material in each living room was 440 kg (970 lb.).

In the sprinklered test, the items that sustained fire damage included the recliner, loveseat, magazine rack, carpet, and carpet padding. The initial and final mass of each of these items is listed in Table 17. The final mass of the magazine rack, carpet, and carpet padding was not recorded; however, based on the post test images, it is assumed that 80% of the magazine rack was consumed in the fire, and a 457 mm x 457 mm (1.5 ft. by 1.5 ft.) area, or 0.75%, of carpet and carpet padding was damaged in the fire.

Table 17: Mass of Combustibles Consumed in Sprinklered Test

Item	Initial Weight kg (lb.)	Final Weight kg (lb.)	Mass Consumed kg (lb.)
Big Easy Recliner	44.5 (98.1)	40.8 (90)	3.7 (8.1)
Kick Back Loveseat	56.9 (125.5)	49.9 (110)	7.0 (15.4)
Carpet + Carpet Padding	94.0 (207)	93.3 (205.7)	0.7 (1.3)
Magazine Rack	1.7 (3.75)	0.34 (0.75)	1.4 (3.0)
Total	**197.1 (434.5)**	**184.3 (406.4)**	**12.8 (28.5)**

Based on the values listed in Table 17, and the initial weight of all the combustibles in the room, the fraction of material burned in the sprinklered test was 3.0%.

In the non-sprinklered test, following the fire extinguishment, none of the items within the room were recognizable and the final mass of individual items could not be determined directly. The mass of materials consumed is, therefore, estimated based on the total energy released and an assumption for the chemical heat of combustion. In Section 3.3, the total energy released from the fire was calculated to be 5,169 MJ. Using the chemical heat of combustion for pine, i.e., 12,400 kJ/kg, as the lower bound and that of flexible polyurethane foam, i.e., 19,000 kJ/kg, as the upper bound, it is calculated that the mass of material consumed in the fire was between 272 kg (600 lb.) and 417 kg (919 lb.), or 62% to 95% of the total room fuel load. For the fire scenario used in this study, in an actual home, the fire would likely have propagated to adjacent rooms increasing the mass of materials damaged.

The increased fire damage, in the non-sprinklered test, will have a direct impact on a building's sustainability via the embodied carbon associated with materials necessary for reconstruction. As stated previously, Norman *et al.* [24] estimated that the average equivalent annual embodied greenhouse gases per unit area for construction materials associated with residential dwellings is $7.4\ kg_{CO_2} / \left(m^2 - year\right)$. Estimates of the embodied carbon associated with furnishings, contents, and carpet are beyond the scope of this study.

4.4 POTENTIAL ENVIRONMENTAL IMPACTS OF WASTEWATER RUNOFF

The following results and discussion related to the wastewater analysis have been extracted directly from Reference 38. The section and table numbering of the original report have been maintained.

4.3 POTENTIAL ENVIRONMENTAL IMPACTS OF FIRE WATER RUNOFF

Fire water runoff carries with it numerous contaminants and solids that may enter soil, groundwater, or a waterbody and potentially pose a health risk or cause ecological harm. There are numerous examples of large industrial fires where fire fighting water runoff resulted in both short- and long-term devastating environmental impacts, such as fish kills [41]. However, even relatively small-scale fires have the potential to affect the local environment as a result of wastewater runoff[‡‡]*.*

During and after fire-fighting activities, there are several major pathways that the resultant fire wastewater can take to enter the environment:

- *Runoff can enter soil, where contaminants in the runoff may adsorb onto soil particles;*
- *Contaminants bound to soil may eventually leach into groundwater;*
- *Runoff may directly discharge into a nearby pond, wetland, or stream; and*
- *Runoff can enter a stormwater system and eventually discharge into a waterbody.*

Both human and ecological receptors may then contact contaminants adsorbed to soils, may ingest or contact contaminated groundwater or surface water, or may ingest contaminants that have accumulated in food items such as home-grown produce or fish. Pollutant loading to the environment will be directly influenced by the volume of water generated from fire fighting activities and associated wastewater runoff. By reducing the volume of fire wastewater, the potential hazard to the environment may be reduced.

To evaluate the difference in pollutant loading and associated environmental hazards between the Sprinkler and No Sprinkler controlled burns, wastewater results generated from the controlled burns conducted on October 1, 2009 were compared to two types of federal water quality standards: Maximum Contaminant Levels (MCLs) and National Recommended Water Quality Criteria (WQC). Although MCLs and WQC are not directly applicable to wastewater, these criteria can be used as tools to assess potential environmental impacts that may be associated with fire wastewater runoff.

MCLs (USEPA 2006) are criteria applicable to ground and surface waters and are relevant to all potable water supplies (both surface and ground) in the United States. MCLs are not available for each constituent detected in the wastewater samples; in such instances, wastewater

[‡‡] Air and particulate emissions from fires are also significant pathways with respect to potential environment impacts; however, this section evaluates only the wastewater pathway. Air emissions from the controlled burn scenarios are discussed in Section 3 of this report.

data lacking MCLs were compared to USEPA Secondary Drinking Water Standards, Action Levels or Health Advisories, when available. These drinking water standards are generally designed to be protective of human health. Note that drinking water standards are not available for several of the detected organic constituents or general chemistry parameters. Drinking water standards are presented on Table 4-4.

WQC (USEPA 2009) are numeric limits on the amounts of chemicals that can be present in a river, lake, wetland, or stream and are designed to be protective of both human health and aquatic life. Altogether, there are six separate sets of WQC. Those protective of human health are applicable to waters that can be used as not only a source of potable water but also for fish or shellfish consumption. There are separate human health criteria for potable and non-potable waters. The "water + organism" WQC (for potable water supplies) are equivalent to or lower (i.e., more conservative) than the "organism only" WQC (for non-potable waters). Aquatic life WQC are available for fresh water and saltwater environments, as well as short- and long-term exposures. Of the aquatic life WQC, the Criterion Maximum Concentration (CMC) represents acute exposures in water, whereas the Criterion Continuous Concentration (CCC) represents chronic exposures. For a single fire event, CMCs are most relevant, since the discharge of fire wastewater to a waterway is expected to be a one-time event that occurs for a relatively short duration. Note that WQC are not available for the detected organic constituents and several of the general chemistry parameters. Water quality criteria are presented on Table 4-5.

For purposes of this evaluation, the net concentrations of constituents detected in the controlled burns conducted on October 1, 2009 were compared to these standards. As discussed, these standards are not applicable to wastewater, and this comparison is intended to be used only as a means to assess the relative impact to water quality of both types of controlled burns. The net concentrations in the wastewater represent a worst-case estimate of ground or surface water contamination. Under a more typical scenario, one would expect that only a portion of the total fire wastewater volume would percolate through the ground into an underlying aquifer or migrate overland and discharge into a waterbody. In all likelihood, the concentrations of pollutants in wastewater could be substantially reduced by the time the wastewater enters the receiving waterbody, or the volume of wastewater may never reach a waterbody.

Because there are a variety of environmental factors (such as soil type, volume of the receiving waterbody, depth to groundwater etc.) that could affect the extent of dilution of wastewater into either surface water or a groundwater aquifer, Woodard & Curran applied a generic ten-fold dilution factor to the net wastewater concentrations of constituents in order to estimate hypothetical surface or groundwater concentrations. This generic dilution factor represents the assumption that a ten-fold dilution of the levels of contaminants in wastewater would occur once the wastewater enters a receiving waterbody and is likely conservative for most situations where wastewater would percolate directly into the ground or discharge into a waterbody containing a relatively high volume of water. (Note that many states [e.g., Massachusetts, Connecticut] also use a generic 10-fold dilution factor to derive groundwater contaminant standards that are protective of groundwater migration to surface water bodies.) For smaller streams or wetlands, however, the ten-fold dilution factor may not necessarily be conservative. Estimated surface/groundwater concentrations were compared to drinking water standards and WQC, as shown on Tables 4-4 and 4-5, respectively.

Table 4-4: Comparison of Wastewater Results to USEPA Drinking Water Standards and Guidelines

Parameter	Units	Drinking Water Standard or Guideline		Analytical Results, 10/1/09					
				Sprinkler			No Sprinkler		
				WW-1		Diluted Concentration[1]	WW-2		Diluted Concentration[1]
		Value	Basis	Result		Estimated	Result		Estimated
General Chemistry									
pH	SU	6.5-8.5	SDWR	7.9		7.9	***12.1***		***12.1***
Specific Conductance	umhos/cm			100		10	5,100		510
Solids, Total Dissolved	ug/l	500,000	SDWR	100,000		10,000	***4,300,000***		430,000
Solids, Total Suspended	ug/l			36,000		3,600	640,000		64,000
Cyanide, Total	ug/l	200	MCL (free CN-)	***639***		63.9	55		5.5
Nitrogen, Ammonia	ug/l	30,000	Lifetime HA	1,470		147	4,850		485
Nitrogen, Nitrate	ug/l	10,000	MCL	130		13	440		44
Phosphorus, Total	ug/l			484		48.4	385		38.5
Chemical Oxygen Demand	ug/l			260,000		26,000	650,000		65,000
Total Organic Carbon	ug/l			56,000		5,600	136,000		13,600
Volatile Organic Compounds									
Benzene	ug/l	5	MCL	***62***		***6.2***	***50***	U	
Styrene	ug/l	100	MCL	50	U		63		6.3
Semivolatile Organic Compounds									
Phenol	ug/l	2,000	MCL	280	U		370		37
2-Methylphenol	ug/l			240	U		180		18
3-Methylphenol/ 4-Methylphenol	ug/l			240	U		290		29
Total Metals									
Antimony, Total	ug/l	6	MCL	***50***	U		***272***		***27.2***
Arsenic, Total	ug/l	10	MCL	5	U		7		0.7
Chromium, Total	ug/l	100	MCL	10	U		10		1
Copper, Total	ug/l	1,300	MCLG	21		2.1	6		0.6
Lead, Total	ug/l	15	Action Level	2		0.2	***18***		1.8
Mercury, Total	ug/l	2	MCL	***2.5***		0.25	0.8		0.08
Silver, Total	ug/l	100	SDWR	0.8	U		1.8		0.18
Zinc, Total	ug/l	5,000 / 2,000	SDWR/ Lifetime HA	172		17.2	185		18.5
Dissolved Metals									
Antimony, Dissolved	ug/l	6		***50***	U		***150***		***15***
Copper, Dissolved	ug/l	1,300	Action Level	30		3	10	U	
Mercury, Dissolved	ug/l	2		1.1		0.11	0.6		0.06
Zinc, Dissolved	ug/l	5,000	SDWR	54		5.4	50	U	

Notes:

U	= Constituent not detected at laboratory reporting limit	MCL	= Maximum Contaminant Level
ug/L	= micrograms per liter	MCLG	= Maximum Contaminant Level Goal
SU	= standard units	SDWR	= Safe Drinking Water Regulation
umhos/cm	= micromhos per centimeter	HA	= Health Advisory
Free CN-	The MCL is available for free cyanide. Results are available for total cyanide.	THM	= Total trihalomethanes (chloroform, bromoform, bromodichloromethane)

(1) Estimated surface or groundwater concentration based on wastewater analytical results, adjusted to account for baseline contamination from firefighting water. Estimated concentration assumes wastewater is diluted to one-tenth of the original concentration. pH level of sample was not adjusted.

Bold italicized font indicates that concentration or detection limit exceeds the drinking water standard or guideline.

(2) Results are presented for only the constituents detected at levels higher than those of the recycled firefighting water sample.

Table 4-5: Comparison of Wastewater Results to Federal Water Quality Criteria

Parameter	Units	National Recommended Water Quality Criteria: Aquatic Life Criteria, Freshwater CMC	Freshwater CCC	Saltwater CMC	Saltwater CCC	Human Health Criteria: Water + Organism	Organism Only	Analytical Results, 10/1/09: Sprinkler, WW-1 Concentration Result	Sprinkler, Diluted Concentration[5] Estimated	No Sprinkler, WW-2 Concentration Result	No Sprinkler, Diluted Concentration[5] Estimated
General Chemistry											
pH	SU		6.5-9		6.5-8.5	5-9		7.9	7.9	***12.1***	***12.1***
Specific Conductance	umhos/cm							100	10	5,100	510
Solids, Total Dissolved	ug/l					250,000		***100,000***	10,000	***4,300,000***	***430,000***
Solids, Total Suspended	ug/l							36,000	3,600	640,000	64,000
Cyanide, Total [1]	ug/l	22	5.2	1	1	140	140	***639***	***63.9***	***55***	***5.5***
Nitrogen, Ammonia	ug/l		100(4)					***1,470***	***147***	***4,850***	***485***
Nitrogen, Nitrate	ug/l		100(4)			10,000		***130***	13	***440***	44
Phosphorus, Total	ug/l		8(4)					***484***	***48.4***	***385***	***38.5***
Chemical Oxygen Demand	ug/l							260,000	26,000	650,000	65,000
Total Organic Carbon	ug/l							56,000	5,600	136,000	13,600
Volatile Organic Compounds											
Benzene	ug/l					2.2	51	***62***	***6.2***	***50*** U	
Styrene	ug/l							50 U		63	6.3
Semivolatile Organic Compounds											
Phenol	ug/l					10,000	860,000	280 U		370	37
2-Methylphenol	ug/l							240 U		180	18
3-Methylphenol/ 4-Methylphenol	ug/l							240 U		290	29
Total Metals[2]											
Antimony, Total	ug/l					5.6	640	***50*** U		***272***	***27.2***
Arsenic, Total	ug/l	340	150	69	36	0.018	0.14	***5*** U		***7***	***0.7***
Chromium, Total[3]	ug/l	16	11	1,100	50			10 U		10	1
Copper, Total	ug/l	13	9	4.8	3.1	1,300		***21***	2.1	***6***	0.6
Lead, Total	ug/l	65	2.5	210	8.1			2	0.2	***18***	1.8
Mercury, Total	ug/l	1.4	0.77	1.8	0.94			***2.5***	0.25	***0.8***	0.08
Silver, Total	ug/l	3.2		1.9				0.8 U		1.8	0.18
Zinc, Total	ug/l	120	120	90	81	7,400	26,000	***172***	17.2	***185***	18.5
Dissolved Metals											
Antimony, Dissolved	ug/l					5.6	640	***50*** U		***150***	***15***
Copper, Dissolved	ug/l	13	9	4.8	3.1	1,300		***30***	3	***10*** U	
Mercury, Dissolved	ug/l	1.4	0.77	1.8	0.94			***1.1***	0.11	0.6	0.06
Zinc, Dissolved	ug/l	120	120	90	81	7,400	26,000	54	5.4	50 U	

Notes:

U	= Constituent not detected at laboratory reporting limit
ug/L	= micrograms per liter
SU	= standard units
umhos/cm	= micromhos per centimeter
CMC	= No CCC available. Value is the Criterion Maximum Concentration
Free CN-	= Cyanide (CN-) criteria are available for free, or bioavailable, cyanide. Wastewater results are reported for total cyanide. Total cyanide concentrations are not necessarily indicative of free cyanide concentrations.

(1) Value is for free (physiologically available) cyanide. Note that wastewater samples were analyzed for total cyanide.
(2) Aquatic life criteria are expressed in terms of dissolved metals. Many of the metals criteria are also dependent on water hardness and/or other chemical properties of the waterbody. The values presented on this table are those reported in the EPA 2009 criteria document and have not been adjusted.
(3) Criteria are presented for hexavalent chromium, the more toxic form of chromium. Note that wastewater samples were analyzed for total chromium.
(4) EPA Ecoregional criteria. Values are the lowest ecoregional criteria for rivers, streams, lakes and reservoirs. Nitrate value is for total nitrogen.
(5) Estimated surface or groundwater concentration based on wastewater analytical results, adjusted to account for baseline contamination from firefighting water. Estimated concentration assumes wastewater is diluted to one-tenth of the original concentration. pH level of sample was not adjusted.
Bold italicized font indicates that concentration or detection limit exceeds the drinking water standard or guideline.
(6) Results are presented for only the constituents detected at levels higher than those of the recycled firefighting water sample.

Comparison to Drinking Water Standards

For this evaluation, wastewater net concentrations based on the October 1, 2009 results were compared to Federal drinking water standards and guidelines (i.e., MCLs and Health Advisories; USEPA 2006), assuming that ground- or surface water at a site could be used as a potential source of potable water. Drinking water standards and guidelines are presented in Table 4-4.

Under a worst-case scenario, where all of the wastewater from a fire runs off or percolates into a potable water source and assuming that there is no decrease in the concentration of contaminants (i.e., the drinking water source would contain 100% of the initial concentration of a contaminant present in the wastewater), the resultant concentrations of numerous contaminants could exceed drinking water standards for both Sprinkler and No Sprinkler *controlled burns, suggesting that wastewater could potentially pose a health risk to users of an impacted water supply. Under a more realistic scenario, assuming that a 10-fold dilution of contaminant concentrations in wastewater would occur once wastewater enters a drinking water supply, fewer constituents exceed the MCLs. The following table summarizes the parameters and constituents that exceed MCLs for each controlled burn.*

Table 4-6: Constituents in Wastewater Exceeding Federal Drinking Water Standards

Sprinkler Controlled Burn	No Sprinkler Controlled Burn
Benzene	pH Antimony

This comparison indicates that different classes of pollutants in wastewater generated from a fire in a structure may potentially be present at levels exceeding Federal drinking water standards.

Comparison to Water Quality Criteria

Detected concentrations and diluted concentrations of constituents in each wastewater sample were compared to WQC, as shown on Table 4-5. Exceedances are summarized in the following table for each controlled burn.

Table 4-7: Constituents in Wastewater Exceeding Federal Water Quality Criteria

Sprinkler Controlled Burn	No Sprinkler Controlled Burn
Total cyanide Nitrogen (ammonia) Phosphorous Benzene	pH Total dissolved solids Total cyanide Nitrogen (ammonia) Phosphorous Antimony Arsenic

As indicated above, more constituents detected in the No Sprinkler controlled burn sample (in particular, heavy metals) exceed WQC compared to the Sprinkler controlled burn sample. Again, assuming that a 10-fold dilution of pollutant concentrations would occur once the wastewater entered a waterbody, several constituents remain at levels exceeding WQC in the No Sprinkler controlled burn, whereas fewer constituents under the Sprinkler controlled burn exceed WQC.

4.5 LANDFILL IMPACTS

In this section the environmental impact associated with disposing solid waste materials in a landfill is discussed[§§] in terms of total lifetime carbon dioxide emissions.

[§§] Evaluating the impact associated with alternative disposal such as recycling or energy recovery is beyond the scope of this project.

In the sprinklered test, only a small portion of the room furnishings was damaged. However, any fire damaged items would need to be replaced. The total mass of materials needing to be disposed of is 184.3 kg (406 lb.); the final mass of each of the items is listed in Table 17. Additional materials damaged due to smoke and water may need to be disposed of and replaced; however, assessment of this part of the damage would be very subjective and beyond the scope of this analysis.

In the non-sprinklered test, the mass of materials within the enclosure requiring disposal is assumed to be the remaining 5.3% to 38.2% of material, or 23.2 kg to 168 kg (51.1 lb. to 370.4 lb.), as discussed in Section 4.3. Although not included in this study, the extensive damage to the entire enclosure would require complete demolition increasing the landfill contribution.

Decomposition rates of furniture and furnishings in landfills, and the associated greenhouse gas emissions, are not readily available; however, estimates can be made based on data for wood and forest products. Micales and Skog [42] state that only "0-3% of the carbon from wood are ever emitted as landfill gas. The remaining carbon . . . remains in the landfill indefinitely." The methane yield for wood in a landfill is reported as 0.000 – 0.013 ${kg_{CH_4}}/{kg_{dry\ wood}}$. To determine the equivalent mass of CO_2 the value is multiplied by the GWP of methane. The resulting equivalent carbon dioxide generated by furniture and furnishings in landfills is 0.000 - 0.325 ${kg_{CO_2}}/{kg_{dry\ wood}}$.

The EPA reports that "as with other inorganic materials…there are zero landfill methane emissions, landfill carbon storage, or avoided utility emissions associated with landfilling carpet" [43]. In other words, carpet in landfills does not contribute to greenhouse gas emissions and can be omitted from this analysis.

The amounts of materials disposed of in a landfill from the sprinklered and non-sprinklered test, based on the analysis in Section 4.3, are listed in Table 18. For the sprinklered test the mass of materials is divided into carpet and furniture. Since the carpet does not contribute to the landfill emissions, the total equivalent carbon dioxide emission of 33.5 kg (74 lb.) is based solely on the quantity of wood products. For the non-sprinklered test, due to the excessive damage, the mass of materials could not be separated. As such, the total equivalent carbon dioxide emission of 7.5 - 54.6 kg (16.5 - 120.4 lb.) is based on the total mass of disposed materials.

Table 18: Mass and Carbon Dioxide Emissions from Damaged Materials in a Landfill

	Mass of Materials [kg (lb.)]		Carbon Dioxide Emissions [kg (lb.)]	
	Carpet	Wood Products	Carpet	Wood Products
Sprinklered	94.0 (207)	103.1 (227.3)	0	33.5 (74)
Non-Sprinklered	---	23.2 – 168 (51.1 - 370.4)	---	7.5 – 54.6 (16.5 – 120.4)

The values presented represent a conservative estimate of the impact of a non-sprinklered fire on landfill greenhouse gas emissions. As noted previously, there was extensive damage to the entire enclosure in the non-sprinklered test that would require complete demolition and add to the mass of material sent to a landfill. Furthermore, if additional rooms had been present, the fire would have propagated and additional materials would have required disposal in a landfill.

4.6 ROOM TENABILITY

Although not the main focus of this project, a brief analysis on the tenability within the sprinklered and non-sprinklered rooms will be provided in this section.

Fires generate a variety of toxic gases that have a synergistic physiological effect on humans; however, carbon monoxide inhalation is considered the key factor in fire fatalities. The physiological effects from carbon monoxide exposure range from headaches to death depending on the level of carbon monoxide exposure and the duration; some examples are provided in Table 19 [44]. In addition to the maximum concentrations, Reference 45 states that a time integrated exposure of 43,000 ppm-minutes will result in incapacitation, while 120,000 ppm-minutes is lethal.

Table 19: Physiological Effects of Carbon Monoxide Exposure and the Times Critical Levels Were Reached in the Sprinklered and Non-Sprinklered Tests

Level of CO (ppm)	Physiological Effects	Non-Sprinklered (s)	Sprinklered (s)
0	Normal, fresh air	0	0
100	Slight headache after 1-2 hours	157	179
200	Possible mild headache after 2-3 hours	167	334
400	Headache and nausea after 1-2 hours	238	NA
800	Headache, nausea, and dizziness after 45 minutes; collapse and possible unconsciousness after 2 hours	246	NA
1,000	Loss of consciousness after 1 hour	247	NA
1,600	Headache, nausea, and dizziness after 20 minutes	249	NA
3,200	Headache and dizziness after 5-10 minutes; unconsciousness after 30 minutes	254	NA
6,400	Headache and dizziness after 1-2 minutes; unconsciousness and danger of death after 10-15 minutes	261	NA
12,800	Immediate physiological effects; unconsciousness and danger of death after 1-3 minutes	272	NA

Elevated temperatures can also impact survivability. Purser states that "a victim exposed for more than a few minutes to high temperatures and heat fluxes (exceeding 120°C) in a fire is likely to suffer burns and die either during or immediately after exposure, due principally to hyperthermia" [46].

For the sake of this analysis, tenability within the rooms will be assessed based on the following three criteria measured at the 1.5 m (5 ft.) elevation within the center of the room:

- Maximum carbon monoxide level
- Time integrated carbon monoxide exposure
- Air temperature

The measured carbon monoxide levels at a 1.5 m (5 ft.) elevation in the center of the room are shown in Figure 32 and Figure 33, for the sprinklered and non-sprinklered rooms respectively.

In addition to the time resolved carbon monoxide concentrations, the integrated carbon monoxide is also plotted for each test.

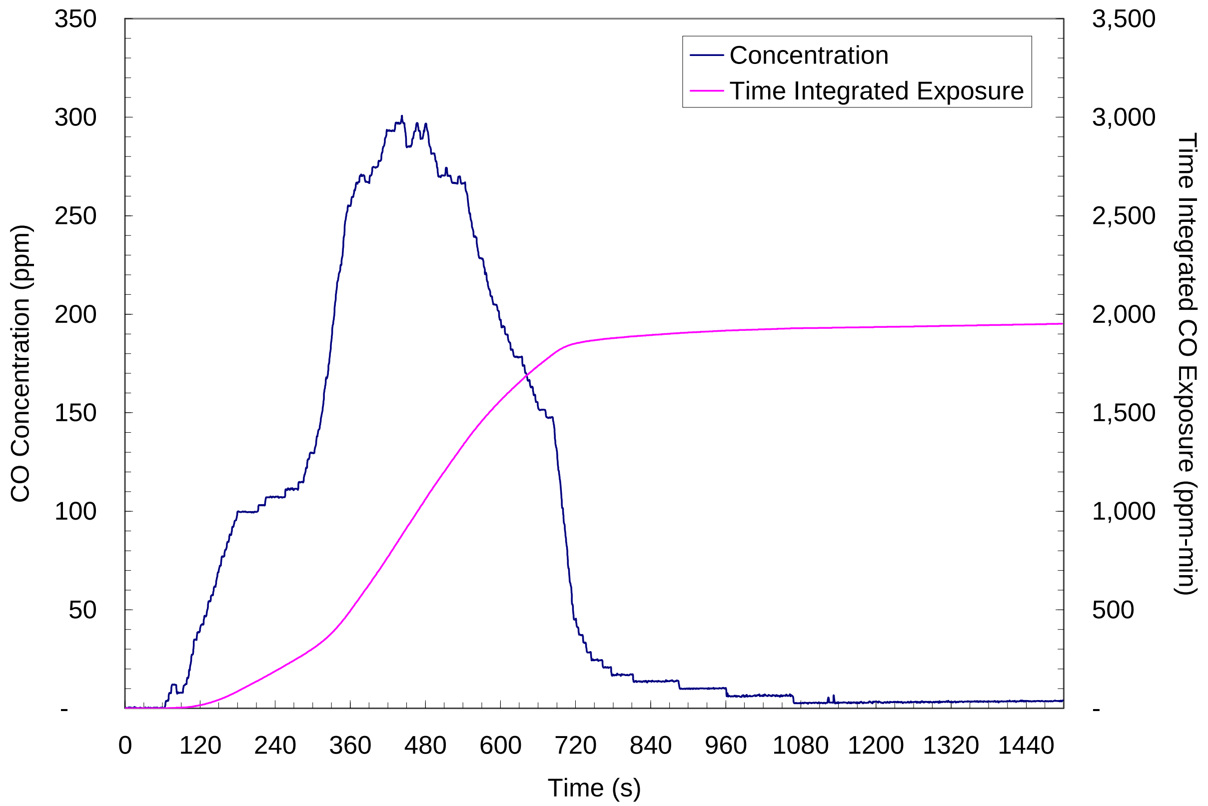

Figure 32: Carbon monoxide concentrations and integrated values as a function of time for the sprinklered test.

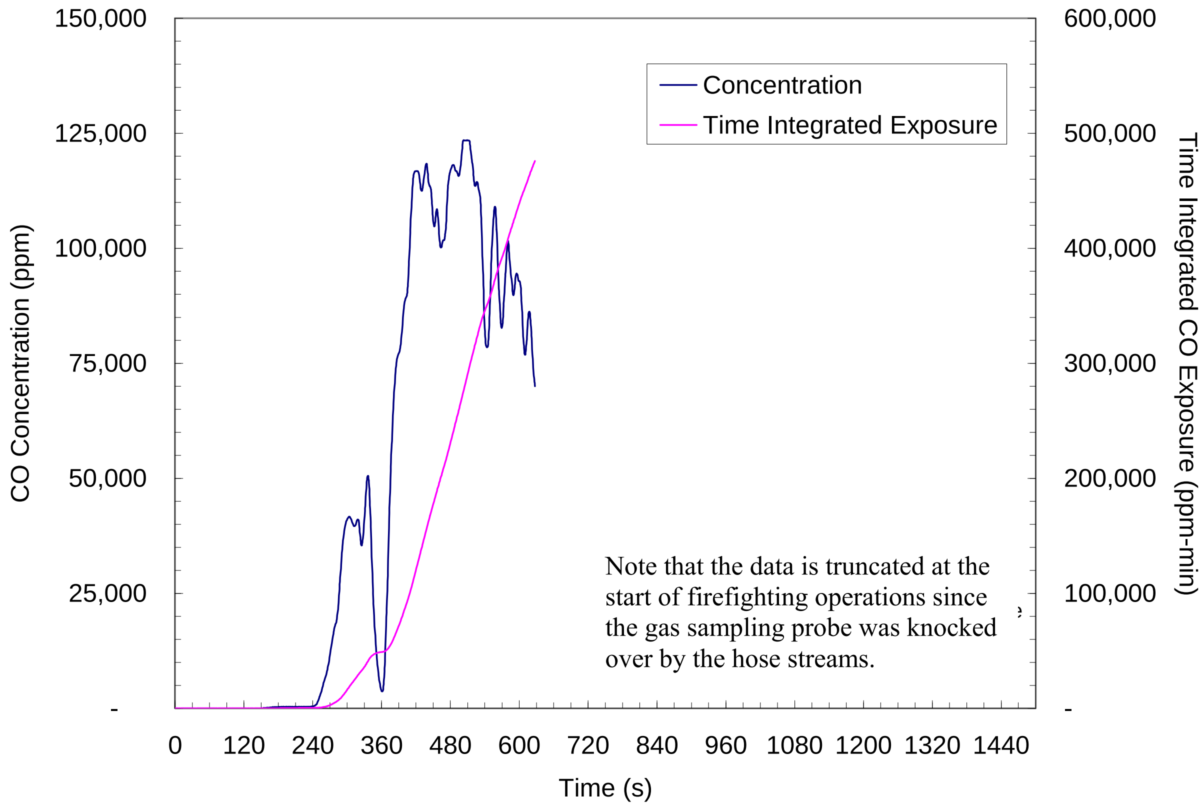

Figure 33: Carbon monoxide concentrations and integrated values as a function of time for the non-sprinklered test.

In the non-sprinklered test the maximum carbon monoxide concentration was in excess of 12% (120,000), an order of magnitude greater than that associated with immediate physiological effects and death. Conversely, in the sprinklered test the maximum carbon monoxide level was 300 ppm, which, based on the data in Table 19, would result in a headache and possibly nausea after one to three hours of exposure.

The integrated carbon monoxide levels in the sprinklered test did not reach either the incapacitation or lethal levels. The maximum value was 1,952 ppm-minutes, more than 20 times lower than the value associated with incapacitation. In the non-sprinklered test, the incapacitation level of 43,000 ppm-minutes was reached 339 seconds after ignition, while the lethal level of 120,000 ppm-minutes was reached 420 seconds after ignition.

The measured air temperatures at the 1.5 m (5 ft.) elevation in the center of the room as a function of time for the sprinklered and non-sprinklered tests are shown in Figure 34.

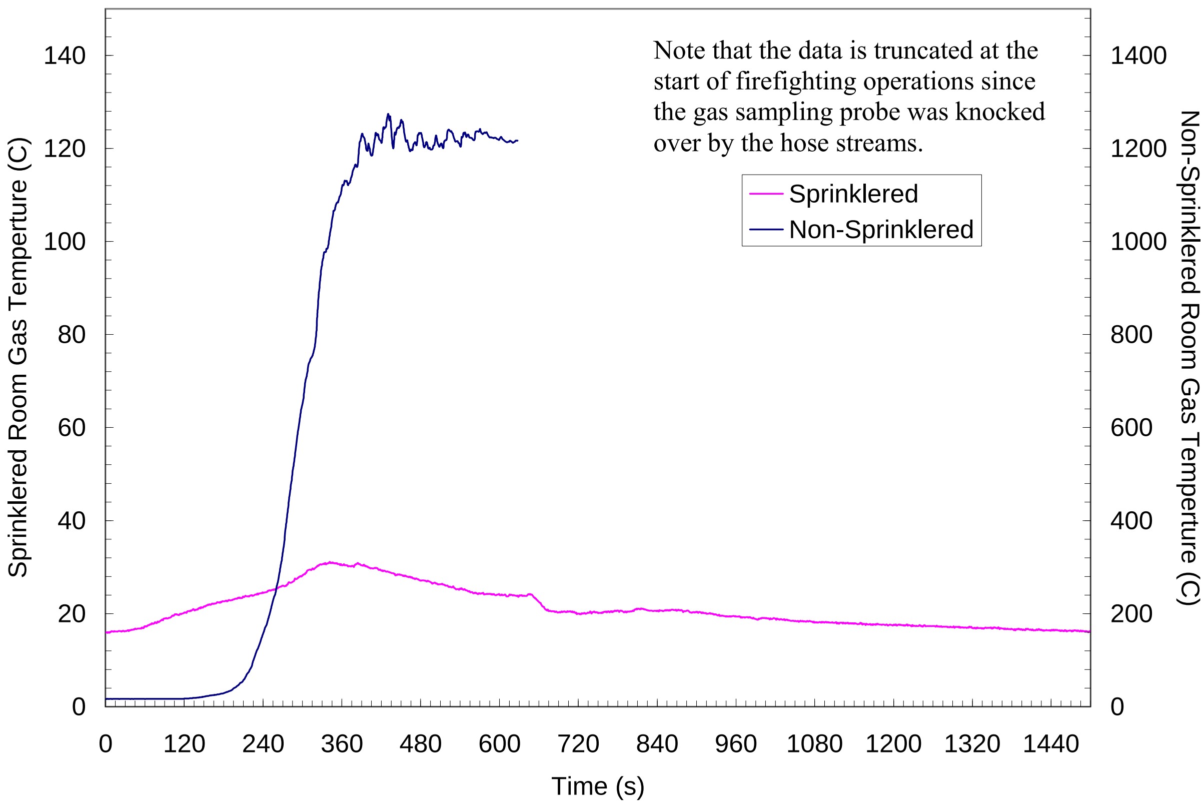

Figure 34: Air temperature as a function of time for the sprinklered and non-sprinklered test at 1.5 m (5 ft.) elevation within the center of the room.

In the non-sprinklered test the critical air temperature of 120°C (248°F) was reached at 230 seconds after ignition and reached a maximum level of 1274°C (2325°F). In the sprinklered test the maximum air temperature at the 1.5 m (5 ft.) elevation was 31°C (88°F).

The results clearly indicate that, in addition to the environmental benefits of using sprinklers, the use of sprinklers also results in maintaining safe, tenable conditions within the room.

5 CONCLUSIONS

The research presented in this report has demonstrated that automatic fire sprinklers protect the environment while further verifying that they reduce property damage and protect lives. The work included an analysis of the contribution of risk factors, such as fire, on the total lifecycle carbon emissions of a home and the reduction to that contribution achieved via the use of automatic fire sprinklers.

In support of the theoretical analysis, large-scale fire tests were conducted to quantify the reduction in the environmental impact via the use of sprinklers. Quantification of the environmental benefit achieved by using automatic fire sprinklers was based on comparisons of measurements between a sprinklered and non-sprinklered test and included total greenhouse gas production, quantity of water required to extinguish the fire, quality of water run-off, potential impact of wastewater runoff on groundwater and surface water, and mass of materials requiring disposal. Key conclusions from the experimental portion of the project are:

- In the event of a fire, the use of sprinklers reduces greenhouse gas emissions by 97.8%.
- In the event of a fire, the use of sprinklers reduces water usage between 50% and 91%.
- In the event of a fire, the use of sprinklers reduces fire damage.
- In the sprinklered test, flashover did not occur and the fire was contained to the room of origin.
- In the non-sprinklered test, flashover occurred prior to fire service intervention; therefore, additional materials would have been damaged, a greater mass of greenhouse gases would have been emitted, and additional materials would have been disposed of in a landfill.
- The total air emissions generated during the sprinklered test were significantly lower than the total air emissions generated during the non-sprinklered test.
- Of the 123 species of greenhouse gas and criteria pollutants, volatile and semi-volatile organic and inorganic compounds, heavy metals, and particulate matter analyzed, only 76 were detected in the air emissions in either the sprinklered or non-sprinklered tests.

- Of the 76 species detected, the ratio of non-sprinklered to sprinklered levels for 24 of the species was in excess of 10:1. Eleven were detected at a ratio in excess of 50:1, and of those six were detected at a ratio in excess of 100:1. The remaining species were detected at the same order of magnitude.
- Fewer persistent pollutants, such as heavy metals, and fewer solids were detected in the wastewater sample from the sprinklered test compared to those found in the non-sprinklered test.
- More constituents were detected in the non-sprinklered test that exceeded both federal drinking water standards and water quality standards than in the sprinklered test.
- The pH value of the non-sprinklered wastewater was between 11.6 and 12.1 versus the pH of 7.9 for the sprinklered test. Wastewater exhibiting pH values greater than 9.0 exceed the allowable discharge range of 5.5 to 9.0 required by environmental regulatory agencies. Wastewater exhibiting pH values greater than 10.0 represent a serious environmental concern.
- Wastewater generated from a fire in a structure not equipped with a sprinkler system may potentially have a greater impact on a water supply, due to the higher pollutant load that is carried with the wastewater stream.
- Analysis of the solid waste samples indicated that the ash/charred materials from neither the sprinklered nor the non-sprinklered test would be considered “hazardous waste,” and that the wastes are not anticipated to significantly leach once landfilled.

6 REFERENCES

1 Kung, H.-C., Spaulding, R. D., Hill, E. E., and Symonds, A. P., "Field Evaluation of Residential Prototype Sprinkler – Los Angeles Fire Test Program," Technical Report J.I. 0E0R3.RA(1), Factory Mutual Research Corporation, Norwood, MA, 1982.

2 Bill, Jr., R. G., Kung, H.-C., Anderson, S. K., and Ferron, R., "A New Test to Evaluate the Fire Performance of Residential Sprinklers," *Fire Technology*, 38, 101-124, 2002.

3 Bill, Jr., R. G., Kung, H.-C., Brown, W. R., Hill, Jr., E. E., and Spaulding, R. D., "Predicting the Suppression Capability of Quick Response Sprinklers in a Light Hazard Scenario, Part 1: Fire Growth and Required Delivered Density Measurements," *Journal of Fire Protection Engineering*, 3, 81-93, 1991.

4 NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes*, 1984 Edition, National Fire Protection Association, Quincy, MA.

5 FM Approvals Standard Class Number 2030, *Approval Standard for Residential Automatic Sprinklers for Fire Protection*, 1983 Edition, FM Approvals, Norwood, MA.

6 UL 1626, *Proposed First Edition of the Standard for Residential Sprinklers for Fire Protection Service*, 1986 Edition, Underwriters Laboratories, Northbrook, IL.

7 UL 1626, *Standard for Residential Sprinklers for Fire Protection Service*, 2008 Edition, Underwriters Laboratories, Northbrook, IL.

8 FM Approvals Standard Class Number 2030, *Approval Standard for Residential Automatic Sprinklers for Fire Protection*, 2009 Edition, FM Approvals, Norwood, MA.

9 NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes*, 2010 Edition, National Fire Protection Association, Quincy, MA.

10 FM Global Property Loss Prevention Data Sheet 2-5, *Installation Guidelines for Automatic Sprinklers in Residential Occupancies*, 2009 Edition, FM Global, Johnston, RI.

11 Madrzykowski, D., and Fleming, R. P., "Residential Sprinkler Systems," *Fire Protection Handbook*, 20th Edition, Vol. II, Section 16, Chapter 6, National Fire Protection Association, Quincy, MA, 2008.

12 U.S. Census Bureau, Current Housing Reports, Series H150/07, *American Housing Survey for the United States: 2007,* U.S. Government Printing Office, Washington, DC, 20401 (2008). http://www.census.gov/hhes/www/housing/ahs/ahs07/ahs07.html

13 Hall, Jr., J. R., "U.S. Experience with Sprinklers and Other Automatic Fire Extinguishment Equipment," NFPA Fire Analysis and Research Division, National Fire Protection Association, Quincy, MA, 2009.

14 Weatherby, S.,"Benefits of Residential Fire Sprinklers: Prince George's County 15-Year History with its Single-Family Residential Dwelling Fire Sprinkler Ordinance," Home Fire Sprinkler Coalition, August 2009.
http://www.firesprinklerinitiative.org/assets/files//PrinceGeorgesCountyReport.pdf

15 NFPA 1, *Fire Code*, 2006 Edition, National Fire Protection Association, Quincy, MA.

16 NFPA 101, *Life Safety Code*, 2006 Edition, National Fire Protection Association, Quincy, MA.

17 NFPA 5000, *Building Construction and Safety Code*, 2006 Edition, National Fire Protection Association, Quincy, MA.

18 Cade, G. B., "A Message from the U.S. Fire Administrator about Residential Sprinklers," United States Fire Administration, U.S. Dept. of Homeland Security, Emmetsburg, MD, March 28, 2008.

19 http://www.residentialfiresprinklers.com/blog/icc-approves-residential-fire-sprinklers-in-the-international-residential-code

20 Gritzo, L. A., Doerr, W., Bill, R., Ali, H., Nong, S., and Krasner, L., "The Influence of Risk Factors on Sustainable Development," FM Global, Johnston, RI, 2009. http://www.fmglobal.com/page.aspx?id=0401030,

21 U.S. Green Building Council, *Leadership in Energy and Environmental Design Brochure*, Washington, DC. http://www.usgbc.org

22 *U.S. EPA Climate Leaders Greenhouse Gas Inventory Protocol*, May 2005. http://www.epa.gov/statply/resourses/design.htlm

23 Brown, M., "The Residential Energy and Carbon Footprint of the 100 Larger U.S. Metropolitan Areas," Working Paper #39, Ivan Allen College, Georgia Tech, May 2008. http://smartech.gatech.edu/handle/1853/22228.

24 Norman, J., MacLean, H. L., and Kennedy, C. A., "Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions," *Journal of Urban Planning and Development*, Vol. 132, No. 1, March 2006.

25 U.S. Census Bureau, Current Housing Reports, Series H-150-99, *American Housing Survey National Tables: 1999,* U.S. Government Printing Office, Washington, DC.

http://www.census.gov/hhes/www/housing/ahs/ahs99/ahs99.html

26 U.S. Census Bureau, Current Housing Reports, Series H150/01, *American Housing Survey for the United States: 2001,* U.S. Government Printing Office, Washington, DC, 2002. http://www.census.gov/hhes/www/housing/ahs/ahs01_2000wts/ahs01_2000wts.html

27 U.S. Census Bureau, Current Housing Reports, Series H150/03, *American Housing Survey for the United States: 2003,* U.S. Government Printing Office, Washington, DC, 2004. http://www.census.gov/hhes/www/housing/ahs/ahs03/ahs03.html

28 U.S. Census Bureau, Current Housing Reports, Series H150/05, *American Housing Survey for the United States: 2005,* U.S. Government Printing Office, Washington, DC, 2006. http://www.census.gov/hhes/www/housing/ahs/ahs05/ahs05.html

29 "The U.S. Fire Problem," Fire Statistics, NFPA Fire Analysis and Research, National Fire Protection Association, Quincy, MA, 2009. http://www.nfpa.org/itemDetail.asp?categoryID=953&itemID=23858&URL=Research/Fire%20statistics/The%20U.S.%20fire%20problem

30 Davoodi, A., "Confinement of Fire," *Fire Protection Handbook*, 20th Edition, Vol. II, Section 18, Chapter 1, National Fire Protection Association, Quincy, MA, 2008.

31 Tewarson, A., "Generation of Heat and Chemical Compounds in Fires," *The SFPE Handbook of Fire Protection Engineering*, 3rd Edition, Section 3, Chapter 4, National Fire Protection Association, 2002, pg. 3-82 – 3-161.

32 http://chronicle.augusta.com/stories/2009/03/30/yrb_516386.shtml (accessed March 3, 2010)

33 NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, 2010 Edition, National Fire Protection Association, Quincy, MA.

34 NFPA 1720, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments*," 2010 Edition, National Fire Protection Association, Quincy, MA.

35 Brady/Prentice Hall Health. Essentials of Fire Fighting and Fire Department Operations. 5th edition. Oklahoma State University: Fire Protection Publications, 2008.

36 ISO/IEC 17025:2005, General Requirements for the Competence of Testing and Calibration Laboratories, 2005 Edition, International Standards Organization, Geneva, Switzerland.

37 Powell, J. H., "Test Burn Emissions Testing," Air Pollution Characterization and Control, LTD., Technical Report, December 2009.

38 "Air and Water Quality Impacts of Residential Fires from Controlled Burns," Woodard and Curran Technical Report prepared for FM Global, 222415, March 2010.

39 ISO/CD 13943, *Glossary of Fire Terms and Definitions*, 1996 Edition, International Standards Organization, Geneva, Switzerland.

40 Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, United Kingdom and New York, NY, USA, 2001.

41 Institute of Environmental Science and Research Limited (ESR), "The Ecotoxicity of Fire-Water Runoff. Part 1: Review of the Literature," New Zealand Fire Service Commission Research Report, No. 17, 2000.

42 Micales, J. A., and Skog, K. E., "The Decomposition of Forest Products in Landfills," *International Biodeterioration & Biodegradation*, Vol. 39, No. 2-3, 1997, pg. 145-158.

43 Environmental Protection Agency, "Background Document for Life-Cycle Greenhouse Gas Emission Factors for Carpet and Personal Computers," EPA530-R-03-018, November 21, 2003.

44 Black, A., "Carbon Monoxide Detection in Residential Occupancies," *Fire Protection Handbook*, 20th Edition, Vol. II, Section 14, Chapter 9, National Fire Protection Association, Quincy, MA, 2008.

45 Bill, R. G., and Kung, H.-C., "Evaluation of an Extended Coverage Sidewall Sprinkler and Smoke Detectors in a Hotel Occupancy," *Journal of Fire Protection Engineering*, Vol. 1, No. 3, 1989, pg. 77-98.

46 Purser, D. A., "Toxicity Assessment of Combustion Products," *The SFPE Handbook of Fire Protection Engineering*, 3rd Edition, Section 2, Chapter 6, National Fire Protection Association, 2002, pg. 2-83 – 2-171.

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NFPA RESEARCH

U.S. Experience with Sprinklers

July 2017

Marty Ahrens

Abstract

Sprinklers are a highly effective and reliable part of a building's fire protection system. National estimates of reported fires derived from the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS) and NFPA's annual fire department experience survey show that in 2010-2014 sprinklers were present in 10% of reported U.S. fires. The death rate per 1,000 reported fires was 87% lower in properties with sprinklers than in properties with no automatic extinguishing systems (AES). The civilian injury rate was 27% lower and the firefighter fireground injury rate per 1,000 fires was 67% lower in sprinklered properties than in fires in properties without AES.

In fires considered large enough to activate the sprinkler, sprinklers operated 92% of the time. Sprinklers were effective in controlling the fire in 96% of the fires in which they operated. Taken together, sprinklers both operated and were effective in 88% of the fires large enough to operate them. In three-fifths of the fires in which the sprinkler failed to operate, the system had been shut off.

This report provides information about the performance of sprinklers in general as well as wet pipe and dry pipe sprinklers. Estimates are provided of sprinkler performance in all fires, with additional details provided about fires in all homes. Properties under construction are excluded from these estimates.

Keywords: Fire suppression, sprinklers, fire statistics, sprinkler performance, home fires

Acknowledgements

The National Fire Protection Association thanks all the fire departments and state fire authorities who participate in the National Fire Incident Reporting System (NFIRS) and the annual NFPA fire experience survey. These firefighters are the original sources of the detailed data that make this analysis possible. Their contributions allow us to estimate the size of the fire problem.

We are also grateful to the U.S. Fire Administration for its work in developing, coordinating, and maintaining NFIRS.

To learn more about research at NFPA visit www.nfpa.org/research.

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FACT SHEET » RESEARCH

Sprinklers in Reported U.S. Fires during 2010 to 2014

Fire sprinklers can control a fire while the fire is still small. Some type of sprinkler was present in an estimated average of 49,840 (10%) reported structure fires during 2010 to 2014. Automatic extinguishing systems (AES) are designed to control fires until the fire department arrives. Sprinklers are a type of AES that uses water to control fires. Other types of AES use something other than water.

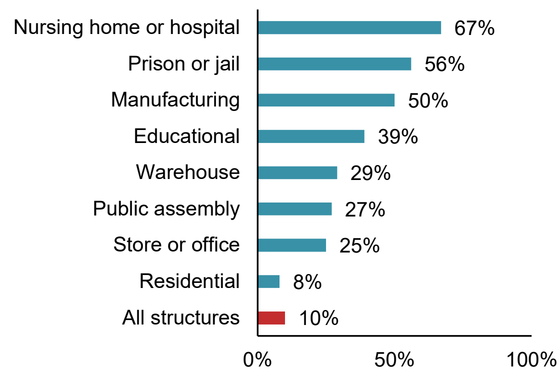
Sprinkler Presence

Sprinklers were most likely to be found in institutional occupancies such as nursing homes, hospitals, and prisons or jails.

Most structure fires and fire deaths occurred in residential properties, particularly homes, but only 8% of the reported residential fires were in properties with sprinklers.

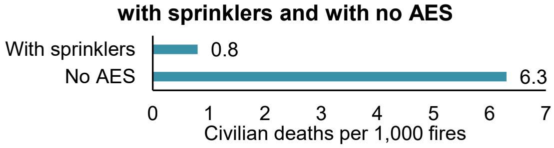
Wet pipe sprinklers accounted for 87% of the sprinklers in reported structure fires, dry pipe systems accounted for 10%, and other types of sprinklers accounted for 3%.

Presence of sprinklers in reported fires by occupancy



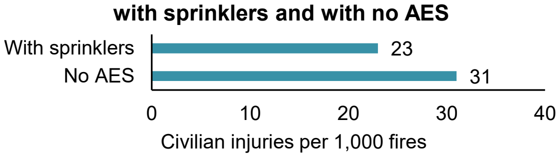
Impact of Sprinklers

Civilian death rates per 1,000 fires in properties with sprinklers and with no AES



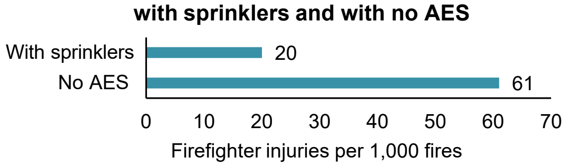
The civilian fire death rate of 0.8 per 1,000 reported fires was 87% lower in properties with sprinklers than in properties with no AES.

Civilian injury rates per 1,000 fires in properties with sprinklers and with no AES



The civilian injury rate of 23 per 1,000 reported fires was 27% lower in properties with sprinklers than in properties with no AES. Many injuries occurred in fires that were too small to activate the sprinkler or in the first moments of a fire before the sprinkler operated.

Firefighter injury rates per 1,000 fires in properties with sprinklers and with no AES



The average firefighter fireground injury rate of 20 per 1,000 reported fires was 67% lower where sprinklers were present than in fires with no AES.

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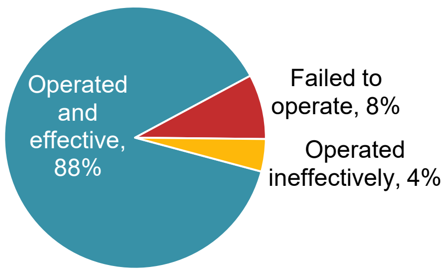
FACT SHEET » RESEARCH *(continued)*

Sprinkler Operation and Effectiveness

Sprinkler operation and effectiveness

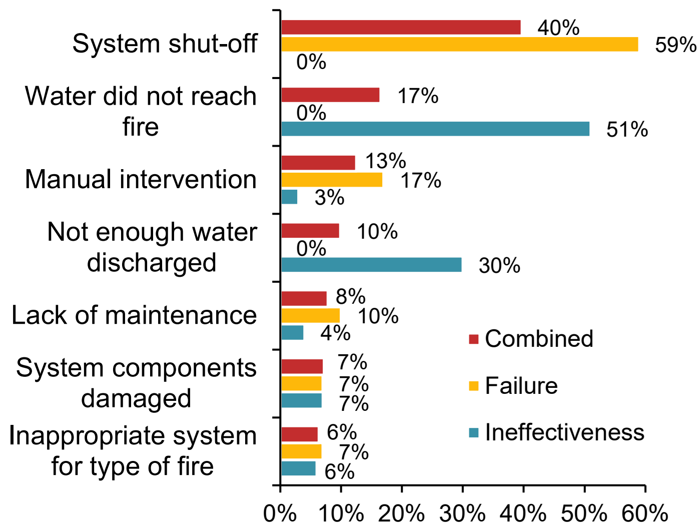


Sprinklers operated in 92% of the fires in which sprinklers were present and the fire was large enough to activate them.

- Sprinklers were effective at controlling the fire in 96% of fires in which they operated.
- Sprinklers operated effectively in 88% of the fires large enough to activate them.

Only one sprinkler head operated in four out of five (79%) fires in which sprinklers operated. In 97% of fires with operating sprinklers, five or fewer heads operated.

Reasons for combined sprinkler failure and ineffectiveness



Source: *U.S. Experience with Sprinklers,* National Fire Protection Association report, 2017.

Reported sprinkler failures (660 per year) were twice as common as reported fires in which sprinklers were ineffective and did not control the fire.

- 40% of the combined sprinkler problems were due to system shut-offs.
- In three of every five (59%) incidents in which sprinklers failed to operate, the system had been shut off.
- In half (51%) of the fires in which sprinklers were ineffective, the water did not reach the fire.

Source: NFPA Research: www.nfpa.org/research
Contact information: 617-984-7451 or research@nfpa.org

FACT SHEET » RESEARCH

Sprinklers in Reported U.S. Home Fires During 2010 to 2014

Some type of sprinkler was present in an estimated total of 24,440 (7%) reported home structure fires during 2010 to 2014. These fires caused an average of 35 (1%) civilian deaths, 616 (5%) civilian injuries, and $198 million (3%) in direct property damage per year. Homes include one- or two-family homes and apartments or other multi-family homes. Properties under construction were excluded from the analysis.

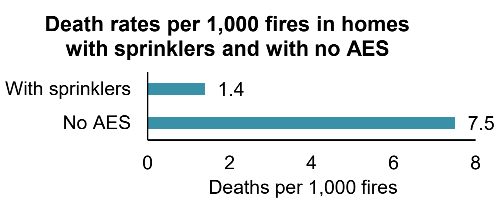
Sprinkler Presence

Automatic extinguishing systems (AES) are designed to control fires until the fire department arrives. Sprinklers are a type of AES that uses water to control fires. Other types of AES use something other than water.

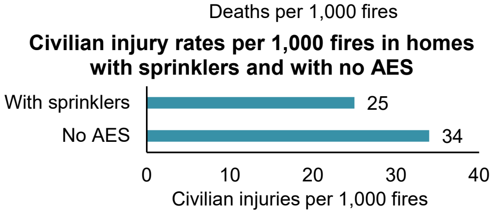
According to the 2011 American Housing Survey, 5% of all occupied housing units had sprinklers. Buildings with more housing units were more likely to have sprinklers. Almost one-third (31%) of units in buildings with 50 or more units were sprinklered.

Wet pipe sprinklers accounted for 89% of the sprinklers in reported home fires, dry pipe systems accounted for 9%, and other types of sprinklers accounted for 2%.

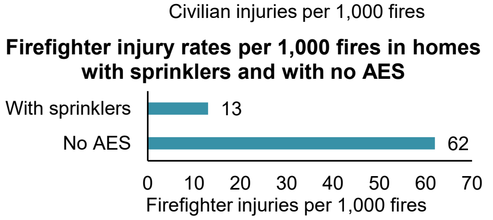
Impact of Sprinklers



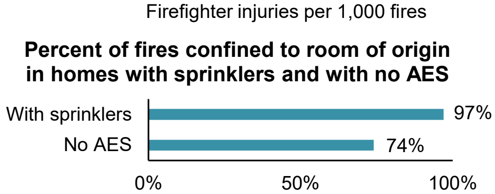
The civilian death rate of 1.4 per 1,000 reported fires was 81% lower in homes with sprinklers than in homes with no AES.



The civilian injury rate of 25 per 1,000 reported fires was 31% lower in homes with sprinklers than in homes with no AES. Many of the injuries occurred in fires that were too small to activate the sprinkler or in the first moments of a fire before the sprinkler operated.



The average firefighter injury rate of 13 per 1,000 reported home fires was 79% lower where sprinklers were present than in fires with no AES.

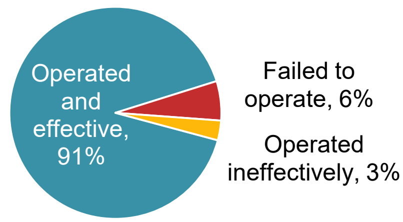


Where sprinklers were present, flame damage was confined to the room of origin in 97% of fires compared to 74% of fires without AES.

FACT SHEET » RESEARCH *(continued)*

Sprinkler Operation and Effectiveness

Sprinkler operation and effectiveness in home fires



Sprinklers operated in 94% of home fires in which sprinklers were present and the fire was considered large enough to activate them.

- They were effective at controlling the fire in 96% of fires in which they operated.
- Sprinklers operated effectively in 91% of the fires large enough to activate them.

Only one sprinkler head operated in 88% of home fires with operating sprinklers. In 98% of fires with operating sprinklers, five or fewer sprinkler heads operated.

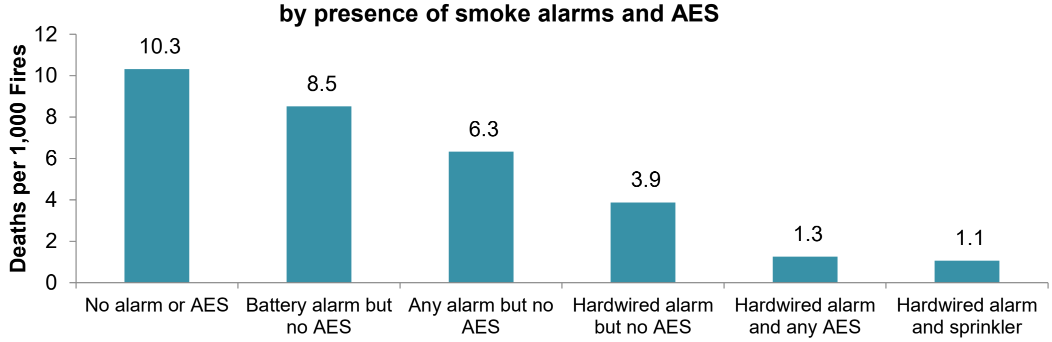
In three out of five (62%) of fires in which sprinklers failed to operate, the system was shut off.

Combined Impact of Smoke Alarms and Sprinklers

The lowest home fire death rate per 1,000 reported fires is found in homes with sprinkler systems and hardwired smoke alarms. Compared to reported home fires with no smoke alarms or AES, the death rate per 1,000 reported fires was as follows:

- 18% lower where battery-powered smoke alarms were present but AES were not
- 39% lower where smoke alarms with any power source were present but AES were not
- 62% lower where hardwired smoke alarms were present but AES were not
- 88% lower where hardwired smoke alarms and any AES were present
- 90% lower where sprinklers and hardwired smoke alarms were present

Average fire death rates per 1,000 reported home structure fires by presence of smoke alarms and AES



Source: *U.S. Experience with Sprinklers*, National Fire Protection Association report, 2017.

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U.S. Experience with Sprinklers

INTRODUCTION

Sprinklers play a critical role in fire protection. Information about sprinkler presence and performance in reported fires is essential to understanding the prevalence, impact, reliability and effectiveness of these systems, as well as avenues for performance improvement. This report provides a statistical overview of sprinkler presence and performance in reported fires. Because the majority of deaths are caused by home fires, additional details are provided on sprinklers in fires in homes.

METHODOLOGY

Estimates were derived from the details collected by the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and NFPA's annual fire department experience survey. NFIRS collects detailed incident-based information about causes and circumstances of fires from local fire departments. The coding structure is documented in the *National Fire Incident Reporting System Complete Reference Guide* [1]. Participation in NFIRS is voluntary at the federal level. Some states require fire departments to report all incidents or all fires, some have a loss threshold, and in other states, reporting is completely voluntary.

NFPA's annual Fire Experience Survey (FES) collects summary data from a sample of fire departments to calculate estimates of fires and associated losses by broad category. More details can be found in NFPA's report, *U.S. Fire Loss during 2015* and other reports in the series. [2]

To compensate for fires reported to local fire departments but not captured by NFIRS, fire and loss estimates from the FES are divided by comparable totals in NFIRS to develop multipliers. NFIRS data are scaled up by these multipliers. In most cases, unknown data are allocated proportionally. The basic approach was documented in a 1989 *Fire Technology* article by John Hall and Beatrice Harwood. [3]

Fires with one of the six NFIRS confined fire incident types are included in estimates of sprinkler presence, fire spread, and heads operating, but not of operation in general. NFIRS 5.0 includes six types of structure fires collectively referred to as "confined fires," identified by incident type codes 113-118. These include confined cooking fires, confined chimney or flue fires, confined trash fires, confined fuel burner or boiler fires, confined commercial compactor fires, and confined incinerator fires. Losses are generally minimal in these fires, which by definition, are assumed to have been limited to the object of origin. Although NFIRS rules do not require data about automatic extinguishing systems for these fires, local departments do sometimes provide it.

All estimates in this report exclude fires in properties under construction. Fires in which partial systems were present and fires in which sprinklers were present but failed to operate because they were not in the fire area were excluded from estimates related to presence and operation.

Casualty and loss estimates can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Property damage has not been adjusted for inflation. In most cases, fires are rounded to the nearest ten, civilian deaths and injuries are generally rounded to the nearest one, and direct property damage is rounded to the nearest million dollars. Less rounding is used when the numbers are smaller.

Appendix A has more details on how national estimates are calculated and Appendix B contains specific information about the NFIRS data elements.

Sprinklers in All Occupancies

SPRINKLER PRESENCE AND TYPE

Some type of sprinkler was present in an estimated average of 49,840 (10%) of reported structure fires during 2010-2014. Sprinkler presence varies widely by occupancy. Figure 1 shows the percentage of fires by occupancy in which any type of sprinkler was present. Sprinklers were most likely to be found in institutional occupancies, such as nursing homes, hospitals, and prisons or jails. Although the majority of structure fires, civilian fire deaths and injuries, and property damage occurred in residential properties, particularly homes, only 8% of the reported residential fires were in properties with sprinklers. Sprinklers in home fires are discussed in greater detail later in the report. High-rise buildings were much more likely to have sprinklers than were shorter structures. [4]

Figure 1. Presence of sprinklers in U.S. structure fires, by occupancy: 2010-2014

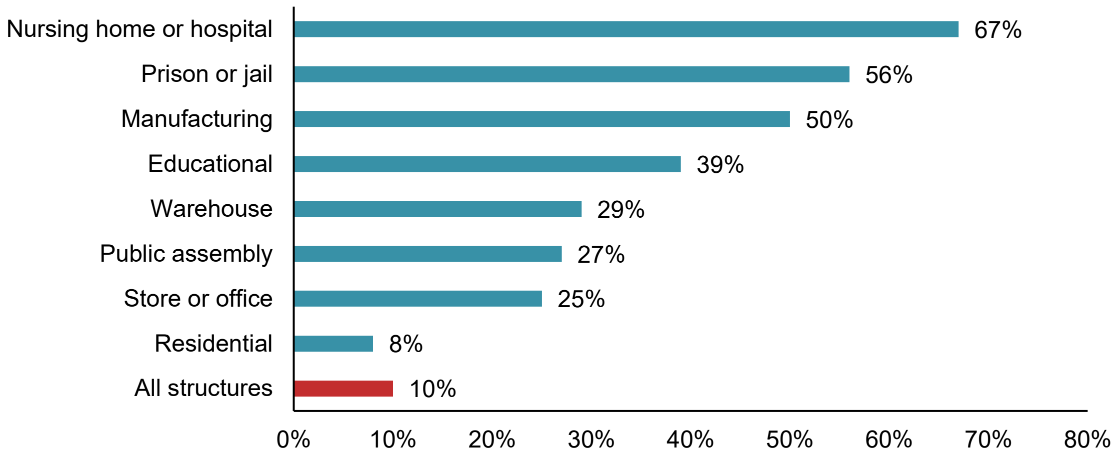


Table 1 provides information about more occupancies and shows estimates of automatic extinguishing system (AES) presence in 1980-1984 and 1994-1998 for historical context.[1] Table A summarizes information about AES in all reported structure fires *except those under construction*.

Table A.
Summary of AES presence and type in reported structure fires
2010-2014 annual averages

AES Presence of Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
AES present	**57,430**	**(12%)**	**45**	**(2%)**	**1,259**	**(9%)**	**$793**	**(8%)**
Sprinkler present	49,840	(10%)	42	(2%)	1,148	(8%)	$709	(7%)
Wet	*43,540*	*(9%)*	*39*	*(1%)*	*1,058*	*(7%)*	*$579*	*(6%)*
Dry	*4,770*	*(1%)*	*2*	*(0%)*	*69*	*(0%)*	*$120*	*(1%)*
Other	*1,530*	*(0%)*	*1*	*(0%)*	*21*	*(0%)*	*$10*	*(0%)*
Non-sprinkler AES present	7,590	(2%)	4	(0%)	110	(1%)	$84	(1%)
Partial system AES of any type	2,190	(0%)	5	(0%)	56	(0%)	$66	(1%)
AES of any type not in fire area and did not operate	1,630	(0%)	2	(0%)	47	(0%)	$75	(1%)
No AES present	**422,180**	**(87%)**	**2,659**	**(98%)**	**13,241**	**(91%)**	**$8,609**	**(90%)**
Total	**483,430**	**(100%)**	**2,711**	**(100%)**	**14,602**	**(100%)**	**$9,544**	**(100%)**

[1] Data about specific types of AES was first collected in NFIRS 5.0, introduced in 1999.

Wet pipe sprinklers accounted for 87% of the sprinklers in reported structure fires, dry pipe systems were in 10%, and other types of sprinklers were in 3%. See Figure 2.

Figure 2. Types of sprinklers found in U.S. structure fires: 2010-2014

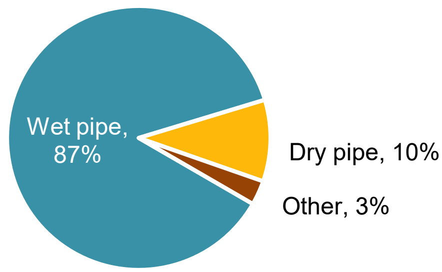
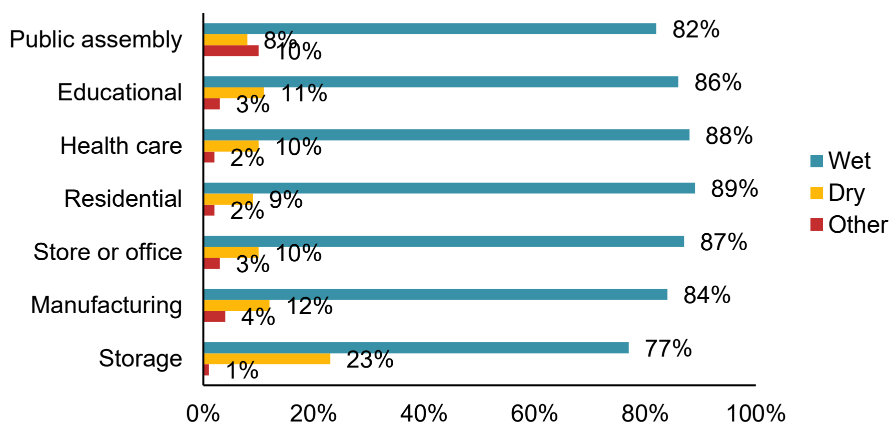


Figure 3 and Table 2 show that dry pipe sprinklers were more common in storage occupancies. "Other" sprinklers were seen most frequently in eating and drinking establishments. It is possible that some of these other sprinklers were actually miscodes of systems designed specifically for cooking equipment.

Figure 3. Sprinkler type by occupancy: 2010-2014

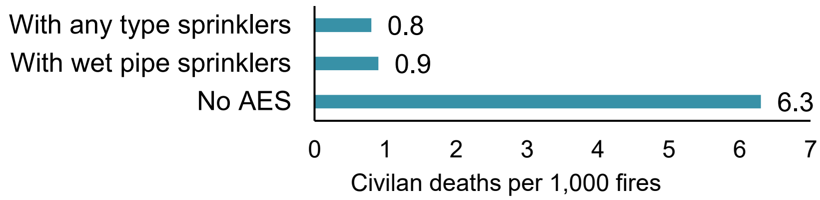


FIRES IN PROPERTIES WITH SPRINKLERS VS. NO AES

The death rate per 1,000 reported fires was 87% lower in properties with sprinklers than in properties with no AES. These rates are based strictly on reported presence or absence. Operation is not considered. Figure 4 shows that in reported structure fires with no automatic extinguishing systems (AES), the civilian death rate was 6.3 per 1,000 fires. When any type of sprinklers were present, the death rate was 0.8 per 1,000 fires. When wet pipe sprinklers were present, the death rate of 0.9 deaths per 1,000 fires was 86% lower than in home fires without AES. Table 3 shows these rates for all sprinklers and wet pipe sprinklers by occupancy. The smallest reduction (33%) was seen in manufacturing properties. Civilian deaths in sprinklered properties are discussed in greater detail later in this report.

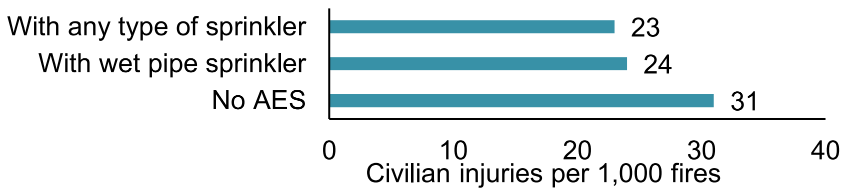
While the reduction in deaths was greater in some occupancies with wet pipe sprinklers than total sprinklers, the differences were small. With so few deaths in sprinklered properties, the differences are not meaningful.

Figure 4. Civilian death rates per 1,000 fires in properties with sprinklers and with no AES: 2010-2014



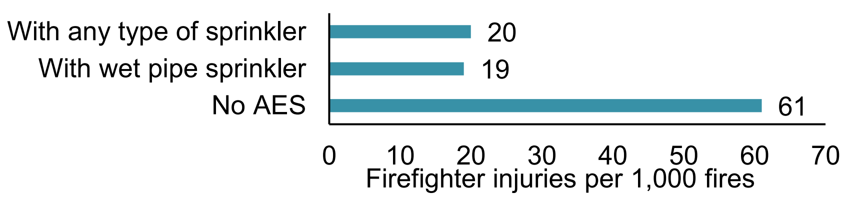
The civilian injury rate per 1,000 reported fires was 27% lower in properties with sprinklers than in properties with no AES. Figure 5 shows that when sprinklers of any type were present, reported civilian injuries averaged 23 per year, compared to 31 per year in which no AES was present. The injury rate in fires with wet pipe sprinklers was 24 per 1,000 fires or 22% lower than in fires with no AES. In more than half of these cases, the fire was too small to trigger the sprinkler. In others, someone was injured while trying to fight a fire in the initial moments before a sprinkler operated.

Figure 5. Civilian injury rates per 1,000 fires in properties with sprinklers and with no AES: 2010-2014



The average firefighter fireground injury rate per 1,000 reported fires was 67% lower when sprinklers were present than in fires with no AES. Figure 6 shows that when sprinklers of any type were present, 20 firefighters were injured per 1,000 fires, compared to 61 firefighter injuries per 1,000 fires in properties without AES protection. The 19 firefighter injuries per 1,000 fires in properties with wet pipe sprinklers was 68% lower than the rate in fires without AES.

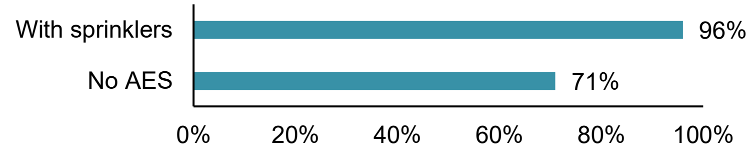
Figure 6. Firefighter injury rates per 1,000 fires in properties with sprinklers and with no AES 2010-2014



Reductions in average dollar loss per fire varied greatly by occupancy. Table 4 shows that compared to properties with no AES, the average overall loss was 30% lower when sprinklers of any type were present and 35% lower when wet pipe sprinklers were present. The average loss was actually higher in sprinklered warehouses than in those with no AES. The reduction in property loss in manufacturing properties ranged from 23% to 34%. Average losses were higher in warehouses and manufacturing than in other properties. A very small fire can damage expensive equipment. Warehouse contents may be rendered valueless by smoke. The reduction in average losses for public assembly and various residential occupancies ranged from 55% to 86%.

When sprinklers were present, fire spread was confined to the room of origin in 96% of fires compared to 71% of fires without AES. See Figure 7. Table 5 shows these percentages in different occupancies. In a change from previous editions of this report, fires with NFIRS incident types indicating confined structure fires (NFIRS incident type codes 113-118) were all considered to have been confined to the room of origin.

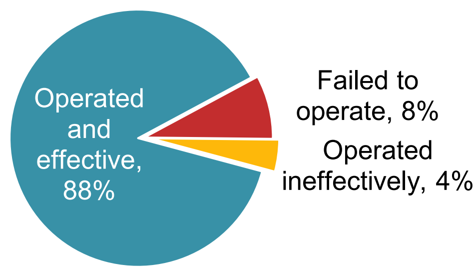
Figure 7. Percent of fires confined to room of origin in properties with sprinklers and with no AES 2010-2014



SPRINKLER OPERATION, EFFECTIVENESS AND PROBLEMS

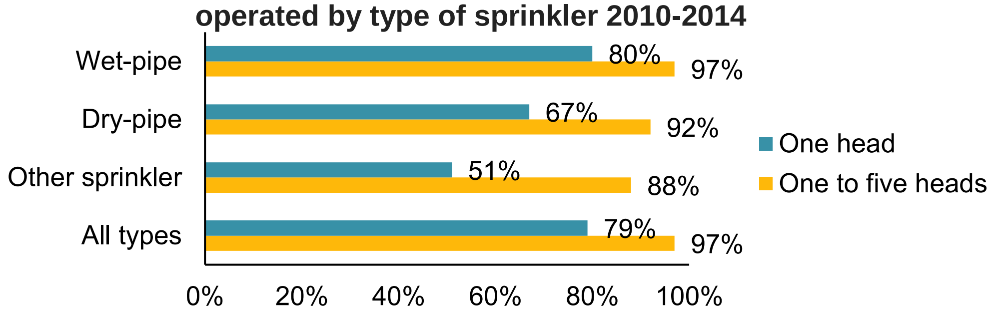
Sprinklers operated in 92% of the fires in which sprinklers were present and the fire was considered large enough to activate them.[2] They were effective at controlling the fire in 96% of fires in which they operated. Figure 8 shows that sprinklers operated effectively in 88% of the fires large enough to trigger them. Table 6 provides details on sprinkler operation and effectiveness in different occupancies and for different types of sprinklers.

Figure 8. Sprinkler operation and effectiveness: 2010-2014



Only one sprinkler activated in four out of five fires in which sprinklers of any type (79%) or wet pipe sprinklers (80%) operated. Figure 9 shows that in 97% of fires with operating sprinklers, five or fewer heads operated. The percentages were smaller for dry pipe and other sprinklers. Table 7 provides more details on number of sprinklers. The percentage of fires in which only one head operated is higher in this report than in previous editions because fires sprinklers operating in fires with the NFIRS confined fire incident types were included in the calculations.

Figure 9. When sprinklers operated, percentage of fires in which one or one to five heads operated by type of sprinkler 2010-2014



In 97% of the fires in which one sprinkler operated, it was effective. Figure 10 shows that sprinklers were somewhat less likely to have operated effectively when more heads operated.

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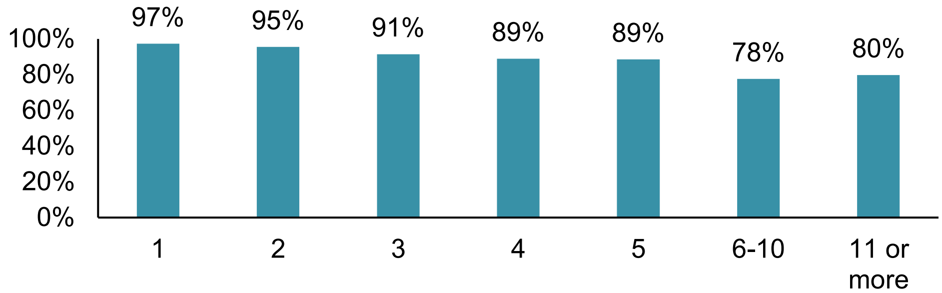
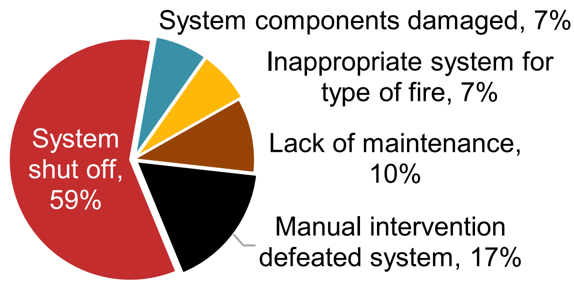
[2] These calculations exclude fires with confined structure fire incident types (NFIRS incident types 113-118). Among confined fires with sprinklers present, the fire was too small to operate 76% of the time, sprinklers operated and were effective 19% of the time and failed to operate 4% of the time. Since these fires are, by definition, confined, it is likely that a substantial share of fires in which the sprinklers were said to fail, were, in fact, too small to cause the sprinkler to operate. The 44% of non-confined (NFIRS incident types 110-123, excluding 113-118) that were too small to activate the sprinkler and 1% of non-confined structure fires with unclassified operation were also excluded.

Figure 10. Percentage of fires in which sprinklers were effective by number operating 2010-2014



In three of every five (59%) incidents in which sprinklers failed to operate, the system had been shut off. Figure 11 shows that manual intervention defeated the system in 17% of the incidents. In some cases, someone turned off the system prematurely.

Figure 11. Reasons for sprinkler failures: 2010-2014.

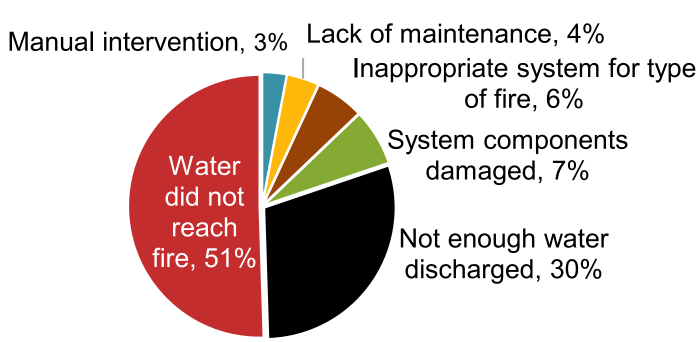


The system was inappropriate for the type of fire in 7% of the incidents in which sprinklers failed to operate. Throughout a building's life cycle, the use and occupancy type may change. A system that was designed for the original purpose may not be sufficient to meet the requirements of the changed building use. In another 7% of sprinkler failures, system components were damaged.

Table 8 shows the failure reasons for different occupancies and different types of sprinklers. In all cases, system shut-off was the leading reason.

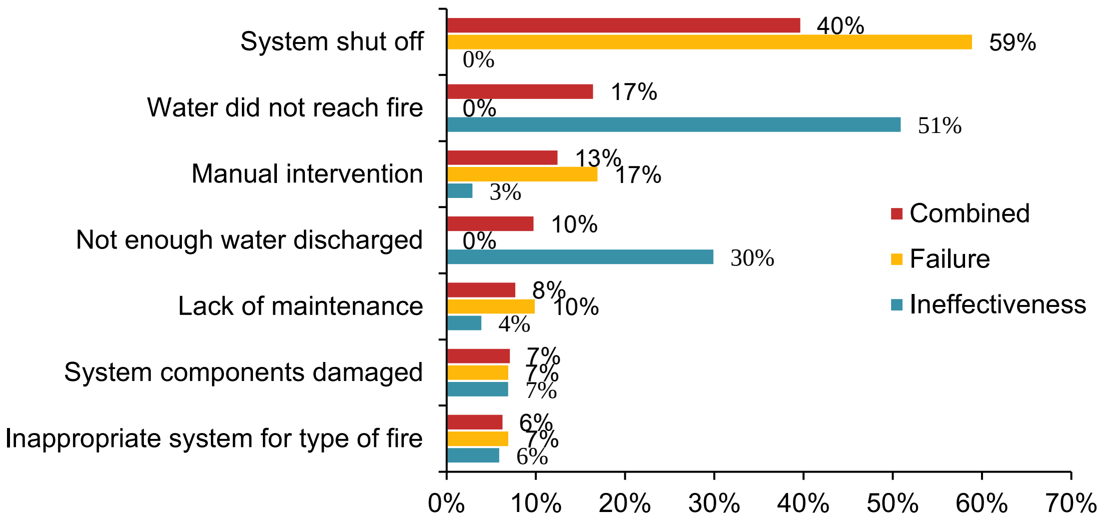
In half (51%) of the fires in which sprinklers were ineffective. the water did not reach the fire. Figure 12 shows that in 30% of the incidents, not enough water was discharged. In 7%, system components were damaged. The system was inappropriate for the type of fire in 6%. Lack of maintenance was identified as a factor in 4% of the incidents. Manual intervention was the cause of 3% of ineffective systems. Table 9 provides more details by occupancy and by type of sprinkler.

Figure 12. Reasons for sprinkler ineffectiveness: 2010-2014



In 2010-2014, reported sprinkler failures (660 per year) were twice as common as reported fires in which sprinklers were ineffective (320 per year). Figure 13 shows that 40% of the combined sprinkler problems were due to system shut-offs. In 17% of these incidents, water did not reach the fire. In 13%, manual intervention defeated the system. In 10%, not enough water was discharged. Lack of maintenance was a factor in 8%, system components were damaged in 7%, and in 6%, the system was inappropriate for the type of fire.

Figure 13. Reasons for combined sprinkler failure and ineffectiveness: 2010-2014

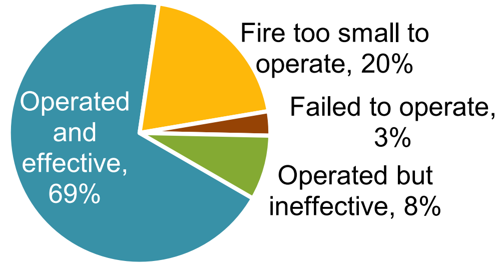


CIVILIAN DEATHS IN SPRINKLERED PROPERTIES

While sprinklers were present in 10% of all properties, only 2% of all fire deaths occurred in these properties. Fires in sprinklered properties killed an average of 42 people per year in 2010-02014. During the same period, fires in properties with no automatic extinguishing systems caused an average of 2,660 civilian deaths per year.

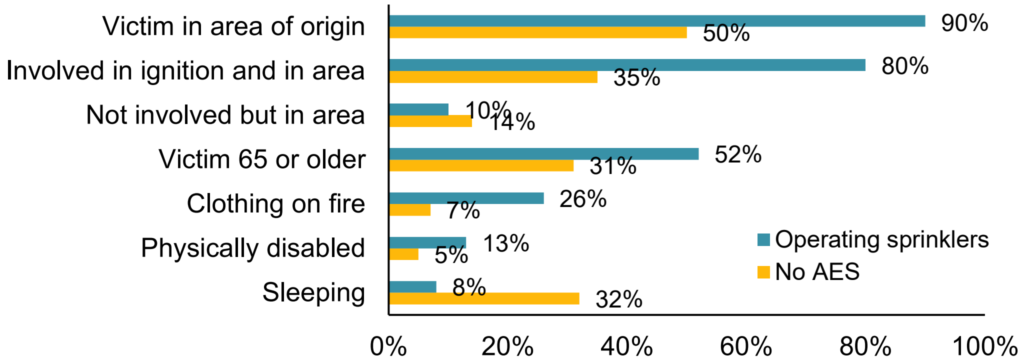
Figure 14 shows that 69% of the deaths in properties with sprinklers were caused by fires in which the sprinklers operated and were effective in controlling the fire. In some of these cases, the sprinklers actually extinguished the fire. The victims were typically fatally injured before the sprinklers activated. In one of every five (20%) such deaths, the fire never became large enough to activate the sprinkler. The sprinklers failed to operate in fires causing 3% of the deaths in sprinklered properties, and operated or were ineffective in controlling fires that caused 8% of the fatalities.

Figure 14. Civilian fire deaths by sprinkler performance: 2010-2014



Compared to victims of fires with no AES, people who died in fires in which sprinklers operated effectively were less likely to have been sleeping and more likely to have been in the area of origin, even more likely to have been involved in the ignition and in the area, to have been at least 65 or older, to have clothing on fire, or to have been physically disabled. Figure 15 shows this contrast; more details are provided in Table 10. Note that many of these differences are also seen in victims of fires with and without working smoke alarms. [5] There are limits to even the best fire protection. When someone is directly involved in the ignition or their clothing is burning, they may be fatally injured before the fire protection operates. If someone is physically incapable of getting themselves to safety, even a fire controlled by sprinklers may still cause harm.

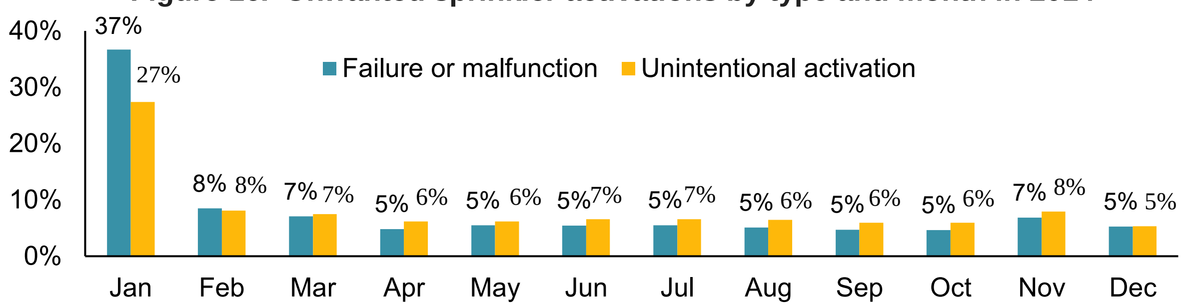
Figure 15. Victim characteristics in fires with effectively operating sprinklers and with no AES 2010-2014



UNWANTED ACTIVATIONS

Fire departments responded to an estimated 29,800 sprinkler activations caused by a system failure or malfunction and 33,600 unintentional sprinkler activations in 2014. According to the *NFIRS 5.0 Complete Reference Guide* [7], false alarms due to sprinkler failures or malfunctions include "any failure of sprinkler equipment that leads to sprinkler activation with no fire present." It "excludes unintentional operating caused by damage to the sprinkler system." Unintentional activations also include "testing the sprinkler system without fire department notification." Figure 16 shows that more than one-third (37%) of the system failures or malfunctions occurred in January, as did one-quarter (27%) of the unintentional activations. This suggests that cold weather may have played a role.

Figure 16. Unwanted sprinkler activations by type and month in 2014



Not all activations result in water flow outside the system. For example, water may flow in the pipes of a dry-pipe system. This could alert a monitoring company and trigger a fire department response.

Sprinklers in Home Fires

SPRINKLER PRESENCE AND TYPE

During 2010-2014, some type of fire sprinkler was present in an average 24,440 reported home structure fires per year. These fires caused an average of 35 civilian deaths, 616 civilian injuries, and $198 million in direct property damage per year. Properties under construction were excluded from these calculations.

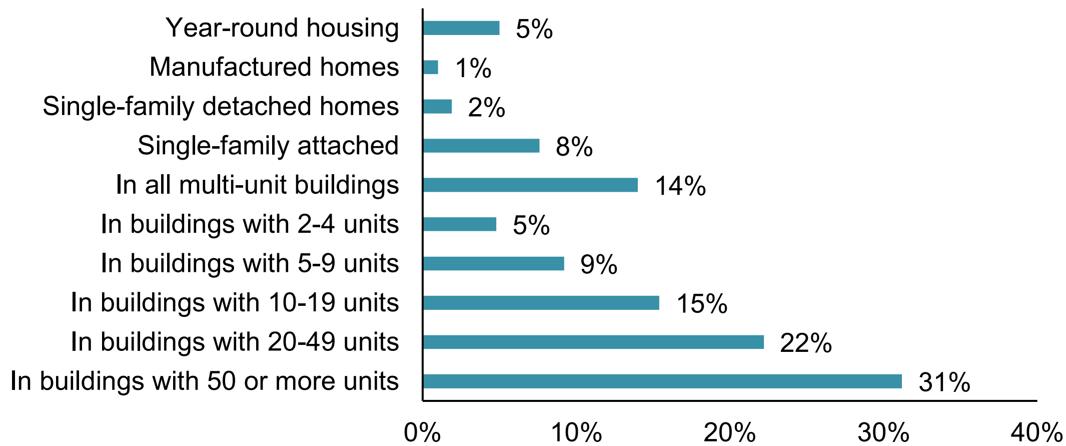
Table B summarizes information about AES in all reported home structure fires except those under construction.

Table B.
Summary of AES presence and type in reported home structure fires
2010-2014 annual averages

AES Presence of Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
AES present	**25,700**	**(7%)**	**36**	**(1%)**	**650**	**(5%)**	**$203**	**(3%)**
Sprinklers present	24,440	(7%)	35	(1%)	616	(5%)	$198	(3%)
Wet	*21,760*	*(6%)*	*34*	*(1%)*	*581*	*(5%)*	*$184*	*(3%)*
Dry	*2,140*	*(1%)*	*0*	*(0%)*	*26*	*(0%)*	*$10*	*(0%)*
Other	*540*	*(0%)*	*1*	*(0%)*	*9*	*(0%)*	*$4*	*(0%)*
Non-sprinkler AES present	1,260	(0%)	1	(0%)	34	(0%)	$5	(0%)
Partial system AES	970	(0%)	5	(0%)	31	(0%)	$17	(0%)
AES Not in fire area and did not operate	600	(0%)	2	(0%)	24	(0%)	$19	(0%)
None present	**329,460**	**(92%)**	**2,471**	**(98%)**	**11,979**	**(94%)**	**$6,359**	**(96%)**
Total	**356,740**	**(100%)**	**2,514**	**(100%)**	**12,684**	**(100%)**	**$6,599**	**(100%)**

According to the 2011 American Housing Survey, buildings with more housing units were more likely to have sprinklers. Figure 17 shows that 5% of occupied year-round housing units had sprinklers, ranging from a low of 1% in manufactured homes to a high of 31% in buildings with at least 50 units. [7]

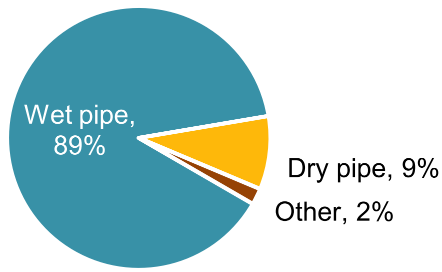
Figure 17. Percentage of occupied units with sprinklers in 2011 American Housing Survey



Source: American Housing Survey

Wet pipe sprinklers accounted for 89% of the sprinklers in reported home fires, dry pipe systems were in 9%, and other types of sprinklers were in 2%. See Figure 18.

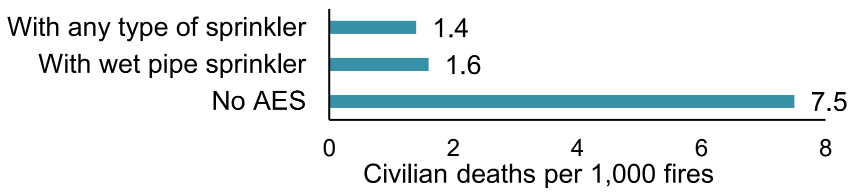
Figure 18. Types of sprinklers found in home structure fires: 2010-2014



FIRES IN HOMES WITH SPRINKLERS VS. NO AES

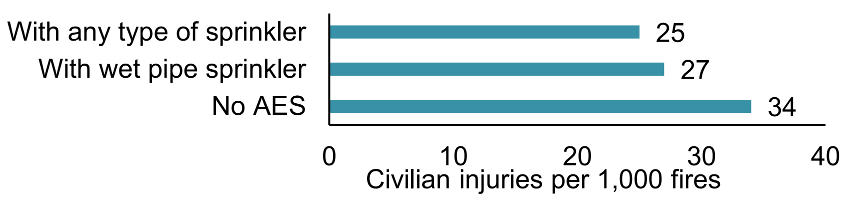
The death rate per 1,000 reported fires was 81% lower in homes with sprinklers than in homes with no AES. These rates are based strictly on reported presence or absence. Operation is not considered. Figure 19 shows that in reported structure fires with no automatic extinguishing systems (AES) present, the death rate was 7.5 per 1,000 fires. When any type of sprinkler was present, the death rate was 1.4 per 1,000 fires, a reduction of 81%. When wet pipe sprinklers were present, the death rate of 1.4 deaths was 79% lower. With so few deaths in sprinklered properties, the differences are not meaningful.

Figure 19. Civilian death rates per 1,000 fires in homes with sprinklers and with no AES 2010-2014



The civilian injury rate per 1,000 reported fires was 31% lower in homes with sprinklers than in homes with no AES. Figure 20 shows that when any type of sprinklers were present, reported civilian injuries averaged 25 per year, compared to 34 per year in which no AES was present. The injury rate for wet pipe sprinklers of 27 per 1,000 fires was 27% lower than in fires with no AES. In many cases, the fire was too small to operate. In others, someone was injured while trying to fight a fire in the initial moments before a sprinkler operated.

Figure 20. Civilian injury rates per 1,000 fires in homes with sprinklers and with no AES 2010-2014



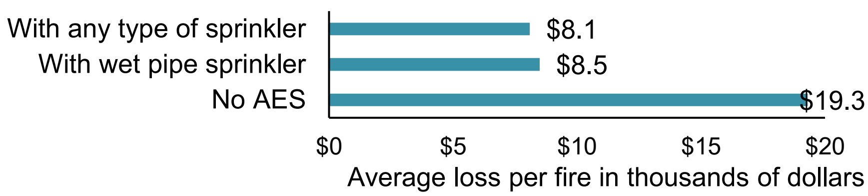
2012 Fire Protection Research Foundation study found that sprinkler presence was associated with a 53% reduction in the medical cost of civilian injuries per 100 home fires. In addition, larger percentages of injuries in sprinklered homes resulted from fires that were limited to the object or room of origin than in home fires without sprinklers. [8]

The average firefighter fireground injury rate per 1000 reported home fires was 79% lower when sprinklers were present than in fires with no AES. Figure 21 shows that when sprinklers were present, 13 firefighters were injured per 1000 fires, compared to 62 firefighter injuries per 1,000 fires in properties without AES protection.

Figure 21. Firefighter injury rates per 1,000 fires in homes with sprinklers and with no AES 2010-2014

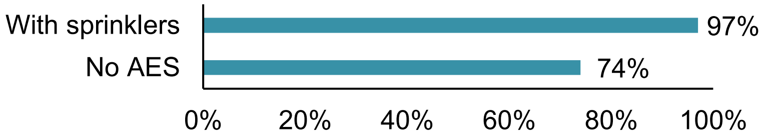
When sprinklers were present in reported home fires, the average property loss per fire was less than half the average in homes with no AES. Figure 22 shows that when any type of fire sprinkler was present in reported fires, the average loss was $8,100 per fire. This was 58% lower than the $19,300 average in home fires in which no AES was present. When wet pipe sprinklers were present, the average loss of $8,500 was 56% lower than in homes with no AES.

Figure 22. Average loss per fire in homes with sprinklers and with no AES 2010-2014



When sprinklers were present, flame damage was confined to the room of origin in 97% of fires compared to 74% of fires without AES. See Figure 23. In a change from previous editions of this report, fires with NFIRS incident types indicating confined structure fires (NFIRS incident type codes 113-118) were all considered to have been confined to the room of origin.

Figure 23. Percent of fires confined to room of origin in homes with sprinklers and with no AES 2010-2014

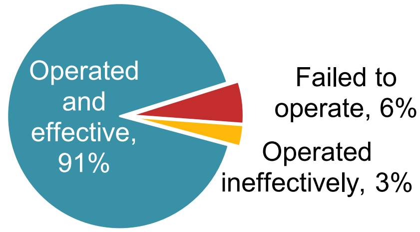


SPRINKLER OPERATION, EFFECTIVENESS AND PROBLEMS IN HOME FIRES

Sprinklers operated in 94% of home fires in which sprinklers were present and fires were considered large enough to activate them.[3] They were effective at controlling the fire in 96% of fires in which they operated. Figure 24 shows that, taken together, sprinklers operated effectively in 91% of the fires large enough to trigger them.

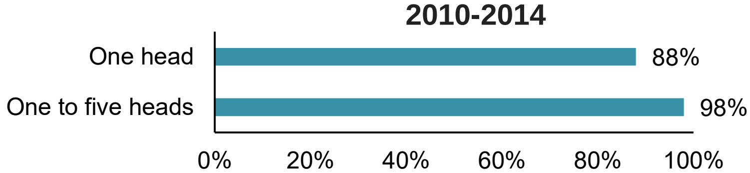
[3] These calculation exclude fires with confined structure fire incident types (NFIRS incident types 113-118). Among confined fires with sprinklers present, the fire was too small to operate 74% of the time, sprinklers operated and were effective 22% of the time and failed to operate 4% of the time. Since these fires are, by definition, confined, it is likely that a substantial share of fires in which the sprinklers were said to fail, were, in fact, too small to cause the sprinkler to operate. The 34% of non-confined (NFIRS incident types 110-123, excluding 113-118) that were too small to activate the sprinkler and 1% of non-confined structure fires with unclassified operation were also excluded.

Figure 24. Sprinkler operation and effectiveness in home fires: 2010-2014



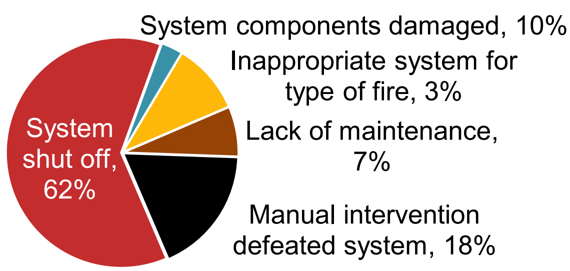
In 98% of home fires with operating sprinklers, five or fewer heads operated. Figure 25 shows that only one sprinkler operated in 88% of fires with operating sprinklers of all types. The percentage of fires in which only one head operated is higher in this report than in previous editions because fires sprinklers operating in fires with the NFIRS confined fire incident types were included in the calculations.

Figure 25. When sprinklers operated, percentage of home fires in which one or one to five heads operated 2010-2014



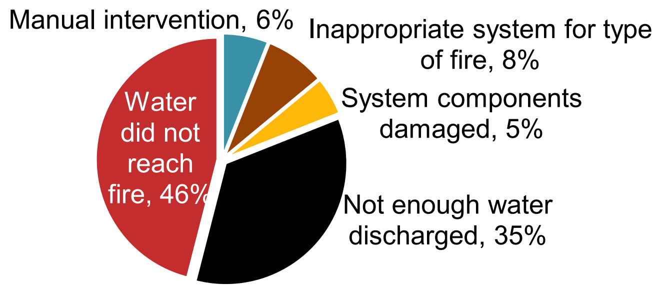
In three of every five (62%) home fires in which sprinklers failed to operate, the system had been shut off. Figure 26 shows that manual intervention defeated the system in 18% of the incidents. System components were damaged in 10% of these fires, lack of maintenance caused 7% of the failures, and 3% occurred because the system was inappropriate for the type of fire that occurred.

Figure 26. Reasons for sprinkler failures in home fires: 2010-2014



In almost half (46%) of home fires in which sprinklers were ineffective, the water did not reach the fire. Figure 27 shows that in one-third (35%) of the incidents, not enough water was discharged. The system was inappropriate for the type of fire in 8% of the incidents. In 5%, system components were damaged. Manual intervention was the cause of 6% of ineffective systems. Table 8 provides more details by occupancy and by type of sprinkler.

Figure 27. Reasons for sprinkler ineffectiveness in home fires: 2010-2014

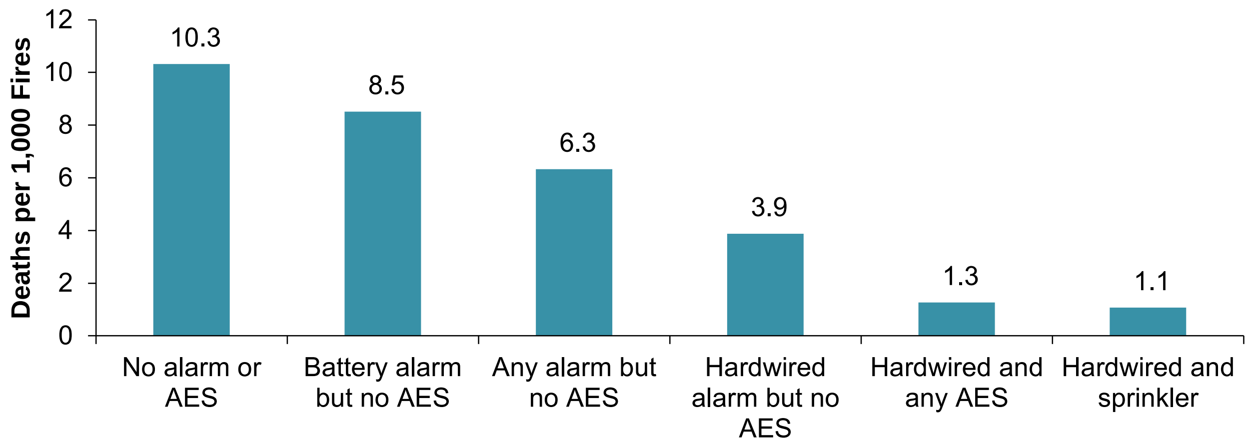


IMPACT OF SMOKE ALARMS AND SPRINKLERS IN DEATHS PER 1,000 HOME FIRES

The lowest home fire death rate per 1,000 reported fires is found in homes with sprinkler systems and hardwired smoke alarms. Figure 28 shows that compared to reported home fires (excluding manufactured home fires) with no smoke alarms or automatic extinguishing systems/equipment (AES) at all, the death rate per 1,000 reported fires was:

- 18% lower when battery-powered smoke alarms were present but AES were not;
- 39% lower when smoke alarms with any power source were present but AES were not;
- 62% lower when hardwired smoke alarms were present but AES were not;
- 88% lower when hardwired smoke alarms and any AES were present; and
- 90% lower when sprinklers and hard-wired smoke alarms were present.

Figure 28. Average Fire Death Rate per 1,000 Reported Home Structure Fires by Presence of Smoke Alarms and AES 2010-2014



UNWANTED ACTIVATIONS

Fire departments responded to an estimated 5,600 non-fire activations of home fire sprinklers caused by a system failure or malfunction and 6,800 unintentional sprinkler activations in 2014. Note that activations in manufactured homes could not be identified or screened out. According to the NFIRS Complete Reference Guide**,** [9] sprinkler failures or malfunctions include "any failure of sprinkler equipment that leads to sprinkler activation with no fire present." It. "excludes unintentional operating caused by damage to the sprinkler system." The latter should be considered unintentional activations. Unintentional activations also include "testing the sprinkler system without fire department notification.

20 Years of Home fire Sprinklers in Scottsdale, Arizona

Survey in Scottsdale, Arizona found that home fire sprinklers were still operational after 20 years. In his 2008 Executive Fire Officer Program Applied Research Project, Residential fire sprinkler reliability in homes older than 20 years old in Scottsdale, AZ, Richard Upham described the results of a survey he conducted of owners of single-family homes built in 1986-1988 after requirements for residential sprinklers systems took effect. [10] Respondents could check yes, no or unsure to four questions. They could also request a free inspection of their system.

Excluding blanks and responses of unsure, all of the respondents answered "Yes" when asked "To the best of your knowledge, is your fire sprinkler system still in operation?"

With the same exclusions, 89% said "No" when asked "Has your sprinkler system ever had a leak or maintenance problem?" The author noted that leaks or maintenance issues on Scottsdale were usually due to either relief valves that had developed a leak or sprinkler heads that were unintentionally damaged. He also noted that more than 300,000 Omega sprinkler heads manufactured between 1983 and 1998 were replaced in Scottsdale after a recall. Some of these may have been considered maintenance issues.

Again, with the same exclusions, slightly more than half (54%) said "Yes" to "Has your fire sprinkler system ever been inspected?" Two (1%) of the respondents said "Yes" to "Has your fire sprinkler system ever been activated as a result of fire?"

Two-thirds provided contact information to request a free fire department inspection of their sprinkler system. No issues were found that would have prevented the systems from working in the 60 inspections completed when his paper was written.

Conclusions and Further Reading

Sprinklers are a very reliable and effective part of fire protection. Their impact is seen most strongly in the reduction of civilian fire deaths per 1,000 reported fires when sprinklers are present compared to fires without AES. Notable reductions are also seen in injury rates, and in most occupancies, average loss per fire. Increasing the usage of sprinklers will the reduce loss of life and property from fire.

NFPA standards provide essential guidance in installation, inspection, testing, maintenance, integration of sprinklers with other systems, and in evaluating needs when an occupancy changes use or contents. See

- NFPA 13: *Standard for the Installation of Sprinkler Systems,*
- NFPA, 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,*
- NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies,*
- *NFPA 25:, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2017 edition, Quincy, MA, U.S.: NFPA, 2016. See NFPA 25 for minimum inspection, testing, and maintenance requirements for sprinkler systems.
- NFPA 4: *Standard for the Integrated Fire Protection and Life Safety Systems Testing,* 2015 Edition, Quincy, MA, U.S.: NFPA, 2014. See NFPA 4 for test protocols to ensure that the fire protection and life safety systems will function correctly together.
- NFPA 1, *Fire Code,* 2015 Edition, Quincy, MA, U.S.: NFPA, 2014. NFPA 1 has evaluation requirements to assess the adequacy of existing sprinkler systems if the use or contents in the space have changed.

Because sprinklers control fires in the early stages, far less water is needed than if the fire extinguished by traditional methods. See FM Global's 2010 report, *The Environmental Impact of Automatic Fire Sprinklers*.

See www.firesprinklerinitiave.org for resources to help increase the number of new one- and two-family homes built protected by sprinklers and to reduce this death toll. Three out of every five fire deaths were caused by fires in one- or two-family homes, excluding manufactured housing. Sprinklers were present in only 1.5% of the fires in these properties.

The Fire Protection Research Foundation has produced a number of reports to inform home fire sprinkler codes and standards. See:

- Stakeholder Perceptions of Home Fire Sprinklers (2016)
- Home Fire Sprinkler Cost Assessment (2013)
- Sprinkler Impact on Fire Injury (2012)
- Residential Fire Sprinklers - Water Usage and Water Meter Performance Study (2011)
- Sprinkler Insulation: A Literature Review (2011)
- Incentives for the Use of Residential Fire Sprinkler Systems in U.S. Communities (2010)
- Analysis of the Performance of Residential Sprinkler Systems with Sloped or Sloped and Beamed Ceilings (2010)
- Antifreeze Solutions in Home Fire Sprinkler Systems - Phase II Interim Report (2010)
- Antifreeze Solutions in Home Fire Sprinkler Systems - Literature Review and Research Plan

Table 1.
Presence of Sprinklers in Structure Fires by Property Use, Excluding Properties under Construction

Property Use	Number of Structure Fires With Equipment Present and Percentage of Total Structure Fires in Property Use — Any Automatic Extinguishing Equipment 1980-1984		1994-1998		2010-2014		Any Sprinkler 2010-2014	
All public assembly	4,280	(13%)	4,380	(26%)	6,610	(47%)	3,760	(27%)
Variable-use amusement place	120	(8%)	140	(16%)	240	(21%)	190	(17%)
Religious property	50	(2%)	90	(5%)	230	(14%)	180	(10%)
Library or museum	80	(14%)	110	(28%)	260	(44%)	230	(39%)
Eating or drinking establishment	3,310	(16%)	3,240	(29%)	4,360	(59%)	1,860	(25%)
Passenger terminal	70	(20%)	60	(35%)	400	(54%)	390	(53%)
Educational property	1,620	(13%)	1,820	(24%)	2,130	(43%)	1,950	(39%)
Health care property*	6,920	(47%)	4,400	(68%)	3,350	(53%)	3,100	(49%)
Nursing home	2,250	(61%)	2,060	(76%)	1,870	(70%)	1,780	(67%)
Hospital	3,370	(47%)	1,650	(74%)	900	(79%)	770	(67%)
Prison or jail	370	(10%)	430	(19%)	260	(59%)	250	(56%)
All residential	7,090	(1%)	11,110	(3%)	33,880	(9%)	31,500	(8%)
Home (including apartment)	5,120	(1%)	8,440	(2%)	26,390	(7%)	24,440	(7%)
Hotel or motel	1,590	(15%)	1,690	(35%)	2,130	(58%)	2,020	(55%)
Dormitory or barracks	430	(16%)	620	(29%)	2,210	(56%)	2,100	(53%)
Rooming or boarding home	70	(4%)	230	(17%)	1,120	(40%)	1,100	(39%)
Residential board and care home or assisted living	Not available		Not available		990	(52%)	950	(50%)
Store or office	5,510	(13%)	5,230	(21%)	5,380	(32%)	4,270	(25%)
Grocery or convenience store	1,160	(15%)	1,190	(27%)	1,820	(47%)	1,000	(26%)
Laundry or dry cleaning or other professional service	330	(8%)	310	(13%)	320	(21%)	310	(20%)
Department store	1,340	(44%)	1,100	(52%)	460	(46%)	440	(44%)
Office	1,240	(12%)	1,470	(25%)	1,150	(37%)	1,100	(36%)
Manufacturing facility	11,910	(44%)	6,400	(50%)	2,660	(55%)	2,390	(50%)
All storage	1,430	(2%)	1,090	(3%)	680	(3%)	660	(3%)
Warehouse excluding cold storage*	1,060	(13%)	740	(22%)	370	(30%)	360	(29%)
All structures	38,620	(4%)	37,100	(7%)	57,430	(12%)	49,840	(10%)

* “Health care property” includes other facilities not listed separately. In 1980-84 and 1994-98, this category excludes doctors’ offices and care of aged facilities without nursing staff (which are assumed to be residential board and care facilities).

Notes: These are structure fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Post-1998 estimates are based only on fires reported in Version 5.0 of NFIRS and include fires reported as confined fires. After 1998, buildings under construction are excluded. Sprinkler statistics exclude partial systems and installations with no sprinklers in fire area.

Table 2.
Type of Sprinkler Reported in Structure Fires
Where Equipment Was Present in Fire Area, Excluding Properties under Construction
by Property Use: 2010-2014 Annual Averages

Property Use	Fires per year with any type of sprinkler	Wet pipe sprinklers		Dry pipe sprinklers		Other sprinklers*	
All public assembly	3,760	3,080	(82%)	300	(8%)	380	(10%)
Variable-use amusement place	190	170	(91%)	20	(8%)	0	(1%)
Religious property	180	160	(88%)	10	(3%)	10	(6%)
Library or museum	230	210	(91%)	20	(9%)	0	(1%)
Eating or drinking establishment	1,860	1,450	(78%)	130	(7%)	280	(15%)
Passenger terminal	390	280	(73%)	50	(13%)	50	(13%)
Educational property	1,950	1,670	(86%)	220	(11%)	60	(3%)
Health care property**	3,100	2,740	(88%)	300	(10%)	60	(2%)
Nursing home	1,780	1,550	(87%)	180	(10%)	40	(2%)
Hospital	770	690	(89%)	80	(10%)	0	(0%)
Prison or jail	250	210	(85%)	30	(11%)	10	(4%)
All residential	31,500	28,050	(89%)	2,700	(9%)	660	(2%)
Home (including apartment)	24,440	21,760	(89%)	2,140	(9%)	540	(2%)
Dormitory or barracks	2,100	1,910	(91%)	160	(8%)	20	(1%)
Hotel or motel	2,020	1,850	(92%)	130	(7%)	40	(2%)
Rooming or boarding house	1,100	970	(88%)	130	(12%)	0	(0%)
Residential board and care or assisted living	950	840	(89%)	90	(9%)	20	(2%)
Store or office	4,270	3,710	(87%)	430	(10%)	140	(3%)
Grocery or convenience store	1,000	830	(83%)	90	(9%)	80	(8%)
Laundry or dry cleaning or other professional service	310	270	(87%)	40	(13%)	0	(1%)
Department store	440	380	(86%)	60	(13%)	10	(1%)
Office	1,100	980	(89%)	100	(9%)	20	(2%)
Manufacturing facility	2,390	2,010	(84%)	290	(12%)	90	(4%)
All storage	660	510	(77%)	150	(23%)	0	(1%)
Warehouse excluding cold storage	360	300	(82%)	60	(17%)	0	(1%)
All structures ***	49,840	43,540	(87%)	4,770	(10%)	1,530	(3%)

* Includes deluge and pre-action sprinkler systems and may include sprinklers of unknown or unreported type.
** Nursing home, hospital, clinic, doctor's office, or development disability facility
*** Includes some property uses that are not shown separately.

Note: These are based on structure fires reported to U.S. municipal fire departments in NFIRS Version 5.0 and so exclude fires reported only to federal or state agencies or industrial fire brigades. Row totals are shown in the leftmost column of percentages, and sums may not equal totals because of rounding error. In Version 5.0 of NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. This field is not required if the fire did not begin within the designed range of the system. Buildings under construction and partial systems are excluded.
Source: NFIRS and NFPA fire experience survey.

Table 3.
Estimated Reduction in Civilian Deaths per Thousand Fires
Associated With All Types of Sprinklers,
by Property Use (Excluding Properties under Construction): 2010-2014 Annual Averages

Property Use	Without AES	With sprinklers of any type	Percent reduction from no AES	With wet pipe sprinklers	Percent reduction from no AES
All public assembly	0.7	0.0	100%	0.0	100%
Health care	0.9	0.3	71%	0.1	83%
Residential	7.5	1.1	85%	1.2	84%
Home (including apartment)	7.5	1.4	81%	1.6	79%
Dormitory or barracks	0.4	0.0	100%	0.0	100%
Hotel or motel	7.0	0.3	95%	0.0	100%
Rooming or boarding house	8.4	0.3	96%	0.4	96%
Residential board and care or assisted living	7.2	1.3	82%	1.5	80%
Store or office	0.9	0.3	68%	0.3	63%
Manufacturing facility	1.6	1.0	33%	1.2	21%
Warehouse excluding cold storage	2.7	0.6	79%	0.7	74%
All structures	6.3	0.8	87%	0.9	86%

Note: These are national estimates of structure fires reported to U.S. municipal fire departments, based on fires reported in NFIRS Version 5.0, and so exclude fires reported only to federal or state agencies or industrial fire brigades.

Source: NFIRS and NFPA fire experience survey.

Table 4.
Estimated Reduction in Average Direct Property Loss per Fire
Associated With All Types of Sprinklers
by Property Use (Excluding Properties under Construction): 2010-2014 Annual Averages

Property Use	Loss without AES	Loss with sprinklers of any type	Percent reduction	Loss with wet pipe sprinklers	Percent reduction from no AES
All public assembly	$37,900	$9,100	76%	$8,900	77%
Health care*	$14,900	$4,000	73%	$3,700	75%
Residential	$19,200	$7,100	63%	$7,300	62%
Home (including apartment)	$19,300	$8,100	58%	$8,500	56%
Dormitory or barracks	$3,900	$1,300	67%	$1,400	65%
Hotel or motel	$35,200	$10,900	69%	$10,700	70%
Rooming or boarding house	$12,200	$1,700	86%	$1,800	85%
Residential board and care or assisted living	$5,500	$2,300	58%	$2,400	55%
Store or office	$52,400	$26,100	50%	$26,300	50%
Manufacturing facility	$107,200	$82,500	23%	$70,900	34%
Warehouse excluding cold storage	$90,700	$138,300	no reduction	$120,800	no reduction
All structures	$20,400	$14,200	30%	$13,300	35%

*Nursing home, hospital, clinic, doctor's office, or other medical facility.

Note: These are national estimates of structure fires reported to U.S. municipal fire departments, based on fires reported in NFIRS Version 5.0, and so exclude fires reported only to federal or state agencies or industrial fire brigades.

Source: NFIRS and NFPA fire experience survey.

Table 5.
Percentage of Fires with Fire Spread Confined to Room of Origin in Fires with Sprinklers Present vs. No Automatic Extinguishing System
2010-2014 Annual Averages

Property Use	Percentage of fires confined to room of origin excluding structures under construction and sprinklers not in fire area		
	With no AES	With sprinklers of any type	Difference (in percentage points)
Public assembly	75%	93%	18%
Religious property	72%	90%	18%
Library or museum	83%	97%	14%
Eating or drinking establishment	70%	92%	22%
Educational	88%	97%	9%
Health care property*	92%	98%	6%
Residential	73%	97%	24%
Home (including apartment)	74%	97%	23%
Dormitory or barracks	96%	99%	3%
Hotel or motel	82%	97%	15%
Store or office	65%	92%	26%
Grocery or convenience store	69%	93%	24%
Department store	65%	72%	7%
Office building	72%	94%	22%
Manufacturing facility	62%	85%	22%
Storage	26%	87%	61%
Warehouse excluding cold storage	53%	77%	24%
All structures**	71%	96%	25%

* Nursing home, hospital, clinic, doctor's office, or other medical facility.

** Includes some properties not listed separately above.

Note: Percentages are based on structure fires reported in NFIRS Version 5.0 to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. All fires with one of the six NFIRS confined structure fire incident types were considered confined to the object of origin by definition. Fires that were confined to the room of origin include fires confined to the object of origin. In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. This field is not required if the fire did not begin within the designed range of the system.

Source: NFIRS and NFPA fire experience survey.

Table 6.
Sprinkler Reliability and Effectiveness When Fire Was Coded as Not Confined and Large Enough to Activate Sprinkler and Sprinkler Was Present in Area of Fire, by Property Use: 2010-2014 Annual Averages

A. All Sprinklers

Property Use	Number of fires per year where sprinklers were present	Non-confined fires too small to activate or unclassified operation	Fires coded as confined fires	Number of qualifying fires per year	Percent where equipment operated (A)	Percent effective of those that operated (B)	Percent where equipment operated effectively (A x B)
All public assembly	3,760	590	2,540	640	90%	94%	85%
Eating or drinking establishment	1,860	300	1,150	410	90%	92%	83%
Educational property	1,950	420	1,360	180	87%	96%	84%
Health care property*	3,100	600	2,200	310	85%	97%	82%
All residential	31,500	2,490	24,870	4,140	93%	96%	89%
Home (including apartment	24,440	1,900	18,970	3,570	94%	96%	91%
Hotel or motel	2,020	350	1,340	330	90%	98%	89%
Store or office	4,270	1,030	2,200	1,040	91%	96%	87%
Grocery or convenience store	1,000	240	570	190	89%	93%	83%
Department store	440	160	170	120	90%	98%	88%
Office	1,100	230	700	180	91%	96%	87%
Manufacturing facility	2,390	610	760	1,030	91%	94%	85%
All storage	660	140	220	300	86%	96%	82%
Warehouse excluding cold storage	360	80	90	180	84%	97%	81%
All structures**	49,840	6,350	35,460	8,040	92%	96%	88%

* Nursing home, hospital, clinic, doctor's office, or other medical facility.
** Includes some properties not listed separately above.

Note: These are percentages of fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. In Version 5.0 of NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. This field is not required if the fire did not begin within the designed range of the system. Buildings under construction are excluded. Percentages are based on estimated total fires reported in NFIRS Version 5.0 with the indicated type of automatic extinguishing system and system performance not coded as fire too small to activate systems. Fires are excluded if the reason for failure or ineffectiveness is "system not present in area of fire." Fires are recoded from "operated but ineffective" to "failed to operate" if the reason for failure or ineffectiveness was "system shut off." Fires are recoded from "failed to operate" to "operated but ineffective" if the reason for failure or ineffectiveness was "not enough agent" or "agent did not reach fire."

Source: NFIRS and NFPA fire experience survey.

Table 6. (Continued)
Sprinkler Reliability and Effectiveness When Fire Was Coded as Not Confined and Large Enough to Activate Sprinkler and Sprinkler Was Present in Area of Fire, by Property Use: 2010-2014 Annual Averages

B. Wet Pipe Sprinklers Only

Property Use	Number of fires per year where sprinklers were present	Non-confined fires too small to activate or unclassified operation	Fires coded as confined fires	Number of qualifying fires per year	Percent where equipment operated (A)	Percent effective of those that operated (B)	Percent where equipment operated effectively (A x B)
All public assembly	3,080	490	2,030	560	90%	96%	86%
Eating or drinking establishment	1,450	250	860	340	93%	95%	89%
Educational property	1,670	370	1,140	160	90%	96%	86%
Health care property*	2,740	530	1,940	270	88%	97%	85%
All residential	28,050	2,320	21,970	3,770	96%	96%	93%
Home (including apartment)	21,760	1,680	16,730	3,350	95%	96%	91.2%
Hotel or motel	1,850	320	1,240	300	91%	99%	89.8%
Store or office	3,710	890	1,860	950	90%	96%	87%
Grocery or convenience store	830	210	460	170	89%	95%	85%
Department store	380	140	140	110	89%	99%	88%
Office	980	200	620	160	91%	98%	89%
Manufacturing facility	2,010	520	650	850	91%	94%	86%
All storage	510	100	150	250	82%	96%	79%
Warehouse excluding cold storage	290	60	80	160	84%	97%	82%
All Structures**	43,540	5,540	30,790	7,210	89%	96%	86%

* Nursing home, hospital, clinic, doctor's office, or other medical facility.
** Includes some properties not listed separately above.

Note: These are percentages of fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. In Version 5.0 of NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. This field is not required if the fire did not begin within the designed range of the system. Buildings under construction are excluded. Percentages are based on estimated total fires reported in NFIRS Version 5.0 with the indicated type of automatic extinguishing system and system performance not coded as fire too small to activate systems. Fires are excluded if the reason for failure or ineffectiveness is "system not present in area of fire." Fires are recoded from "operated but ineffective" to "failed to operate" if the reason for failure or ineffectiveness was "system shut off." Fires are recoded from "failed to operate" to "operated but ineffective" if the reason for failure or ineffectiveness was "not enough agent" or "agent did not reach fire."

Source: NFIRS and NFPA fire experience survey.

Table 6. (Continued)
Sprinkler Reliability and Effectiveness When Fire Was Coded as Not Confined and Large Enough to Activate Sprinkler and Sprinkler Was Present in Area of Fire, by Property Use: 2010-2014 Annual Averages

C. Dry Pipe Sprinklers Only

Property Use	Number of fires per year where sprinklers were present	Non-confined fires too small to activate or unclassified operation	Fires coded as confined fires	Number of qualifying fires per year	Percent where equipment operated (A)	Percent effective of those that operated (B)	Percent where equipment operated effectively (A x B)
All residential	2,700	240	2,230	230	79%	95%	76%
Homes	2,140	180	1,800	160	91%	95%	88%
Store or office	450	110	260	80	77%	89%	68%
Manufacturing facility	290	70	80	150	82%	93%	77%
All storage	150	40	70	50	73%	93%	68%
All structures*	4,770	660	3,480	630	79%	94%	74%

* Includes some properties not listed separately above.

Note: These are percentages of fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. In Version 5.0 of NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. This field is not required if the fire did not begin within the designed range of the system. Buildings under construction are excluded. Percentages are based on estimated total fires reported in NFIRS Version 5.0 with the indicated type of automatic extinguishing system and system performance not coded as fire too small to activate systems. Fires are excluded if the reason for failure or ineffectiveness is “system not present in area of fire.” Fires are recoded from “operated but ineffective” to “failed to operate” if the reason for failure or ineffectiveness was “system shut off.” Fires are recoded from “failed to operate” to “operated but ineffective” if the reason for failure or ineffectiveness was “not enough agent” or “agent did not reach fire.”

Source: NFIRS and NFPA fire experience survey.

Table 7.
Number of Sprinklers Operating, by Type of Sprinkler
2010-2014 Structure Fires Excluding Properties under Construction

Number of Sprinklers Operating	Percentage of structure fires where that many sprinklers operated			
	Wet pipe	Dry pipe	Other type sprinkler	All sprinklers
1	80%	67%	51%	79%
1 or 2	93%	82%	66%	91%
1 to 3	95%	87%	77%	94%
1 to 4	97%	89%	86%	96%
1 to 5	97%	92%	88%	97%
1 to 10	99%	97%	99%	99%

Note: Percentages are based on structure fires reported in NFIRS Version 5.0 to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percentages are based on fires where sprinklers were reported present and operating and there was reported information on number of sprinklers operating. Figures reflect recodings explained in Introduction: Fires are excluded if the reason for failure or ineffectiveness is "system not present in area of fire." Fires are recoded from "operated but ineffective" to "failed to operate" if the reason for failure or ineffectiveness was "system shut off." Fires are recoded from "failed to operate" to "operated but ineffective" if the reason for failure or ineffectiveness was "not enough agent" or "agent did not reach fire." In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. Buildings under construction are excluded, as are partial systems and fires reported as confined fires.

Source: NFIRS and NFPA fire experience survey.

Table 8.
Reasons for Failure to Operate in Fires with Non-Confined Structure Fire Incident Types Large Enough to Activate Sprinkler that Was Present in Area of Fire, by Property Use Based on Estimated Number of 2010-2014 Structure Fires per Year

A. All Sprinklers

Property Use	System shut off	Manual intervention defeated system	System component damaged	Lack of maintenance	Inappropriate system for type of fire	Total fires per year
All public assembly	45%	17%	4%	22%	12%	63
Eating or drinking establishment	43%	12%	3%	27%	15%	39
All residential	59%	21%	9%	7%	4%	257
Home (including apartment)	62%	18%	10%	7%	3%	203
Store or office	62%	16%	7%	5%	9%	97
Manufacturing facility	59%	14%	5%	12%	9%	89
All structures*	59%	17%	7%	10%	7%	657

* Includes some properties not listed separately above.

Note: Percentages are based on structure fires reported in NFIRS Version 5.0 to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percentages are based on fires where sprinklers were reported present and operating and there was reported information on number of sprinklers operating. Figures reflect recodings explained in Introduction: Fires are excluded if the reason for failure or ineffectiveness is “system not present in area of fire.” Fires are recoded from “operated but ineffective” to “failed to operate” if the reason for failure or ineffectiveness was “system shut off.” Fires are recoded from “failed to operate” to “operated but ineffective” if the reason for failure or ineffectiveness was “not enough agent” or “agent did not reach fire.” In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. Buildings under construction are excluded, as are partial systems and fires reported as confined fires. Fires reported with unclassified reason for failure are treated as cases of unknown reasons for failure.

Source: NFIRS and NFPA fire experience survey.

Table 8. (Continued)
Reasons for Failure to Operate in Fires with Non-Confined Structure Fire Incident Types Large Enough to Activate Sprinkler that Was Present in Area of Fire, by Property Use Based on Estimated Number of 2010-2014 Structure Fires per Year

B. Wet Pipe Sprinklers Only

Property Use	System shut off	Manual intervention defeated system	System component damaged	Lack of maintenance	Inappropriate system for type of fire	Total fires per year
All public assembly	50%	24%	3%	13%	10%	44.00
Eating or drinking establishment	47%	16%	5%	21%	11%	25.00
All residential	60%	21%	9%	6%	4%	225.00
Home (including apartment)	63%	19%	9%	6%	3%	181.00
Store or office	60%	19%	8%	4%	10%	81.00
Manufacturing facility	58%	18%	2%	8%	14%	64.00
All structures*	59%	20%	7%	7%	7%	530.00

C. Dry Pipe Sprinklers Only

Property Use	System shut off	Manual intervention defeated system	System component damaged	Lack of maintenance	Inappropriate system for type of fire	Total fires per year
All structures	61%	9%	8%	16%	5%	98.00

* Includes some properties not listed separately above.

Note: Percentages are based on structure fires reported in NFIRS Version 5.0 to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percentages are based on fires where sprinklers were reported present and operating and there was reported information on number of sprinklers operating. Figures reflect recodings explained in Introduction: Fires are excluded if the reason for failure or ineffectiveness is "system not present in area of fire." Fires are recoded from "operated but ineffective" to "failed to operate" if the reason for failure or ineffectiveness was "system shut off." Fires are recoded from "failed to operate" to "operated but ineffective" if the reason for failure or ineffectiveness was "not enough agent" or "agent did not reach fire." In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. Buildings under construction are excluded, as are partial systems and fires reported as confined fires. Fires reported with unclassified reason for failure are treated as cases of unknown reasons for failure.

Source: NFIRS and NFPA fire experience survey.

Table 9.
Reasons for Ineffectiveness in Fires with Non-Confined Structure Fire Incident Types Large Enough to Activate Sprinkler that Was Present in Area of Fire, by Property Use Based on Estimated Number of 2010-2014 Structure Fires per Year

A. All Sprinklers

Property Use	Water did not reach fire	Not enough water released	System Component damaged	Manual intervention defeated system	Lack of maintenance	Inappropriate system for type of fire	Fires per year
All public assembly	69%	21%	0%	0%	5%	5%	41
Eating or drinking establishment	69%	25%	0%	0%	6%	0%	33
All residential	39%	40%	7%	3%	5%	7%	119
Home (including apartment)	40%	35%	8%	3%	6%	9%	102
Store or office	39%	32%	8%	13%	4%	4%	34
Manufacturing facility	39%	26%	9%	9%	13%	6%	62
All structures*	44%	30%	8%	7%	7%	5%	300

* Includes some properties not listed separately above.

Note: Percentages are based on structure fires reported in NFIRS Version 5.0 to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percentages are based on fires where sprinklers were reported present and operating and there was reported information on number of sprinklers operating. Figures reflect recodings explained in Introduction: Fires are excluded if the reason for failure or ineffectiveness is “system not present in area of fire.” Fires are recoded from “operated but ineffective” to “failed to operate” if the reason for failure or ineffectiveness was “system shut off.” Fires are recoded from “failed to operate” to “operated but ineffective” if the reason for failure or ineffectiveness was “not enough agent” or “agent did not reach fire.” In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. Buildings under construction are excluded, as are partial systems and fires reported as confined fires. Fires reported with unclassified reason for failure are treated as cases of unknown reasons for failure.

Source: NFIRS and NFPA fire experience survey.

Table 9. (Continued)
Reasons for Ineffectiveness When Fire Was Coded as Not Confined and Large Enough to Activate Sprinkler and Equipment that Was Present in Area of Fire, by Property Use
Based on Estimated Number of 2010-2014 Structure Fires per Year

B. Wet Pipe Sprinklers Only

Property Use	Water did not reach fire	Not enough water released	System component damaged	Manual intervention defeated system	Lack of maintenance	Inappropriate system for type of fire	Total fires per year
All public assembly	66%	26%	0%	0%	0%	8%	25
Eating or drinking establishment	66%	34%	0%	0%	0%	0%	17
All residential	42%	37%	8%	3%	3%	6%	108
Home (including apartment)	43%	33%	10%	4%	3%	7%	93
Store or office	34%	35%	6%	19%	0%	5%	29
Manufacturing facility	36%	31%	3%	12%	12%	6%	46
All structures*	43%	32%	6%	10%	5%	5%	240

C. Dry Pipe Sprinklers Only

Property Use	Water did not reach fire	Not enough water released	System component damaged	Manual intervention defeated system	Lack of maintenance	Inappropriate system for type of fire	Total fires per year
All structures	**42%**	**27%**	**11%**	**0%**	**12%**	**8%**	**33**

* Includes some properties not listed above.

Note: Percentages are based on structure fires reported in NFIRS Version 5.0 to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. Percentages are based on fires where sprinklers were reported present and operating and there was reported information on number of sprinklers operating. Figures reflect recodings explained in Introduction: Fires are excluded if the reason for failure or ineffectiveness is “system not present in area of fire.” Fires are recoded from “operated but ineffective” to “failed to operate” if the reason for failure or ineffectiveness was “system shut off.” Fires are recoded from “failed to operate” to “operated but ineffective” if the reason for failure or ineffectiveness was “not enough agent” or “agent did not reach fire.” In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. Buildings under construction are excluded, as are partial systems and fires reported as confined fires. Fires reported with unclassified reason for failure are treated as cases of unknown reasons for failure.

Source: NFIRS and NFPA fire experience survey.

Table 10.
Characteristics of Fatal Victims
In Fires with Sprinklers vs. No Automatic Extinguishing Equipment
2010-2014 Annual Averages

A. Fire or Victims by Sprinkler Presence and Performance

Sprinkler/AES Status	Deaths when sprinklers present		Deaths when no AES present	
Total civilian deaths	42	(100%)	2,659	(100%)
Operated and effective	*29*	*(69%)*		
Fire too small to operate	*8*	*(20%)*		
Failed to operate	*1*	*(3%)*		
Operated but ineffective	*3*	*(8%)*		

B. Characteristics in Fires with Operating Sprinklers vs. No AES

Fire or Victim Characteristic	Deaths when sprinklers present		Deaths when no AES present	
With operating Sprinklers	29	(100%)	2,659	(100%)
Victim in area of origin	26	(90%)	1,319	(50%)
Involved in ignition	*23*	*(80%)*	*940*	*(35%)*
Not involved in ignition	*3*	*(10%)*	*379*	*(14%)*
Victim 65 or older	15	(52%)	833	(31%)
Clothing on fire	7	(26%)	192	(7%)
Physically disabled	4	(13%)	139	(5%)
Victim returned to fire, unable to act, or acted irrationally	7	(25%)	535	(20%)
Intentional fire	5	(16%)	368	(14%)
Sleeping	8	(8%)	854	(32%)

Note: Statistics are based on structure fires reported in NFIRS by U.S. municipal fire departments and so exclude fire reported only to federal or state agencies or industrial fire brigades. In NFIRS, if multiple systems are present, the system coded is supposed to be the one system designed to protect the hazard where the fire started. This field is not required if the fire did not begin within the designed range of the system. Buildings under construction are excluded.

Here is an example of how to read this table: Nearly all (90%) the people who died in fires despite the presence of operating sprinklers were located in the area of fire origin, hence closer to the fire and probably less able to escape than victims located farther from the fire, compared to only 50% of fatal victims in fires with no automatic extinguishing equipment present who were located in the area of fire origin.

Source: NFIRS and NFPA fire experience survey.

Appendix A.
How National Estimates Are Calculated

The statistics in this analysis are estimates derived from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual survey of U.S. fire departments. NFIRS is a voluntary system by which participating fire departments report detailed factors about the fires to which they respond. Roughly two-thirds of U.S. fire departments participate, although not all of these departments provide data every year. Fires reported to federal or state fire departments or industrial fire brigades are not included in these estimates.

NFIRS provides the most detailed incident information of any national database not limited to large fires. NFIRS is the only database capable of addressing national patterns for fires of all sizes by specific property use and specific fire cause. NFIRS also captures information on the extent of flame spread, and automatic detection and suppression equipment. For more information about NFIRS visit http://www.nfirs.fema.gov/. Copies of the paper forms may be downloaded from http://www.nfirs.fema.gov/documentation/design/NFIRS_Paper_Forms_2008.pdf.

NFIRS has a wide variety of data elements and code choices. The NFIRS database contains coded information. Many code choices describe several conditions. These cannot be broken down further. For example, area of origin code 83 captures fires starting in vehicle engine areas, running gear areas or wheel areas. It is impossible to tell the portion of each from the coded data.

Methodology may change slightly from year to year.
NFPA is continually examining its methodology to provide the best possible answers to specific questions, methodological and definitional changes can occur. *Earlier editions of the same report may have used different methodologies to produce the same analysis, meaning that the estimates are not directly comparable from year to year.*

NFPA's fire department experience survey provides estimates of the big picture.
Each year, NFPA conducts an annual survey of fire departments which enables us to capture a summary of fire department experience on a larger scale. Surveys are currently sent to all municipal departments protecting populations of 5,000 or more and a random sample, stratified by community size, of the smaller departments. Typically, a total of roughly 3,000 surveys are returned, representing about one of every ten U.S. municipal fire departments and about one third of the U.S. population.

The survey is stratified by size of population protected to reduce the uncertainty of the final estimate. Small rural communities have fewer people protected per department and are less likely to respond to the survey. A larger number must be surveyed to obtain an adequate sample of those departments. (NFPA also makes follow-up calls to a sample of the smaller fire departments that do not respond, to confirm that those that did respond are truly representative of fire departments their size.) On the other hand, large city departments are so few in number and protect such a large proportion of the total U.S. population that it makes sense to survey all of them. Most respond, resulting in excellent precision for their part of the final estimate.

The survey includes the following information: (1) the total number of fire incidents, civilian deaths, and civilian injuries, and the total estimated property damage (in dollars), for each of the major property use classes defined in NFIRS; (2) the number of on-duty firefighter injuries, by type of duty and nature of illness; 3) the number and nature of non-fire incidents; and (4) information on the type of community protected (e.g., county versus township versus city) and the size of the population protected, which is used in the statistical formula for projecting national totals from sample results. The results of the survey are published in the annual report *Fire Loss in the United States*. To download a free copy of the report, visit http://www.nfpa.org/assets/files/PDF/OS.fireloss.pdf.

Projecting NFIRS to National Estimates

As noted, NFIRS is a voluntary system. Different states and jurisdictions have different reporting requirements and practices. Participation rates in NFIRS are not necessarily uniform across regions and community sizes, both factors correlated with frequency and severity of fires. This means NFIRS may be susceptible to systematic biases. No one at present can quantify the size of these deviations from the ideal, representative sample, so no one can say with confidence that they are or are not serious problems. But there is enough reason for concern so that a second database -- the NFPA survey -- is needed to project NFIRS to national estimates and to project different parts of NFIRS separately. This multiple calibration approach makes use of the annual NFPA survey where its statistical design advantages are strongest.

Scaling ratios are obtained by comparing NFPA's projected totals of residential structure fires, non-residential structure fires, vehicle fires, and outside and other fires, and associated civilian deaths, civilian injuries, and direct property damage with comparable totals in NFIRS. Estimates of specific fire problems and circumstances are obtained by multiplying the NFIRS data by the scaling ratios. Reports for incidents in which mutual aid was given are excluded from NFPA's analyses.

Analysts at the NFPA, the USFA and the Consumer Product Safety Commission developed the specific basic analytical rules used for this procedure. "The National Estimates Approach to U.S. Fire Statistics," by John R. Hall, Jr. and Beatrice Harwood, provides a more detailed explanation of national estimates.

Version 5.0 of NFIRS, first introduced in 1999, used a different coding structure for many data elements, added some property use codes, and dropped others. The essentials of the approach described by Hall and Harwood are still used, but some modifications have been necessary to accommodate the changes in NFIRS 5.0.

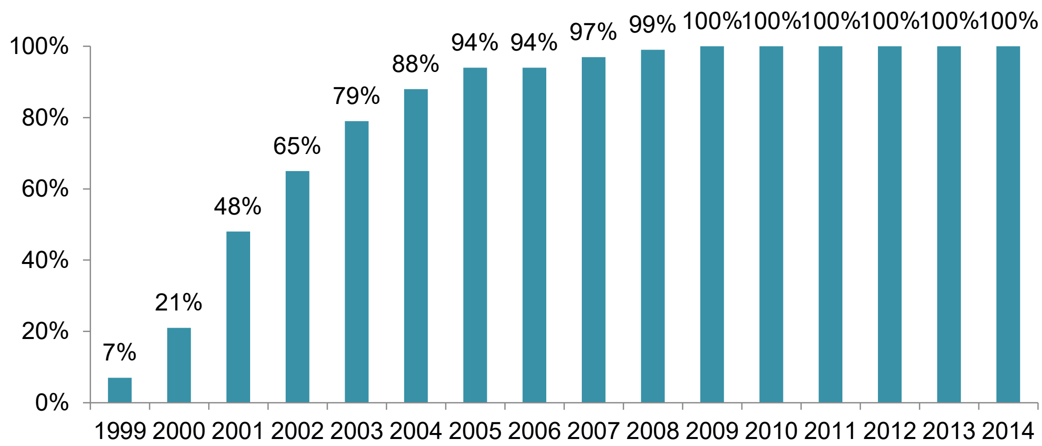
Figure A.1 shows the percentage of fires originally collected in the NFIRS 5.0 system. Each year's release version of NFIRS data also includes data collected in older versions of NFIRS that were converted to NFIRS 5.0 codes.

From 1999 data on, analyses are based on scaling ratios using only data originally collected in NFIRS 5.0:

$$\frac{\text{NFPA survey projections}}{\text{NFIRS totals (Version 5.0)}}$$

For 1999 to 2001, the same rules may be applied, but estimates for these years in this form will be less reliable due to the smaller amount of data originally collected in NFIRS 5.0; they should be viewed with extreme caution.

Figure A.1. Fires Originally Collected in NFIRS 5.0 by Year



NFIRS 5.0 introduced six categories of confined structure fires, including:

- cooking fires confined to the cooking vessel,
- confined chimney or flue fires,
- confined incinerator fire,
- confined fuel burner or boiler fire or delayed ignition,
- confined commercial compactor fire, and
- trash or rubbish fires in a structure with no flame damage to the structure or its contents.

Although causal and other detailed information is typically not required for these incidents, it is provided in some cases. Some analyses, particularly those that examine cooking equipment, heating equipment, fires caused by smoking materials, and fires started by playing with fire, may examine the confined fires in greater detail. Because the confined fire incident types describe certain scenarios, the distribution of unknown data differs from that of all fires. Consequently, allocation of unknowns must be done separately.

For most fields other than Property Use and Incident Type, NFPA allocates unknown data proportionally among known data. This approach assumes that if the missing data were known, it would be distributed in the same manner as the known data. NFPA makes additional adjustments to several fields. *Casualty and loss projections can be heavily influenced by the inclusion or exclusion of unusually serious fire.*

Rounding and percentages. The data shown are estimates and generally rounded. An entry of zero may be a true zero or it may mean that the value rounds to zero. Percentages are calculated from unrounded values. It is quite possible to have a percentage entry of up to 100% even if the rounded number entry is zero. The same rounded value may account for a slightly different percentage share. Because percentages are expressed in integers and not carried out to several decimal places, percentages that appear identical may be associated with slightly different values.

Appendix B
Data Elements in NFIRS 5.0 Related to Automatic Extinguishing Systems

M1. Presence of Automatic Extinguishment System (AES)
This is to be coded based on whether a system was or was not present in the area of fire and is designed to extinguish the fire that developed. (The latter condition might exclude, for example, a range hood dry chemical extinguishing system from being considered if the fire began in a toaster.)

Codes:

N	None Present
1	Present
2	Partial system present (Added in 2005 for use beginning in 2006)
8	NFPA recode when M1AES Presence was coded as 1- Present, M3 AES Operation was coded as 4- Failed to operate and M5 AES Failure Reason was coded as 5- Fire not in area protected
U	Undetermined (restored to coding in 2003 for use beginning in 2004)

M2. Type of Automatic Extinguishment System
If multiple systems are present, this is to be coded in terms of the (presumably) one system designed to protect the hazard where the fire started. This is a required field if the fire began within the designed range of the system. It is not clear whether questions might arise over a system that is not located in the area of fire origin but has the area of fire origin within its designed range; this has to do with the interpretation of the "area" of fire origin.

Codes:

1	Wet pipe sprinkler
2	Dry pipe sprinkler
3	Other sprinkler system
4	Dry chemical system
5	Foam system
6	Halogen type system
7	Carbon dioxide system
0	Other special hazard system
U	Undetermined

M3. Automatic Extinguishment System Operation
This is designed to capture the "operation and effectiveness" of the system relative to area of fire origin. It is also said to provide information on the "reliability" of the system. The instructions say that "effective" does not necessarily mean complete extinguishment but does mean containment and control until the fire department can complete extinguishment.

Codes:

1	System operated and was effective
2	System operated and was not effective
3	Fire too small to activate the system
4	Failed to operate
0	Other
U	Undetermined

M4. Number of Sprinklers Operating
The instructions say this is not an indication of the effectiveness of the sprinkler system. The instructions do not explicitly indicate whether this data element is relevant if the automatic extinguishment system is not a sprinkler system (as indicated in M2). The actual number is recorded in the blank provided; there are no codes.

M5. Automatic Extinguishment System Failure Reason
This is designed to capture the (one) reason why the system "failed to operate or did not operate properly." The instructions also say that this data element provides information on the "effectiveness" of the equipment. It is not clear whether this is to be completed if the system operated properly but was not effective.

Text shown in brackets is text shown in the instructions but not on the form. Note that for code 4, the phrase "wrong" is replaced by "inappropriate" in the instructions; the latter term is more precise and appropriate, although it is possible for the type of fire to be unexpected in a given occupancy.

Codes:

1	System shut off
2	Not enough agent discharged [to control the fire]
3	Agent discharged but did not reach [the] fire
4	Wrong type of system [Inappropriate system for the type of fire]
5	Fire not in area protected [by the system]
6	System components damaged
7	Lack of maintenance [including corrosion or heads painted]
8	Manual intervention [defeated the system]
0	Other ____________ [Other reason system not effective]
U	Undetermined

References

[1] U.S. Fire Administration, National Fire Data Center, *National Fire Incident Reporting System Complete Reference Guide* (U.S. Fire Administration, 2015), https://www.usfa.fema.gov/downloads/pdf/nfirs/NFIRS_Complete_Reference_Guide_2015.pdf.

[2.] H.J. Haynes, *U.S. Fire Loss during 2015* (FLX10), (Quincy, MA, U.S.: National Fire Protection Association, 2016), 2-3, http://www.nfpa.org//~/media/files/news-and-research/fire-statistics/overall-fire-statistics/osfireloss.pdf.

[3] J. R. Hall, Jr. and B. Harwood, B**.** "The National Estimates Approach to U.S. Fire Statistics," *Fire Technology* 25 no. 2 (1989): 99-113, http://www.nfpa.org/~/media/files/news-and-**research**/fire-statistics/latest-estimates/nationalestimatesapproach.pdf?la=en

[4.] M. Ahrens, *High-Rise Building Fires* (USS30) (Quincy, MA: National Fire Protection Association, 2016), 8. http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/fires-by-property-type/high-rise-building-fires.

[5] M Ahrens, *Smoke Alarms in U.S. Home Fires* (USS04) (Quincy, MA: National Fire Protection Association, 2015), 47, http://www.nfpa.org/~/media/files/news-and-research/fire-statistics/fire-protection-systems/ossmokealarms.pdf?la=en.

[6] U.S. Fire Administration, National Fire Data Center, *National Fire Incident Reporting System Complete Reference Guide* (U.S. Fire Administration, 2015) 3-27- 3-28. https://www.usfa.fema.gov/downloads/pdf/nfirs/NFIRS_Complete_Reference_Guide_2015.pdf.

[7] U.S. Census Bureau, American Housing Survey, "2011 National - Health and Safety Characteristics - All Occupied Units, Variable 1, Units by Structure Type." American Housing Survey Table Creator, accessed March 23, 2017 , https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html#?s_areas=a00000&s_year=n2011&s_tableName=TableS01&s_byGroup1=a3&s_byGroup2=a1&s_filterGroup1=t1&s_filterGroup2=g1

[8] J. Hall, Jr., M. Ahrens, and B. Evarts, *Sprinkler Impact on Fire Injury*, (Quincy, MA: Fire Protection Research Association, 2012), 6, 19.

[9] U.S. Fire Administration, National Fire Data Center, *National Fire Incident Reporting System Complete Reference Guide* (U.S. Fire Administration, 2015): 3-27- 3-28. https://www.usfa.fema.gov/downloads/pdf/nfirs/NFIRS_Complete_Reference_Guide_2015.pdf

[10] Richard Upham, *Residential fire sprinkler reliability in homes older than 20 years old in Scottsdale, AZ* (Emmitsburg, MD: National Fire Academy, 2008), 17-19, 28-29. https://nfa.usfa.fema.gov/pdf/efop/efo42677.pdf

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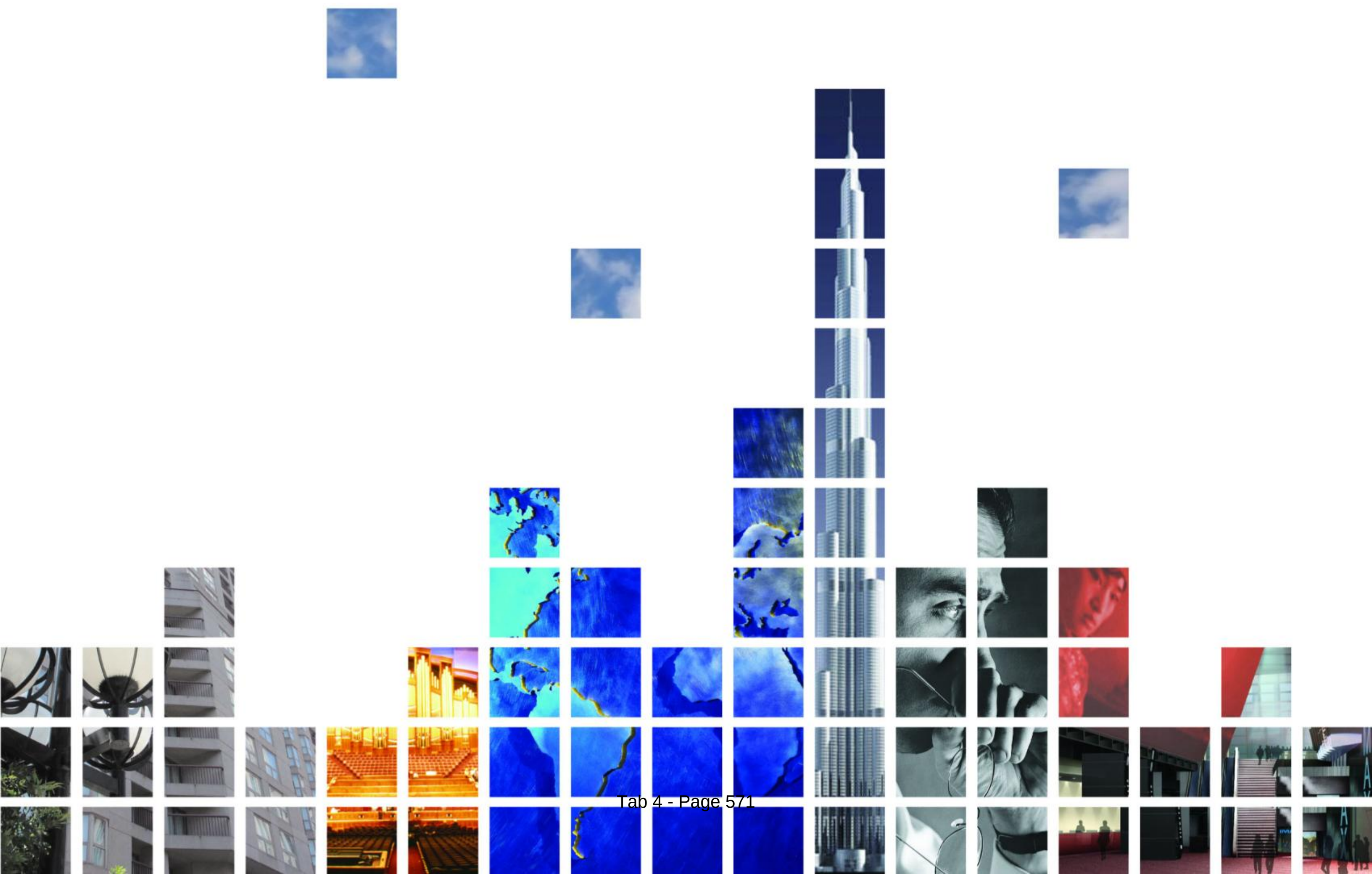
STUDY ON THE LIFE CYCLE COST OF PORTABLE FIRE EXTINGUISHERS



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STUDY ON THE LIFE CYCLE COST OF PORTABLE FIRE EXTINGUISHERS

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Prepared for:

Fire Equipment Manufacturers' Association
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January 8, 2014

RJA Project No. C58655

BACKGROUND

First developed in the early 19th century, portable fire extinguishers have long played an important role in fire safety strategy. When detected early by building occupants, portable extinguishers can be used to extinguish a fire before any significant damage occurs, often eliminating the need for fire department suppression activities. As a required feature in many buildings, portable extinguishers are subject to regular inspection and maintenance by the model fire codes, International Fire Code (IFC) and NFPA 1, and by the primary technical standard, NFPA 10, *Standard for Portable Fire Extinguishers*. Since proposals to the model codes that would mandate portable extinguishers in certain occupancies are required to consider the economic impact of such mandates, this life cycle cost analysis quantifies the impact for any size facility.

LIFE CYCLE COST ANALYSIS

Life Cycle Cost (LCC) analysis is a widely accepted methodology for comparing alternative investments or purchases to determine the most cost-effective option under a specific set of assumptions. There is a consensus standard in the US published by ASTM International that details the methodology for such an analysis, *Standard Practice for Measuring Life Cycle Costs of Buildings and Building Systems, ASTM E0917-05*.

LCC techniques are used to collect all associated costs, either single costs at a point in the system life or recurring costs over the system life, and move them to a single point in time utilizing an assumed discount (interest) rate. The discount rate selected represents the interest rate that could be realized if the money spent on the system was invested. LCC permits valid comparisons of cost over a specific period, even if the life of the alternative systems vary, since replacement costs and even cost of removal and disposal (including any salvage value) can be included.

PORTABLE EXTINGUISHER REQUIREMENTS

NFPA 10, *Standard for Portable Fire Extinguishers,* is the base document for the requirements for portable fire extinguishers and is either adopted by reference or extracted to the fire codes (NFPA 1 and the IFC), building codes (NFPA 5000, NFPA 101, and the IBC), and to specialty documents for specific occupancies, such as boats and RVs. Portable extinguishers are required in a long list of occupancies, primarily divided among those containing Class A hazards and those with Class B hazards. Sufficient Class A- or B-rated extinguishers are to be provided so that the maximum travel distance from any point to an extinguisher is 75 feet for Class A, or 30 to 50 feet from the hazard (depending on rating) for Class B. Class D and K hazards are handled as special cases with extinguishers located near the hazards.

INSPECTION AND MAINTENANCE

Portable extinguishers are required to be visually inspected at 30-day intervals and maintained at intervals of 1 year with an examination of internal parts at 1 year (unpressurized), 3 years (AFFF and FFFP) or 5/6 years (stored pressure) where such maintenance generally involves disassembly for examination of internal parts, recharging, and replacement of some parts. Pressurized extinguishers require hydrostatic pressure testing at 5 or 12 year intervals depending on agent.

MONTHLY INSPECTIONS

Every extinguisher must be inspected every 30 days to determine that:

1. The extinguisher is present;
2. Access and visibility is not obstructed; and,
3. Pressure is within a specified range.

While maintenance (annual or longer) must be performed by certified personnel [NFPA 10, Sec. 7.1.2], monthly inspections can be performed by anyone. Often these are performed by staff of the facility as an additional duty but, in any case, the recordkeeping requirements must be followed to demonstrate compliance to various authorities.

DATA AND ASSUMPTIONS

Annual extinguisher maintenance required by NFPA 10 is usually performed by an extinguisher technician under a separate contract. RJA obtained (via online search) public details of fire extinguisher contract awards by municipalities that included prices for new extinguishers and for performance of required inspections and maintenance on portable extinguishers located in municipal facilities ranging from a small town to an entire state. Quoted prices, which often included a per-building service charge and a per-extinguisher charge, covered a range reflecting the size of areas needing services and the number of extinguishers present in any building.

Because the cost data includes ranges for some costs, the economic analysis was performed as a bracketing, present value comparison. Further, since such cost analyses require an assumed service life for the equipment, it was assumed that the life of an extinguisher is 24 years, having been hydrostatically tested once (at 12 years) and then replaced at Year 24, just before a second hydrostatic test is due. For an assumed 24 year service life, there will be one hydrostatic test at Year 12 and three disassembly and recharge services at Years 6, 12, and 18 because any service due at the end of life would not be performed.

The salvage value at the end of the service life is assumed to be zero since the initial cost of each component is low. Also, disposal costs of the units and equipment are assumed to be zero.

Another assumption is the discount (interest) rate. This is set at the estimated (annual) rate of return that could be realized on alternative investment of the funds to be used for the purchase being evaluated. A rate of inflation may be included in the discount rate but does not have to be. A discount rate that includes inflation over the service life is called the *nominal* discount rate and one that does not include inflation is called the *real* discount rate. The nominal discount rate (i) is defined as:

$$i = (1+r)(1+I)-1$$

where r is the (annual) interest rate and I is the (annual) inflation rate.

Since inflation has been very low for some years, the real discount rate was used for this analysis. The baseline discount rate was assumed to be 5% which is the commonly used value for economic analysis

COST ANALYSIS SPREADSHEET

The economic analysis is easily performed using an Excel spreadsheet. See Appendix A, Present Value Analysis, attached to this report. Costs per extinguisher were listed using the low and high costs obtained to bracket the values. Costs were further categorized as first, monthly, semi-annual, annual, maintain and recharge (6 years), and hydrostatic test (12 years) to facilitate identification of costs that had the greatest impact on the overall cost.

The assumed number of extinguishers in the facility, interest rate, and service life assumptions were based to the extent possible on actual buildings. RJA examined drawings for a dozen actual health care facilities ranging in size from 33,000 sq. ft. to 560,000 sq. ft. to determine the number of extinguishers required in each, which ranged from 15 to 420. The number of extinguishers required in each facility was then divided by the gross floor area to obtain the number of extinguishers per sq. ft. This ranged from 1500 to 2000 sq. ft. per extinguisher across all 12 facilities. NFPA 10 limits area coverage to not more than 6000 sq. ft., but other requirements make this density difficult to reach in real buildings. For this analysis, it was assumed that all extinguishers are nominal 5 pound ABC dry chemical type units rated 2-A:10-B:C, as these would be the most common in these applications.

It should be understood that in a present value analysis such as this, the discount (interest) rate only affects future payments, reducing their present cost. Thus, changing the assumed discount rate will only reduce monthly, semi-annual, annual, 6- and 12-year costs that are assumed to be made at the end of the period. (Monthly costs are paid at the end of the year in which they accrued.) First costs are not affected by the discount rate.

Monthly inspection costs consist of a per-extinguisher charge only, based on the cost of an employee spending 10 to 20 minutes per month per extinguisher at $18/hr salary (including benefits) performing the inspection. If these inspections are performed by an outside contractor, the cost would likely be higher, consisting of a service charge and a per-extinguisher charge.

Annual, 6- and 12-year costs include both a fixed service charge (one per visit per facility) and a per-extinguisher charge. Costs associated with the 6- and 12-year maintenance do not include costs associated with the provision of temporary replacement extinguishers since NFPA 10 does not require such replacements where maintenance is performed on-site as is the common practice of the service industry.

Charges for hydrostatic testing are applied at Year 12 but not at Year 24 since the analysis assumes that the extinguisher will be replaced at that time. Similarly, the disassembly and recharge is performed at Years 6, 12, and 18, but not at Year 24 because the extinguisher is assumed to be replaced.

RESULTS

Because actual costs vary depending on many factors, including the facility size and geographic location, costs were calculated as a bracketing range, following conservative assumptions in each case. For 5 lb., 2-A:10-B:C extinguishers the first cost (procurement, installation, and all required inspection, testing, and maintenance over a 24 year life all paid at the time of purchase) ranged from just over $700 to just over $1400 per extinguisher.

Based on the actual health care facility extinguisher location drawings, the annual cost per square foot ranged from $.015 to $.04 per square foot per year. If a facility was able to maximize extinguisher coverage at 6,000 square feet per extinguisher, the annual cost per foot would range from .005 to $.01. While unlikely that any facility can achieve the maximum permitted coverage, this calculation is provided for comparative purposes.

APPENDIX A -- PRESENT VALUE ANALYSIS
RJA PROJECT NO. C58655-1

Activity	Cost per Extinguisher		Service Charge per Facility Visit		Notes
	Low	High	Low	High	
Initial extinguisher purchase (5 lb., 2-A:10-B:C)	$40	$56	NA	NA	Plans for 12 health care facilities were reviewed to determine extinguisher quantities and sizes
Monthly inspection labor cost (10 to 20 minutes per extinguisher per month @$18/hr.)	$3	$6	$3	$6	Where inspection performed by owner, no service charge assessed
Annual maintenance per NFPA 10	$3	$6	$50	$100	
Disassembly and recharge per NFPA 10 @ 6, 12, 18 years, incl. cost of temporary replacements	$10	$12	$50	$100	
Hydrostatic testing @12 years, incl. recharge and cost of temp. repl.	$20	$25	$50	$100	Assumes extinguisher is replaced before second hydro. test
First costs	$400	$560			
Monthly insp. cost	$33	$66	Assumes "payment" at end of each year (24 periods in analysis).		
Annual NFPA 10 cost per year	$80	$160			
Maintain and recharge per 6 years	$150	$220			
Hydrostatic test per 12 years	$150	$230			
Total extinguishers per facility	**10**		Calculation amortizes service charge over 10 extinguishers per facility		
Interest rate (%)	**5%**				
Service life (years)	**24**				
First cost	($400)	($560)			
Annual costs over life	($6,568)	($13,136)			
6 year costs over life	($258)	($378)			
12 year costs over life	($84)	($128)			
Total cost over life per exnguisher	**($731)**	**($1,420)**			
Square feet per extinguisher	2000	1500			
Annual cost per extinguisher per sq ft	($0.015)	($0.039)			

Ordinary People and Effective Operation of Fire Extinguishers

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Abstract

There is much speculation about the average person's ability to use a fire extinguisher effectively. This speculation includes the ability of a novice user to adequately extinguish a fire with a fire extinguisher without harming oneself or others.

This study employed a random sampling of the population to gather data that described and quantified several aspects relating to use, technique, and safety. Participants were presented with an extinguisher and asked to extinguish a controlled propane fire. The BullEx Intelligent Training System was used in this study to simulate a Class A fire through a controlled propane system.

Participants were recruited from the campuses of Worcester Polytechnic Institute and Eastern Kentucky University. The sample pool consisted of 276 participants who participated in a two-trial process. The first trial observed the participant's ability to use a fire extinguisher without any training or guidance from the investigators. The second trial observed the participant's ability to use a fire extinguisher with a small amount of training provided immediately after the first trial. This enabled the investigators to determine the level of ability without training or guidance (Trial 1), and improvement demonstrated for each variable after a short training session (Trial 2).

Overall, the results demonstrate that the subjects of the study were able to operate a fire extinguisher without prior training. In addition, participants demonstrated increased confidence and performance in effective operation of the extinguisher when exposed to just basic levels of training.

Executive Summary

The ordinary person is able to use a fire extinguisher without hurting themselves or others. These same people's ability to use a fire extinguisher is improved by a measureable amount when they were exposed to a minimal amount of training.

This research investigated how effectively an untrained person would be able to extinguish a small or incipient fire. Specifically, the study posed two main questions that were answered by defining the four aspects that represent effective use of a fire extinguisher: usage, technique, safety, and extinguishment simulation. These aspects were represented by variables that can be measured.

The project team conducted a search of the literature on similar studies, i.e., a person's ability to use a fire extinguisher, but no archival published literature was found. Studies do exist related to incidents in which a fire extinguisher was used in an industrial setting, whether adults above age 60 are able to extinguish a small fire, and whether a fire extinguisher is useful to have in an academic setting. It should be noted that decisions are being made about placement, use, maintenance, and testing of portable fire extinguishers. No other studies were found, however, on the untrained individual's ability to use a fire extinguisher.

The study was carried out by Worcester Polytechnic Institute and Eastern Kentucky University. To assure repeatability and constituency throughout the tests, the project team employed the BullEx Intelligent Training System (ITS). The BullEx ITS is a training simulator that teaches participants how to use a fire extinguisher against Class A, B, or C fires. For this study, the BullEx ITS was used to replicate a repeatable Class A fire for participants to extinguish. Unlike a woodcrib, the BullEx ITS allowed for a fire to be simulated in the safest conditions possible with numerous fail safes. Specifically, the ITS has the ability to extinguish the simulated fire instantly through the controller.

For two years, the study collected data from a random sampling of the population on their ability to use a fire extinguisher. Specifically, the research answered the two main study questions.

1) What is ability of the study participants to use a fire extinguisher with respect to the four key aspects: usage, technique, safety, extinguishment simulation – without prior training?
2) How much would the participants' usage, technique, safety, and fire control and extinguishment simulation improve, if at all, with a minimal amount of training?

The project team addressed these questions by conducting two trials. Trial 1 observed a participant's performance on the 10 individual variables that make up the four aspects without any prior training. In the Trial 2, participants were given a small amount of training, similar to the instructions found on the side of a fire extinguisher, and observed for any improvement on the same variables.

The results were very consistent between the two investigating universities. Overall, participants are able to use a fire extinguisher with great effectiveness. However, the studies scope was limited to only the participants' ability. It is recommended, therefore, that this study should continue on a greater scale by focusing on:

- The flight-or-fight response when confronted with a fire.
- How the BullEx ITS compares to a real Class A fire.

Acknowledgements

We would like to thank the following organizations that contributed funds, equipment, and expertise to this project. Without benefactors such as these generous groups, this project would not have been possible.

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1.0 Introduction

In most public buildings and many other locations, fire and building codes require fire extinguishers. Extinguishers are typically bright red and highly visible to the occupants. Questions surround the placement of fire extinguishers in areas where the general, untrained population may use them. If a small or incipient fire were to break out, would the untrained individual be able to operate the extinguisher? That is a central question debated by the fire-protection community every time a protection designer considers the selection and placement of portable fire extinguishers.

Currently, some fire protection professionals hypothesize that an ordinary person (“amateur”) untrained in the operation of a fire extinguisher will not use the device effectively. Furthermore, these same professionals often speculate that, even if an untrained person chose to operate the fire extinguisher, he or she would be unable to do so safely. Such questions result, in part, due to a lack of research on the many elements of the interaction between amateurs and fire extinguishers. An extensive search of the archival published literature failed to uncover any tests specifically aimed at people’s ability to use a fire extinguisher.

The purpose of this study was to collect data from a random sampling of the general population on an ordinary person’s ability to use a fire extinguisher safely and effectively. For the purposes of this study, an ordinary person is defined as an untrained, novice, or amateur user of a fire extinguisher. Specifically this study addresses the following questions and data points:

Question 1. What is an amateur’s ability to use a fire extinguisher with respect to four aspects describing this ability: usage, technique, safety, and extinguishment simulation– without prior training?

Usage – Ability of a random sampling of the population to operate a fire extinguisher.

Data points collected:

- Percentage able discharge the agent on the fire?
- Average pre-discharge time?
- Percentage that reads the label before usage?

Technique – What percentage of the same random sampling of the population who use good techniques of extinguishment?

Data points collected:

- Aims at the base of the fire?
- Uses a back and forth sweeping motion?
- Continues spraying agent after the fire appeared to be extinguished?

Safety - What percentage of the population completes the task safely?

Data points:

- Stands a safe distance away from the fire?
- Doesn’t turn his/her back on the fire?

Extinguishment Simulation – What percentage of the population is able to control and extinguish a fire?

Data Points:

- Percentage who are able to simulate extinguishment of the fire?
- Average time to extinguish a simulated Class A fire?

Question 2. With a minimal amount of training, how much would the participant improve his/her performance on the four aspects: usage, technique, safety, and extinguishment simulation?

During the 1980s a series of tests were conducted at the Underwriters Laboratories[1]. These tests were not designed to determine a person's ability to use a fire extinguisher, but to develop revisions to the UL test standard for portable fire extinguishers (1). During 1979, 1985, and 1996, the National Association of Fire Equipment Distributors (NAFED) collected data on incidents of use of portable fire extinguishers in industrial or building environments. The data from 1979 showed that 5,076 out of 5,400 fires (94%) reported were extinguished solely by one or more portable fire extinguishers. The data from 1985 showed that 1,049 out of 1,153 (91%) fires were extinguished solely by one or more portable fire extinguishers. The data from 1996 showed that 2,154 out of 2,267 fires (95%) were extinguished solely by one or more portable fire extinguishers. Of all the fires extinguished, it is unknown whether the person using the extinguisher had any formal training. The fires extinguished were a Class A, Class B, and a mixture of fire classes. The study concluded that portable fire extinguishers had an "extraordinary success rate" (2).

In 2010, D. Bruck and I. Thomas investigated "Interactions Between Human Behavior and Technology: Implications for Fire Safety Science." One part of the study examined the ability of adults above the age of 60 to use a fire extinguisher on a small fire. This study concluded that 18 out of 23 (78%) of the participants were able to extinguish a fire with a fire extinguisher in a moderate amount of time (3). The average time for extinguishment for the fire was 38 seconds with a standard deviation of 16.3 seconds (3). Of the five participants who were not able to extinguish a fire, three were able to extinguish the fire after failing the first part of the experiment's protocol. The study by Mr. Bruck and Mr. Thomas provides valuable insight on how older people use fire extinguisher equipment. As stated in their study, older adults have altered reflexes and cognition abilities that limit their reaction time.

Raymond Ranellone, a WPI graduate, conducted an investigation in 2010 called "Fire Extinguishers in Academic Settings." (4) His research involved tracking detailed news reports of incidents in which a fire extinguisher was used in an academic setting from 2001-2010 (4). Specifically, his project used Google Alerts to estimate the number of incidents in which "fire extinguishers were beneficial in providing life safety and property protection…" (4). The report documented that fire extinguishers do provide "life safety and property loss prevention." A close look at a fire incident reporting system showed that, when a fire extinguisher is used effectively, it goes largely unreported, as there is no need for further action by anyone.

A literature search was also performed that showed "to date, no study has addressed these concerns that are facing many fire protection professionals in their everyday design considerations, yet all major authors of fire, life safety, and building codes require them in many occupancies." (5) The National Fire

[1] Note: The 1984 edition of UL 711 was a revision; UL 711 was established long before then and is used to evaluate relative effectiveness of various extinguishers by using repeatable, live fire testing. The 1984 Edition of UL 299 made major changes to the design of the extinguishers, including new operating instructions and other changes based on live fire testing with novices.

Protection Association's Standard 10, Standard for Portable Fire Extinguishers, is one of the most commonly "incorporated by reference" source on the inspection, testing, and maintenance for these devices and addresses many topics on the matter. A search in the NFPA online code subscriptions using EKU's library search engine shows that this standard is referenced in at least 103 NFPA documents as of March 2, 2012 (5). The International Code Council's International Fire Code section 906 and International Building Code section 906 require the placement of fire extinguishers in many occupancies, save for few exceptions, and incorporate NFPA 10 for requirements of testing, inspection, and maintenance. The same applies to the Occupational Safety and Health Administration's Regulations in both general industry and construction as found in 1910.157, Fire Extinguishers, and many others, which also incorporates NFPA 10 by reference. As such, NFPA 10 is considered the authoritative document on the topic.

NFPA 10, 2010 edition Annex D addresses several areas related to this study, and although not mandatory, every annex to such a document must be carefully considered by the individual applying the code to the built environment. First, D.1.1.1 recognizes three types of users — those trained in extinguisher use, such as responders and employees, and two additional groups of novice users – untrained private owners and untrained members of the general public. It was the latter group, the general public novices, whom the authors of this study sought to observe.

Section D.1.2.1 in NFPA 10 recognizes five basic steps to the operation of a fire extinguisher:

1. Recognition of a device as a fire extinguisher
2. Selection and suitability of a fire extinguisher
3. Transport of a fire extinguisher to the fire
4. Actuation of the fire extinguisher
5. Application of the extinguishing agent to the fire

This study assessed the abilities of untrained individuals in all the listed areas, except number 2. This is in no way intended to minimize the importance of selecting a suitable extinguisher, but simply was not within the scope of the present study.

The United States Department of Labor and Occupational Safety and Health Administration (OSHA) has outlined a series of strict standards for the placement, use, maintenance, and testing of portable fire extinguishers provided for the use of employees. In its guidelines, "Should employees evacuate or be prepared to fight a small fire?" there is a table on options a business can take depending on its circumstances. The options range from "total evacuation with no fire extinguishers required" to "certain or all employees being able to use a fire extinguisher. (6)

The Fire Protection Engineering Department at Worcester Polytechnic Institute (WPI) and the Fire and Safety Engineering Technology Program at Eastern Kentucky University (EKU) jointly conducted a study of 276 participants. Participants between ages 18 and 76 were asked to extinguish a controlled propane fire using the BullEx Intelligent Training System (ITS) before and after some limited training. After the trials they were surveyed on their comfort level and knowledge of fire safety.

2.0 Background

The following background information provides *a Brief History on Fire Extinguishers* that will provide context on past fire extinguishers and many of the common chemical agents used today in fire extinguishers. The *Types of Fire* section details briefly the classifications of fire and classifications on the fire extinguishers used to extinguish them. Finally, the *BullEx I.T.S.* and *Smart Extinguishers* section provides details on the systems used by WPI and EKU for this research.

2.1 A Brief History of Fire Extinguishers

From hand pumps to bucket chains to portable fire extinguishers, fire extinguishing devices have been around for a long time. Can these devices be considered fire extinguishers? According to *Merriam-Webster*, a fire extinguisher is "a portable or wheeled apparatus for putting out small fires by ejecting extinguishing chemicals." (7) In 1723, German Chemist Ambrose Godfrey-Hanckwitz built the first fire extinguisher. (8; 9) His invention was a "cask of fire-extinguishing liquid containing a pewter chamber of gunpowder." (9) Notably his invention was used with great efficiency in stopping a fire in London, according to *Bradley's Weekly Messenger* on November 7, 1729. (9; 8)

However, it was not until 1818 that the modern fire extinguisher was invented by British Captain George William Manby. His invention, nicknamed "Extincteur," consisted of "a copper vessel of 3 gallons (13.6 litres) of pearl ash (potassium carbonate) solution contained within compressed air." (10; 9) The soda-acid extinguisher was invented in 1866 by Francois Carlier of France. His fire extinguisher mixed water and sodium bicarbonate with tartaric acid that produced a stream of carbon dioxide (CO_2) gases. Almon M. Granger also invented a soda-acid extinguisher in the U.S. in 1881. The soda-acid extinguisher used "the reaction between sodium bicarbonate solution and sulphuric acid to expel pressurized water onto a fire." (9; 11)

The Russian Aleksandr Loren invented the first chemical foam fire extinguisher in 1904. Similar to how the soda-acid fire extinguisher worked, the chemical reaction between water, foam of licorice root, and sodium bicarbonate would expel the CO_2-rich foam onto the fire. (9; 8; 11)

In 1910, the Pyrene Manufacturing Company of Delaware patented the use of carbon tetrachloride (CTC) on fires and in 1911 deployed this agent in their own fire extinguisher. This fire extinguisher utilized a "brass or chrome container with integrated hand pump, which was used to expel a jet of liquid towards the fire." (9) One unique aspect of this fire extinguisher was the ability to be refilled with CTC. However, CTC is toxic and converts into phosgene gas, which is most commonly found today in chemical weapons. (9) In essence, the hazards to occupants were just as great as that posed by the fire and by products of combustion.

Bell Telephone Company encouraged the invention of the next fire extinguisher. Bell needed an "electrically non-conductive chemical for extinguishing the previously difficult to extinguish fires in telephone switchboards." (9) In 1924, Walter Kidde Company invented the carbon dioxide fire extinguisher to meet Bell's need. The carbon dioxide fire extinguisher was a tall metal cylinder that held 7.5 lbs. of $CO_{2.}$ (9)

In 1954, DuPont and the U.S. Army created Halon 1301, or bromotrifluoromethane. (9) This chemical agent "opened a new era in...industrial fire protection." (12) Though Halon 1301 is not a type of fire extinguisher, this chemical agent is an incredible extinguishment tool. This miracle chemical attacks fires without harming sensitive electronics. Halon 1301 was used widely across Europe and the U.S. up to the 1980s, when speculation began that Halon 1301 caused ozone depletion. Now heavily restricted, Halon 1301 and its other iterations have phased out in favor of more environmentally friendly options. (12; 9)

Over the past century, fire extinguishers have naturally evolved from the common bucket to today's sophisticated portable fire extinguisher. This evolution implies that fire extinguishers have been a useful tool for trained or untrained individuals for close to 300 years.

2.2 Types of Fire and Extinguisher Classification

There are five different types of fire classifications, labeled A, B, C, D, and K. NFPA 10, Standard on Portable Fire Extinguishers, dictates the color, pictograph, and other components of these markings. A fire can be classified in more than one class. A campfire that uses lighter fluid to ignite can be classified as a Class A and B fire until the lighter fluid is completely burned away. (14) The following pictures used in the figures were taken from the New York City Fire Department's website [http://www.nyc.gov/html/fdny/html/home2.shtml], but are representative of those being used throughout the United States.

Figure 1: Class A Fire Symbol

Class A fires are those that are fueled by materials that, when burned, leave a residue in the form of ash. (15)
Examples: paper, wood, cloth, rubber, certain plastics

Figure 2: Class B Fire Symbol

Class B fires are those that involve flammable liquids or gasses. (15)
Examples: gasoline, paint thinner, kitchen grease, propane, acetylene

Figure 3: Class C Fire Symbol

Class C fires are those that are energized by electrical wiring or equipment. When the electricity to the equipment is cut, the classification changes to the other types of fire. (15)
Examples: motors, computers, circuit breakers

Figure 4: Class D Fire Symbol

Class D fires are those that involve "combustible metals." (15)
Examples: magnesium, titanium, sodium

Figure 5: Class K Fire Symbol

Class K fires are those that involve cooking oils and fats used in cooking appliances. (15)
Examples: vegetable oils, animal oils, fats

For this study, a Class A fire is simulated for extinguishment using the BullEx Intelligent Training System. It should be noted that Class A fires are complex fires that involve many variables. A fairly detailed discussion of Class A fires can be found in NFPA 12A, Standard on Halon 1301 fire extinguishing systems, 2009 Edition, Annex I, Fire Extinguishment. Section I.2 reads in part:

> **I.2 Fires in Solid Materials**. Two types of fires can occur in solid fuels: one in which volatile gases resulting from heating or decomposition of the fuel surface are the source of combustion; and another in which oxidation occurs at the surface of, or within, the mass of fuel. The former is commonly referred to as "flaming" combustion, while the latter is often called "smoldering" or "glowing" combustion. The two types of fires frequently occur concurrently, although one type of burning can precede the other. For example, a wood fire can start as flaming combustion and become smoldering as burning progresses. Conversely, spontaneous ignition in a pile of oily rags can begin as a smoldering fire and break into flames at some later point.

This excerpt provides the background for discussion on the complexity of Class A fires and extinguishment with portable fire extinguishers. Portable fire extinguishers are installed in buildings to be used on small fires during their incipient stage. Typically, the incipient stage of a Class A fire includes flaming combustion at the surface of the fuel and will not include smoldering (deep seated) combustion because significant heat buildup is needed that can only occur over a prolonged period of time (not at the beginning stages of a fire).

The discussion in NFPA 12A continues:

> Flaming combustion, because it occurs in the vapor phase, is promptly extinguished with low levels of Halon 1301. In the absence of smoldering combustion, it will stay out.

Although the excerpt references the extinguishing agent Halon 1301, the concept can be used in a discussion of other extinguishing agents and portable fire extinguishers. A reasonable assumption is that the flaming combustion of an incipient fire can also be promptly extinguished with other more potent extinguishing agents applied with portable fire extinguishers. Once extinguished, these fires will stay out due to the absence of smoldering combustion.

2.3 BullEx Intelligent Training System

The BullEx Intelligent Training System (ITS) is a tool for training ordinary people how to properly and effectively use a fire extinguisher. The ITS uses sensor technology to determine if the trainee demonstrates the proper technique to extinguish a fire. The proper technique to extinguish a fire using the BullEx ITS is described later in the methods section.

On the front of the unit, there are four sensors that detect the sound of compressed air and water vapor being discharged from the Smart Extinguisher. These sensors are connected to a microprocessor that controls the flow of propane to the burner. (16) The system responds to different scenarios depending on how the user performs. For example, if the participant is aiming above or below the base of the flames, the system will dim the flames but not fully extinguish them. If the participant aims at one side of the flames only, it will extinguish on that side but increase in intensity on the other.

The Bull-Ex ITS consists of four parts: the unit, a propane fuel source, an electrical source, and a controller. The unit is 28 3/4" x 18" x 13", is made out of stainless steel, and has four 40 kHz ultrasonic sensors on the front. (16) Fueled by a conventional 20-lb. propane tank, the system produces 500,000 Btu/h. (16) The entire system is powered by a 12V DC battery pack that draws up to 6 amps. The final part of the unit, the controller, controls the fire. (16) The controller has settings for a Class A, B, or C fire. For each setting, the fire can be assigned a difficulty ranging from 1 to 4, with 1 being the easiest and 4 the hardest. (16)

Figure 6: BullEx ITS Activated

The system has five safety features that prevent accidental injury to the participant or trainer.

1. The controller has an emergency stop/deadman switch on the controller. The switch needs to be fully depressed and held for the system to run. If the switch is released or controller disconnected while testing, the system will immediately shut off. (16)
2. A bump/tilt sensor. If the system is no longer level, the unit will issue a loud beep and will need user input to reset the system. (16)
3. An auto-ignition pilot light that continuously sparks until there is ignition. (16)
4. An auto-off after 25 seconds of full-flame evolution. (16)
5. The system cannot be started unless a key-code entry is entered at start up. If an incorrect code is entered, the system will force the user to reassemble the unit before allowing the code to be input again. (16)

2.3 BullEx Smart Extinguishers

BullEx Smart Extinguishers are training extinguishers used to deploy agent on the controlled propane fire. The extinguisher comes in a variety of sizes to represent different types of fire extinguishers. The fire extinguishers are differentiated by how many discharges it has before refilling. This is marked either by 5X or 7X, standing for five or seven discharges before refilling respectively. (16) 5X extinguishers are filled with four liters of water. 7X extinguishers need six liters of water. All extinguishers are filled with 100 PSI of regular air. (16) This is marked by the Schrader valve on the extinguisher. The extinguishers have approximately 15 seconds of discharge time of the agent before the pressure inside the extinguisher is too low. (15)

BullEx Smart Extinguishers mimic actual fire extinguishers in their size, shape, and weight. Most fire extinguishers can be described as metal cylinders filled with an agent to be deployed at high pressure on a fire. The agent is deployed from the extinguisher by the depression of the lever, allowing the pressurized air and water to escape (13).


Figure 7: BullEx Smart Extinguisher filled and ready for use.

3.0 Methods

This section details the study methodologies used for selecting participants, setting up the BullEx ITS, conducting the experiments, recording on each of the four aspects, and surveying the participants after the trials. The methods used during the study are discussed by topic. The *Participant Selection* section details information on the types of participants selected in the study. The *Set Up* section provides information concerning the materials used on how the BullEx system was set up in the WPI Fire Lab and EKU test site. *The Experiment* describes how the trials were carried out along with information defining the four aspects of fire extinguishers and their variables. Finally, the *Survey* details the final steps of experiment and how the survey was administered. A copy of the survey form given to participants can be found on page 18.

3.1 Participant Selection

The most effective way to test an amateur's ability to operate a fire extinguisher is to use a random sample of the population near the testing site. For WPI, the testing site is located in Higgins Laboratory in Worcester, MA WPI's random sampling of the population consisted of a diverse group of participants, including undergraduate and graduate students, faculty and staff at WPI. At EKU, the sample came from faculty and staff only employed at EKU's main campus in Richmond, KY, as well as the remote campuses in Corbin, Manchester, and Danville, KY.

3.2 Set Up

The BullEx ITS testing protocol set up was duplicated at both investigating locations, save for the type of location itself. At WPI, the location was in the WPI Fire Labs. The test areas for EKU's data collection mimicked the set up as described below, but occurred at several locations consisting of the main and several remote campuses. An outdoor location at the site of each EKU test was chosen to provide protection from wind gusts and vehicular traffic.

The complete system was assembled and disassembled following the BullEx guidelines. The BullEx ITS unit was placed in the middle of the identified test area free of any debris or unassociated items. To one side of the unit, a gas source and power source was located. There was a distance of at least four feet between the system and any object, wall or bench.

Two Bull-Ex Smart Extinguishers 7x were placed 10 feet away from the front of the propane training system. Each extinguisher was filled with six liters of water and pressurized to 100 PSI.

After the BullEx ITS base unit was placed in the center of the test areas, the quick-connect propane hose was connected to the rear of the ITS base unit. The other end of the hose was attached to the propane tank. The male end of the black controller cable was inserted into the ITS, and the female end inserted into the handheld controller. The yellow power cable was inserted into the rear of the ITS base unit. The other end of the power cable was inserted into the 12 V battery pack. The battery pack had an industrial-grade extension cable inserted into the battery pack and wall circuit. The ITS unit was leveled by adjusting the position and adjustable feet. The unit was then filled with water until it overflowed the overflow cut-outs. The sensor guard was then removed and placed eight feet away in front of the unit. The propane valve was opened and soapy water solution was added on all connections on the propane hose and unit to check for leaks.

The head assemblies of the BullEx Smart Extinguishers were removed and placed gently on the table to prevent damage. Six liters of water were measured out and slowly added into the fire extinguisher. The head assemblies were then placed back inside the fire extinguisher and screwed on hand-tight. They were carried to the air pressure valve and filled with 100 PSI or until no sound of filling was heard. This was marked by the sound of no rushing bubbles inside the fire extinguisher. The single metal pin was inserted into the tank so that the loop was beside the valve. The pin was perpendicular to the floor when the BullEx plastic break-away tamper tab was inserted around the top part of the handle and tightened so the pin could not move freely. The extinguisher was placed off to the side one foot away from where the participant was asked to stand.

The startup sequence was entered into the controller and the ITS was started up to make sure all systems were working on a setting of Class A Level 2. The system ran for 15 seconds before the switch was let go and testing could begin.

3.3 The Experiment

WPI and EKU employed the same experimental procedure and data-recording procedure. This was achieved by common test protocol and data-collection spreadsheet. Each participant was provided a date and a location for the test. When participants arrived, they were directed to read through the Institutional Review Board Approved Informed Consent Agreement for Participation. After they reported that they fully understood the form and signed it, they were given a safety briefing. Only one participant was permitted in the testing area at a time. For Trial 1, the participant stood 10 feet away from the system and was read a short introduction to the study and what to do:

> Hello, today you are participating in our study on fire extinguishers. There is a fire extinguisher to your left (POINT TO BULLEX EXTINGUISHER). We will be remotely lighting the fire. When you see the flames from the BullEx ITS (POINT TO BULLEX ITS), we will ask you to grab the extinguisher and use it to extinguish the fire we have created. Please stay behind the safety line at all times (Point at safety line). There is a label on the extinguisher to answer any questions. We are now ready to start the study. The BullEx System takes a few seconds to warm up so I will give you a verbal “Go” when you may look at the fire extinguisher and use it to extinguish the fire to the best of your abilities.

The area was checked once more to ensure the safest possible testing environment. After pressing down the BullEx ITS ignition key, the fire lit and the investigator gave a verbal “Go” when the fire reached full intensity. Two stopwatches were used to record the pre-discharge time and the total time it took to discharge agent. At any time, the test was stopped when the subject stopped discharging agent, the fire extinguisher ran out of compressed air, or there was a safety violation.

In this experiment, the BullEx ITS worked as a constant test source, as it was able to reproduce the same intensity fire for every simulation. When the BullEx ITS had reached full flame evolution or intensity, the system emitted a beep and began recording time until extinguishment. When the beep was heard by the investigator, he/she gave the verbal “Go.” The ITS continued to simulate a Class A fire until the participant was able to extinguish the simulated fire. For a participant to extinguish the fire, the water spray from the Smart Extinguisher would be recognized as an acoustic signature by the BullEx ITS. Depending on the signature made by the water spray, the system would be able to understand the trajectory of the agent and vary the heights of the flames by metering the flow of propane. The fire was considered extinguished when the controller displayed an extinguishment time.

The participants were observed and measured on the two main questions posed at the start of this paper. The two main questions can be broken down into four aspects, each with a set of variables.

3.3.1 Usage

Percent Discharged: The percentage of subjects who were able to expel the agent onto the simulated fire.

Pre-Discharge Time: The time from when the subject was told to start until the time when the agent was discharged from the fire extinguisher, measured in seconds. This time involves the subject picking up the fire extinguisher, reading the label if he/she choose to do so, breaking the seal, removing the pin, and applying pressure to the level to expel the agent.

Read the Label: The percentage of subjects who read the label of the fire extinguisher before or during the individual trial.

3.3.2 Technique

Percent Aimed at Base of the Fire: The percentage of subjects who consistently aimed at the base of the fire as they discharged agent.

Swept Back and Forth: The percentage of subjects that used a proper sweeping motion when applying agent to the fire. The proper sweeping motion is detailed as a moderate sweep of the agent across the entire fire from both left to right or right to left and back again.

Continued to Apply Agent: The percentage of subjects that continued to apply agent after the fire was no longer visible and the BullEx ITS indicated extinguishment.

3.3.3 Safety

Stood a Safe Distance Away from the Fire: The percentage of subjects that did not cross the eight-feet safety line.

Back to Fire: The percentage of subjects who physically turned their backs to the fire. This is measured by observing the subject and noting whether their shoulders were parallel with the sides of the BullEx ITS.

<u>3.3.4 Extinguishment Simulation</u>

Able to Simulate Extinguishment: The percentage of the subjects who were able to simulate extinguishment and an extinguishment time was displayed on the BullEx controller.

Average Time to Extinguish a Simulated Class A Fire: Time from when the BullEx ITS activated its internal stopwatch until the BullEx system determined that the simulated Class A fire was extinguished, subtracted from the amount of time the participant took to deploy agent onto the fire.

For Trial 2 of the experiment, the participant was directed back to the 10-foot mark for the test to begin. The investigators briefed the participant on the proper way to safely and effectively use a fire extinguisher via a training sheet. The sheet was modeled after the "P.A.S.S" technique (Pull, Aim, Squeeze, and Sweep). The first tip on the sheet was "Twist pin to break seal." The investigator showed the physical action in the air of inserting fingers into the imaginary pin and twisting left or right.

The next tip is to "Pull pin put". The investigator demonstrated this with a quick tug of the imaginary pin in the air. The investigator also verbally mentioned that the plastic seal can be broken by pulling it apart with their fingers instead of using the pin to break the seal.

After "Pull pin out," the sheet recommends to "Stand back 6-8 feet" from the fire. The investigator reiterated the point of that this is general fire safety information and for lab safety. If the participant crosses a safety line that is eight feet away from the fire, the investigator stops the test.

The sheet then briefed the participant on the proper way to deploy the agent stored in the fire extinguisher: "Aim and squeeze the lever. Aim at the base of flame. Use a slow sweeping motion. Continue to spray until you are sure fire will not rekindle." The investigator gestured and mimicked aiming at the base while using a slow sweeping motion toward the BullEx ITS.

When the participant indicated an understanding of the proper technique, he/she was briefed for the next trial:

> You have now been briefed on the proper way to extinguish a fire. We ask you now to use the training we have just issued you while you repeat our experiment. We ask you again to be sure to not step over the tape line for your safety. The extinguisher is full and ready for use. We are now ready to begin the second trial of our experiment; we will again be giving you a verbal "Go" for when to begin.

The participant was then timed and observed again on fire extinguisher usage and general fire safety knowledge. When the second trial was over, the participant was directed out of the lab area to a place where he/she could fill out the survey. Any questions or concerns of the participant were addressed at this point. At this time, one of the investigators reset the experiment area by clearing away the floor from the plastic break-away tamper tabs and refilling the extinguisher. The extinguishers were refilled with compressed air after every test and with water after every two to three tests.

<u>3.4 Survey</u>

A post-trial survey was used to gauge the participant's general knowledge of fire safety, his/her experiences with fire, and overall comfort level with the experiment. The survey was given directly after completion of Trial 2. The investigator briefed participants to fill out the survey to the best of their abilities and said to feel free to ask questions about the survey if any arose. The investigator then left the room to help his/her partner in setting up the experiment for the next participant or briefing new participants on what they were about to test for.

Fire Protection Lab (Survey Form)

Fire extinguishment assessment

Please put an "X" in the column that best shows your answer:

How often does this happen?	Never/None	A little	Some	A lot	Strongly agree/Always	Yes	No
Have you ever used a fire extinguisher before?							
What is your knowledge level of fire extinguishers?							
Have you ever witnessed a real fire?							
Can you remember your last fire training course?							
Can you remember your last fire drill?							
Comfort level in extinguishing a Fire before the experiment?							
Comfort level in extinguishing a fire after the experiment?							

- What was your age during your most recent fire drill or fire safety training?
- Have you had a real life situation with a fire? If so please explain what actions you took.
- Briefly state any Do's and Don'ts in extinguishing fires:
- What is your first form of action when a fire is present? Ex. Run, call authorities, or look for a fire extinguisher
- Did you find the training sheet is an effective way to teach an individual how to properly use a fire extinguisher or do you find that the instructions on the fire extinguisher are sufficient?

4.0 Results

The quantitative data collected on each of the four aspects of ordinary people and the effective operation of fire extinguishers is presented here. This data answers the two main study questions[2]:

1. What is an amateur's ability to use a fire extinguisher with respect to the four aspects (usage, technique, safety, extinguishment simulation) without prior training?
2. How much, if at all, would the participants improve their usage, technique, safety, and fire control and extinguishment simulation with a minimal amount of training?

Presentation of the results is organized by the four individual aspects of fire extinguishers: usage, technique, safety, and extinguishment simulation. For each aspect, multiple data points were collected.

[2] The Results section of this report details the results collected from WPI 2011, WPI 2012, and EKU 2011-2012. WPI 2011 and WPI 2012 are not combined, as there were different primary investigators collecting the research. For WPI 2011, Scott Brady and Chrystian Dennis were the primary investigators. Along with Professor William Hicks and Professor Kathy Notarianni, they created the procedure, handout, and survey to give to students. For WPI 2012, Brandon Poole was the primary investigator. Working with Professor Notarianni, they updated the procedure and survey for clarification. As previously mentioned, all investigators at WPI and EKU followed the same guidelines and procedures to collect the data.

Each section of the results focuses one of these aspects and the specific data points collected that define the aspect both for Trial 1 – with no prior training, and Trial 2 – with minimal amount of training. The last section contains data concerning the survey administered to participants from EKU and WPI 2012.

Between January 20 to February 22, 2012, 85 participants were tested using the BullEx ITS on key aspects of fire extinguisher usage for WPI 2012 testing. During the previous academic year (2011-2012), WPI and EKU also collected data, bringing the grand total of number of participants that chose to contribute to the study to a staggering 276. WPI 2010-2011 data contributed 64 participants. EKU 2010-2012 data contributed 127 participants. WPI 2011-2012 data contributed 85 participants.

For WPI 2011, 80% of those were male and 20% were female. The average age of participants was 20 years. For WPI 2012, 74% of those were male and 26% were female. This ratio, while skewed in favor of the male population, was expected as the ratio of male to female students at WPI is 3:1. (17) The average age of the participants was 21 years. The range of ages for WPI 2011-2012 was 18 to 56 years. For EKU 2010-2012, 61% of participants were males and 39% were female. The average age of the participants was 36 years. The range of ages for EKU was 20 to 76 years.

4.1 Key Milestones of Usage Results

During the experiment, participants demonstrated their ability to use a fire extinguisher as they deployed agent. Specifically, the investigators observed whether or not the participants read the label on the extinguisher, if they were able to discharge agent from the extinguisher, and the amount of time it took them to deploy the agent.

Observations from both locations included:

- Throughout the experiment, it was observed that many participants had difficulty pulling the pin out from the extinguisher.
- There were occurrences in which participants did not use enough strength to pull the pin, which led them to read or reread the label.
- For Trial 1, one participant was not able to understand how to pull the pin out of the extinguisher, and the machine timed out after the fire had burned for one minute and 30 seconds.
-

Table 1: Trial 1 Collected Data for Key Milestones of Usage

Trial 1 Collected Data for Key Milestones of Usage*				
	# of tests conducted	% able to discharge agent	Ave. Pre-discharge time (sec)	Read Label
WPI ‘11	64	100%	15.2	47%
WPI ‘12	85	99%	14.6	49%
EKU ’11-‘12	127	97%	11.6	16%
TOTAL/AVERAGE	276	98%	13.4	33%

*BullEx ITS and Smart Extinguishers were used to measure these variables

Table 1, Trial 1 Collected Data for Key Milestones of Usage, shows all the collected data throughout the entire experiment for key milestones of usage for Trial 1. Specifically this table looks at the number of participants in Trial 1 and the averages for the trial. For WPI ’11, all 64 participants were able to discharge agent onto the fire; 47% chose to read the label with an average discharge time of 15.2 seconds. EKU ’11-’12 had 127 participants, of which 97% were able to discharge the agent; 16% read the label; and the average discharge time was 11.6 seconds. WPI ’12 had 85 participants; 99% of those were able to discharge the agent with 49% reading the label and an average discharge time of 14.6 seconds. The total number of tests conducted for Trial 1 was 276, with 98% of those who participated being able to discharge agent, 33% chose to read the label, and an average discharge time of 13.4 seconds overall.

Table 2: Trial 2 Collected Data for Key Milestones of Usage

Trial 2 Collected Data for Key Milestones of Usage*				
	# of tests conducted	% able to discharge agent	Ave. Pre-discharge time (sec)	Read Label
WPI ‘11	64	100%	6.5	2%
WPI ‘12	85	100%	6.7	7%
EKU ’11-‘12	127	100%	7.9	22%
TOTAL/AVERAGE	276	100%	7.2	13%

* BullEx ITS and Smart Extinguishers were used to measure these variables

Table 2, Trial 2 Collected Data for Key Milestones of Usage, shows all collected data throughout the entire experiment for key milestone of usage for Trial 2. Specifically this table looks at the numbers of participants in Trial 2 and the averages for the trial. For all participants, they were able to discharge the agent. For WPI ’11, 2% chose to read the label, EKU ’11-’12, 22% chose to read the label and WPI ’12 7% chose to read the label. Of the 276 particpants, 13% chose to read the label. WPI ’11 discharge times average for 64 participants was 6.5 seconds. EKU ’11-’12 average discharge times average for 127 was 7.9 seconds. WPI ’12 average discharge time for 85 participants was 6.7 seconds. The average time for the 276 participants was 7.2 seconds.

Table 3: Percent Improvement with Training for Key Milestones of Usage

Percent Improvement with Training for Key Milestones of Usage*				
	# of tests conducted	% able to discharge	Pre-discharge time (sec)	Read Label
WPI '11	64	All Subjects Discharged Agent	Decreased by 57%	Decreased by 45%
WPI '12	85	All Subjects Discharged Agent	Decreased by 54%	Decreased by 42%
EKU '11-'12	127	All Subjects Discharged Agent	Decreased by 31%	Decreased by 6%
TOTAL/AVERAGE	276	All Subjects Discharged Agent	Decreased by 44%	Decreased by 26%

* BullEx ITS and Smart Extinguishers were used to measure these variables

Table 3, Percent Improvement with Training for Key Milestones of Usage, shows the percentage improvement from Trial 1 to Trial 2 for key milestones of usage. Overall, all 276 participants were able to discharge agent. There was a 46% decrease in discharge agent time. And there was a 20% decrease in reading the label.

Figure 8: Participant viewing the label on the BullEx Smart Extinguisher while BullEx ITS was active

Figure 8 shows a participant squatting down to read the label on the fire extinguisher. The participant was not permitted to read the label on the fire extinguisher before the BullEx system reached full intensity. A verbal "Go" was given when the system started recording the time until stopping the discharge and this was the first action of the participant. At all times the participant had the fire and BullEx ITS in his field of vision.

4.2 Technique in Handling a Fire Extinguisher Results

Participants were then observed on their technique as they handled the fire extinguisher. Did they aim at the base of the fire, use a slow back and forth sweeping motion, and continue to spray after the fire was not visible?

Observations from both locations included:

- In one occurrence a participant did not grab the hose from the holder on the fire extinguisher and used the base of the fire extinguisher to aim at the fire.
- Another participant misread the instructions and pulsed on the handle of the fire extinguisher to deploy the agent instead of allowing for a continuous stream.

Table 4: Trial 1 Technique in Handling a Fire Extinguisher

Trial 1 Technique in Handling a Fire Extinguisher*				
	# of tests conducted	Aimed at base of fire	Back/forth sweeping motion	Continued to spray after fire not visible
WPI '11	64	64%	81%	50%
WPI '12	85	54%	45%	32%
EKU '11-'12	127	88%	89%	57%
TOTAL/AVERAGE	276	72%	74%	48%

* BullEx ITS and Smart Extinguishers were used to measure these variables

Table 4, Trial 1 Technique in Handling a Fire Extinguisher, shows all the collected data for Trial 1. For WPI '11, 64% aimed at the base of the fire, 81% used a back-and-forth sweeping motion, and 50% continued to spray after the fire was not visible. For EKU '11-'12, 88% aimed at base of fire, 89% used a back-and-forth sweeping motion, and 57% continued to spray after the fire was not visible. For WPI '12, 54% aimed at the base of the fire, 45% used a back-and-forth sweeping motion, and 32% continued to spray after fire was not visible. For all 276 participants, 72% aimed at the base of the fire, 74% used a back-and-forth sweeping motion, and 48% continued to spray after fire was not visible.

Table 5: Trial 2 Technique in Handling a Fire Extinguisher

Trial 2 Technique in Handling a Fire Extinguisher*				
	# of tests conducted	Aimed at base of fire	Back/forth sweeping motion	Continued to spray after fire not visible
WPI '11	64	98%	100%	80%
WPI '12	85	86%	94%	86%
EKU '11-'12	127	96%	95%	82%
TOTAL/AVERAGE	276	93%	96%	83%

* BullEx ITS and Smart Extinguishers were used to measure these variables

Table 5, Trial 2 Technique in Handling a Fire Extinguisher, shows all the collected data for Trial 2. For WPI ’11, 98% aimed at the base of the fire, 100% used a back-and-forth sweeping motion, and 80% continued to spray after the fire was not visible. For EKU ’11-’12, 96% aimed at base of fire, 95% used a back-and-forth sweeping motion, and 82% continued to spray after the fire was not visible. For WPI ’12, 86% aimed at the base of the fire, 94% used a back-and-forth sweeping motion, and 86% continued to spray after fire was not visible. For all 276 participants, 93% aimed at the base of the fire, 96% used a back-and-forth sweeping motion, and 83% continued to spray after fire was not visible.

Table 6: Percent Improvement of Technique in Handling a Fire Extinguisher

Percent Improvement of Technique in Handling a Fire Extinguisher*				
	# of tests conducted	Aimed at base of fire	Back/forth sweeping motion	Continued to spray after fire not visible
WPI ‘11	64	Increased by 34%	Increased by 19%	Increased by 30%
WPI ‘12	85	Increased by 32%	Increased by 49%	Increased by 52%
EKU ’11-‘12	127	Increased by 8%	Increased by 6%	Increased by 25%
TOTAL/AVERAGE	276	Increased by 21%	Increased by 22%	Increased by 34%

*BullEx ITS and Smart Extinguishers were used to measure these variables

Table 6, Percent Improvement of Technique in Handling a Fire Extinguisher, shows the percentage improvement from Trial 1 to Trial 2. Overall, 276 participants improved their ability to aim at the base of the fire by 21%, so 93% aimed at the base. Participants improved their ability to use the proper sweep technique by 22%, so 96% used the sweeping back-and-forth motion. Finally, 83% of participants continued to spray after the fire was not visible, a 35% increase.

Figure 9: Participant aiming above the base of the BullEx ITS

Figure 9 shows the participant incorrectly aiming at the top of the flames. The compressed air and water mixture was depolyed to the top of the flames and sprayed the door instead of the base of the flames. A black line was added to indicate where the base of the flames are.

Figure 10: Participant aiming at the base of the BullEx ITS

Figure 10 shows a participant correctly aiming at the base of the BullEx ITS unit. The participant also used a slow sweeping motion as she aimed at the base of the flames to deploy agent.

Figure 11: Participant using a sweeping motion to deploy agent on BullEx ITS

Figure 11 shows a participant aiming at the base of the flames and using a slow sweeping motion across the BullEx ITS system. The two arrows represent the path that should be followed as the extinguisher is swept slowly from side to side. The BullEx ITS system reacts to the correct sweeping motion and aiming at the base, as signified by dimming of the flames on the right side of the unit.

 

Figure 12 and 13: Participant is not continuously deploying agent

Figures 12 and 13 shows a particpant extinguishing the fire but but not continuing to deploy agent. The fire re-ignites in Figure 13 as the participant begins to turn away from the fire.

Figure 14: Participant continuously deploys agent on propane fire, thereby preventing re-ignition

Figure 14 shows a participant continuously deploying agent onto the fire by using the proper technique. The participant continued to spray the unit until she was told that the trial was over.

4.3 Key Knowledge in Fire Safety Results

During the test, participants were observed for key knowledge in fire safety. Did the participant turn his/her back to the fire once it was started, and did the participant cross the recommended safety distance of eight feet from the fire?

Table 7: Key Knowledge in Fire Safety for Trial 1

Key Knowledge in Fire Safety for Trial 1*			
	# of tests conducted	Stood a safe distance away	Turned back to fire
WPI '11	64	100%	2%
WPI '12	85	100%	4%
EKU '11-'12	127	99%	6%
TOTAL/AVERAGE	276	100%	4%

*BullEx ITS and Smart Extinguishers were used to measure these variables

Table 7, Key Knowledge in Fire Safety for Trial 1, shows data for Trial 1. For WPI '11, all participants stood a safe distance away from the fire, and 2% turned their backs to the fire. For EKU '11-'12, 99% of participants stood a safe distance away from the fire, and 6% turned their backs to it. For WPI '12, all participants stood a safe distance away, and 4% turned their backs to the fire. Overall, on average all participants stood a safe distance away, and 4% turned their backs to the fire.

Table 8: Key Knowledge in Fire Safety for Trial 2

Key Knowledge in Fire Safety for Trial 2*			
	# of tests conducted	Stood a safe distance away	Turned back to fire
WPI '11	64	100%	0%
WPI '12	85	100%	4%
EKU '11-'12	127	100%	2%
TOTAL/AVERAGE	276	100%	2%

*BullEx ITS and Smart Extinguishers were used to measure these variables

Table 8, Key Knowledge in Fire Safety for Trial 2, shows data, for Trial 2. For WPI '11, all participants stood a safe distance away from the fire and no one turned their backs to the fire. For EKU '11-'12, all participants stood a safe distance away from the fire, and 2% turned their backs to it. For WPI '12, all participants stood a safe distance away, and 4% turned their backs to the fire. Overall, on average all participants stood a safe distance away, and 2% turned their backs to the fire.

Table 9: Percent Improvement of Key Knowledge in Fire Safety

Percent Improvement of Key Knowledge in Fire Safety*			
	# of tests conducted	Stood a safe distance away	Turned back to fire
WPI '11	64	All participants stood a safe distance back	Decreased by 2%
WPI '12	85	All participant stood a safe distance back	Decreased by 0%
EKU '11-'12	127	All participants stood a safe distance back	Decreased by 4%
TOTAL/AVERAGE	276	All participants stood a safe distance back	Decreased by 2%

*BullEx ITS and Smart Extinguishers were used to measure these variables

Table 9, Percent Improvement of Key Knowledge in Fire Safety shows the percent improvement of key knowledge in fire safety from Trial 1 to Trial 2. Overall, all participants stood a safe distance away. The percentage of participants who turned their backs to the fire was decreased by 2%

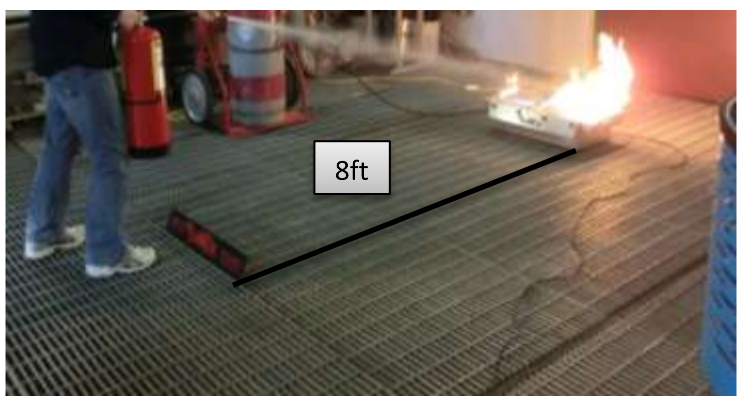

Figure 16: Participant standing just over 8ft away from the BullEx ITS

Figure 16 shows a participant standing more than eight feet away from the BullEx ITS system. Due to safety regulations, if a participant were to cross the BullEx black sensor guard, the investigator would immediately end the test due to safety concerns.

Figure 17: Participant turning back to the fire while attempting to free the pin from the BullEx Smart Extinguisher

Figure 17 shows a participant turning her back to the fire. The participant immediately turned her back to the fire to read the label and then attempted to free the pin from the fire extinguisher.

4.4 Participants Effectiveness in Extinguishing a Simulated Fire Results

During the tests, participants were observed on how effective they use the BullEx device to simulate extinguishment. For this study, we used a setting that simulates a Class A fire. Although the device provides an extinguishment time when the proper technique is used and simulated extinguishment occurs, the results are not intended to be used as a direct correlation with actual Class A fires due to the many variables that are associated with a Class A fire.

Further testing is needed to determine if the extinguishment times achieved using a BullEx training tool correlate with the extinguishment times achieved using a fire extinguisher on a real fire. The following information lists the percentages of participants able to cause extinguishment simulation via the BullEx ITS and the average amount of time it took to simulate extinguishment for all the trials.

In Trial 1, 65% of the 276 participants (both WPI and EKU) were able to extinguish the fire using the BullEx ITS. The average amount of time it took to extinguish the simulated fire was 11.2 seconds. In Trial 2, 90% of the participants were able to cause extinguishment simulation via the BullEx ITS. The average amount of time it took to extinguish the simulated fire was 7.3 seconds. In this portion of the study, there was a 25% increase in the number of test subjects able to cause a simulated extinguishment in the second trial. In addition to this increase, the time to achieve a simulated extinguishment was reduced by an average of 34%.

4.5 Survey Results

The same survey was given out to all study participants. The survey's purpose was to understand the participant's knowledge about fire safety, experiences with fire, and overall comfort level with the experiment. Participants were surveyed on 15 questions in a table or free response.

Only one question from the table section generated useful information: Have you ever witnessed a real fire? The remaining questions in the table had a wide variety of responses to the seven possible choices.

In the free response section, eight questions gave adequate responses. Of the five questions on the original survey sheet, four more were asked verbally and added at the end of the survey. The verbal questions were:

1. Have you ever used a fire extinguisher before? Yes/no.
2. On a scale of 1-10 with 1 being the most uncomfortable and 10 being the most comfortable, what was your comfort level of using an extinguisher before this experiment?
3. On the same scale of 1-10, what is your comfort level with using an extinguisher after this experiment?
4. Did you find the training sheet an effective way to teach an individual how to properly use a fire extinguisher, or do you find that the instructions on the fire extinguisher are sufficient?

Table 10: Survey Responses

WPI	Witnessed Fire	Age of Last Fire Drill	Used a Fire Extinguisher	Comfort Level Before Using the BullEx ITS	After using the BullEx ITS	Instructions after Trial 1 were more helpful
	49%	19	11%	6	9	31%

EKU	Witnessed Fire	Age of Last Fire Drill	Used a Fire Extinguisher	Comfort Level Before Using the BullEx ITS	After using the BullEx ITS	Instructions after Trial 1 were more helpful
	54%	32	17%	5	9	45%

Table 10, Survey Responses, show the percentage of participants from both test locations who have witnessed a fire, the average age of participants' last fire drill, the percentage of participants who have used a fire extinguisher before, the average comfort level of the use of a fire extinguisher before and after an experiment, and the percentage of participants who clearly stated that the instructions were more helpful.

Of the 127 participants tested by EKU, 54% had witnessed a fire emergency. The average age of the participants' last fire drill was 32 years. Seventeen percent of participants had used a fire extinguisher before this experiment. On a scale of 1-10 with 1 being the most uncomfortable and 10 being the most comfortable, the average participant had a comfort level of 5 before picking up a fire extinguisher. After the experiment, the average participant had a comfort level of 9. Of the 127 participants, 45% said that the instructions were more helpful than what was written on the fire extinguisher.

Of the 85 participants tested by WPI '12, 49% had witnessed a fire emergency. The average age of the participants' last fire drill was 19 years. Eleven percent of participants had used a fire extinguisher before this experiment. On a scale of 1-10 with 1 being the most uncomfortable and 10 being the most comfortable, the average participant had a comfort level of 6 before picking up a fire extinguisher. After the experiment, the average participant had a comfort level of 9. Of the 85 participants, 31% said that the instructions were more helpful than what was written on the fire extinguisher. This does not mean that 69% did not find the instructions more helpful, but chose not to respond to the final question.

Both studies collected similar results for the query *Briefly state any Do's and Don'ts in extinguishing a fire.* Most participants chose to respond by reiterating the instructions on the fire extinguisher and what was verbally told to them. Some participants added this *Do*: Keep calm during a fire and not to panic. A few participants added specific information on how to extinguish specific fires, such as not using water on grease fires.

5.0 Discussion

The purpose of this study was to examine the current questions of the fire protection industry concerning the ability of amateurs to operate a portable fire extinguisher. The study was conducted in two stages to answer the two separate questions:

- What are the capabilities of the novice population to operate a fire extinguisher effectively?
- How well can the above performance improve with a small amount of training?

WPI and EKU studied this problem and conducted experiments involving 276 participants. Study participants discharged a fire extinguisher on a simulated fire using the BullEx ITS. They were observed on the four aspects of fire extinguishers, which were quantitatively measured by 10 variables.

5.1 Key Milestones of Usage

In the data point titled Key Milestones of Usage, participants were observed for their ability to discharge agent onto the fire, their average pre-discharge time, and whether or not they read the label. As shown in Table 3, Percent Improvement with Training for Key Milestones of Usage, participants were able to increase their ability to discharge the agent as well as being able to decrease the time it took to discharge the agent. Overall, participants were more confident in their second trial in not needing to read the label for instructions.

For both WPI '11 and WPI '12, the average age of the participants was the early 20s. The *read the label* variable for WPI '11-'12 decreased from Trial 1 to Trial 2. Overall, 33% of participants read the label for Trial 1, and 13% of participants read the label for Trial 2. This suggests that most participants do not need to read the label to use a fire extinguisher. This decrease in reading the label was expected as approximately half of the participants viewed the label in the first trial.

For EKU '11-'12, the average age of the participants was the late 30s. There was an increase of 6% in reading the label. EKU '11-'12 also had the least amount of improvement for time to discharge agent by 31%. For WPI '11 and '12 pre-discharge time, they decreased by 57% and 54%, respectively, for Trial 1 to Trial 2. This suggests that the younger generation has a faster reaction time.

5.2 Technique in Handling a Fire Extinguisher

In technique in handling a fire extinguisher, participants were observed for if they were able to aim at the base, used a slow back and forth sweeping motion, and continued to spray agent on the fire even after the fire was no longer visible. As shown in Table 6, Percent Improvement of Technique in Handling a Fire Extinguisher, all milestones showed improvement from Trial 1 to Trial 2. EKU '11-'12 had the smallest overall amount of improvement with WPI '11 following and WPI '12 with the greatest amount of improvement. EKU '11-'12 had the highest starting numbers for their key milestone data for Trial 1. The data suggests that most participants are able to use the proper technique to deploy agent onto the fire and with verbal instructions of how to use a fire extinguisher, the participants' ability to use a fire extinguisher improved.

5.3 Key Knowledge in Fire Safety

For the key knowledge in fire safety, participants were observed on if they turned their backs to the fire and if they kept a safe distance from the fire. Of all the aspects, this one resulted in the smallest improvement. Overall, only 4% of the participants turned their backs to the fire in Trial 1. Two percent of EKU '11-'12 still turned their backs to the fire in Trial 2. WPI '11 had the greatest improvement, with no participants turning their backs to the fire in Trial 2. WPI '12 had no improvement in the number of participants who turned their backs to the fire.

The data suggests that most participants know not to turn their backs to the fire. All participants respected the eight-foot mark after being briefed not to go beyond it at the start of the experiment, per Institutional Review Board general guidelines and BullEx safety instructions. There were some instances at EKU in which a participant did cross the line but by a marginal amount. For WPI '11-'12, many participants stood at a distance greater than eight feet away. This finding suggests that participants will approach the fire at a distance they are comfortable with.

5.4 Participants Effectiveness in Extinguishing a Simulated Fire

Investigators observed participants on their effectiveness in extinguishing a simulated fire. Two key factors from the data collected are considered in this measure: the percentage of participants able to simulate extinguishment of the fire, and the amount of time it took to extinguisher a simulated Class A fire. According to the data collected, nearly all participants were proficient in their ability to discharge agent onto the fire (98% in Trial 1, 100% in Trial 2). The majority of participants were able to simulate complete extinguishment in the Trial 1 (65%), and almost all were able to do so in Trial 2 (90%). Participants that were able to complete extinguishment in Trial 1 accomplished this task in 11.2 seconds and 7.3 seconds in Trial 2.

The question remains: Can this data validate the current ability of an ordinary operate a fire extinguisher successfully? Before this is answered, what does the study need to accomplish to answer this question? In order to compare extinguishment of Class A fires, they need to be created in repeatable configurations and materials, provided with a reliable/repeatable ignition source, and allowed a known pre-burn time. For example, UL 711, Standard for Safety for Rating and Testing of Fire Extinguishers, goes into great detail to specify exact lengths and sizes of lumber used in their wood crib fire tests, prescribing the percentage of moisture content as determined by ASTM D2016-74, Test for Moisture Content of Wood; the exact configuration of the crib; the flammable liquid ignition source in a specific pan; and a precise pre-burn time in order to establish a standardized repeatable test.

However, the Bull Ex system, like any good simulator, is capable of presenting very challenging and similar conditions. This makes it highly likely that in real world incipient fires, the extinguishment success rate would be higher. Therefore the data reported in this report may or may not correlate with an amateur person's ability to extinguish a Class A fire or any other type of fire. The data does show the ability of participants to extinguish the Class A fire simulated by the BullEx ITS.

5.5 Survey

The post-test survey provided valuable insight on how knowledgeable and comfortable the "current" generation is with fire safety. Of the 276 participants surveyed, more than half had witnessed a fire emergency. Therefore is can be speculated that, when the population is in their early 20's, about 50% will have witnessed a fire emergency. For WPI '12, the average age of their last fire drill was 19 years; at EKU the average age of their last fire drill was 32 years. Only 11% of the 85 participants surveyed from WPI '12 and 17% of the 127 participants at EKU have used a fire extinguisher before participating in this study. Yet judging from the experiments results, this did not affect the participant's ability to use a fire extinguisher.

For both EKU and WPI '12, the comfort level before using a fire extinguisher was 5-6 on a scale of 1-10. After using the BullEx ITS, their comfort level rose to a 9. Due to the safe environment created by the experiment, it is unknown what the ordinary person's comfort level would be while using a fire extinguisher during a true emergency. The data does show that, with one trial and a brief instruction on how to effectively use a fire extinguisher, a participant's comfort level rose significantly. The verbal instructions given to participants were received well by 45% of EKU's 127 participants and 31% of WPI's '12 85 participants. This suggests that verbal directions about how to effectively use a fire extinguisher improved the participant's performance.

5.6 Conclusion, Limitations, and Further Study

As shown throughout the Results section, the data collected strongly suggests that the ordinary person can operate a fire extinguisher and utilize proper technique to effectively extinguish a fire. Overall, 98% of the 276 participants were able to discharge extinguishing agent onto a fire on their first trial; 100% of the participants were successful on their second trial. Second, with a minimal amount of training, there was a measureable improvement in all variables measured for in this experiment from Trial 1 to Trial 2.

During testing, many ideas surfaced on how to improve the experiment and possible areas of further study. This section addresses these ideas.

As previously mentioned, the BullEx Smart Extinguisher can deploy agent for approximately 15 seconds before the effectiveness of the extinguisher decreases. Specifically, the sound signature produced by the extinguisher begins to weaken. This time limit affected the participants' ability to extinguish the simulated fire through proper use of the fire extinguisher. Many participants went past the 15-second mark of extinguishment and were unable to extinguish the fire at this point, as there was no longer any pressure inside to expel the agent. When it was obvious to the investigators that the extinguisher ran out of pressurized air to expel agent, the test was stopped and marked as not extinguished. It is reported that real fire extinguishers have up to 30 seconds of agent to deploy. Given this extra 15 seconds to extinguish the fire, it is expected that many participants would have been able to extinguish the fire on their first trial. This hypothesis is support by the results of Trial 2 extinguishment, in which 90% of the 276 participants were able to extinguish the simulated fire.

According to the BullEx recommendations, the Smart Extinguishers would need to be refilled with water after 3-4 trials of use. This recommendation was followed in the experiment, enabling some participants to use a fire extinguisher weighing slightly less to extinguish the fire. There were no instances where a participant ran out of water to extinguish the fire, only out of pressurized air. There was only one instance in which a participant struggled to lift the fire extinguisher and had to drag it on its base toward the safety line to deploy agent.

Due to the enclosed area, which included a ventilation system for added safety, the BullEx ITS tended to operate at a somewhat higher difficulty setting. This caused a small increase in extinguishment time for WPI compared to normal outdoor usage, such as at the EKU the setting.

The experiments conducted by EKU occurred on the main campus as well as several remote campuses. These locations were out-of-doors in areas sheltered from wind gusts. No negative factors were observed in these locations that affected data collection.

The participants gathered at WPI and EKU were limited to participants that visit or work on a college campus. This includes students, faculty, staff, friends, and family. Thus the data collected represents only a small portion of the general amateur population.

The experiment conducted by WPI and EKU brought participants into an environment that controlled as many variables as possible, with a focus on participant safety. Participants had the knowledge of where the fire extinguisher and simulated fire were located and were allowed to ask any questions that could be answered without influencing the study. This alleviated anxiety that could exist when confronted with a real fire. Participants did have a choice to stop the experiment at any time if they felt they were unsafe, even though they were also surrounded by numerous safety precautions that they had been briefed on.

An area meriting further study is to examine the percentage of participants that would pick up a fire extinguisher in a real fire emergency along with the other factors studied for in the present experiment. The participant would need to be deceived and walk into a normal room where a controlled fire is lit remotely. The participant would be provided access to a fire alarm, fire extinguisher, and several exits.

To further study an ordinary person's ability to use a fire extinguisher effectively, a study needs to be conducted investigating an ordinary person's ability to extinguish different types of fire classifications or whether a fire extinguisher should be used at all.

As noted in the Results section, participants had difficultly removing the pin. During data collection at both EKU and WPI '12, it was noted that most participants during either Trial 1 or Trial 2 had difficultly removing the pin. This can be seen in the number of participants whose pre-discharge time was more than 15 seconds. While this can be attributed to the participant being flustered in a stressful situation, the use of a fire extinguisher can be a very stressful activity. An investigation should be conducted to see if there is a more user-friendly design for the pin or more appropriate way to prevent accidental discharge.

6.0 Bibliography

1. **Inc, Underwriters Laboratories.** *Rating and Fire Testing of Fire Extinguishers. Standard for Safety.* s.l. : American National Standards, 1984. ANSI/UL 711-1984.

2. **Fire Marshals Association of North America.** Fire Marshals Bulletin: FMANA News. *NFPA.org.* [Online] February 1986. [Cited: March 26, 2012.] http://www.nfpa.org/assets/files/pdf/ifma%20quarterlies/fmana_fire_marshals_bulletin_february_1986.pdf. 86-1.

3. **Bruck, D and Thomas, I.** *Interactions Between Human Behaviour and Technology: Implications for Fire Safety Science.* Melbourne : Springer Science + Business Media, LLC, 2010. 10.1007/s10694-010-0161-1.

4. **Ranellone, Raymond and Notarianni, Kathy Ann.** *Fire Extinguishers In Academic Setting.* Worcester : WPI, 2011. E-project-090211-153811.

5. **EKU.** National Fire Protection Association Search. [Online] [Cited: March 2, 2012.] http://codesonline.nfpa.org.libproxy.eku.edu/NFPA/A/advsearchresults/0/11/1.

6. Flight or Flee? Evacuation Plans and Procedures . *United States Department of Labor Occuptational Safety & Health Administration.* [Online] 9 18, 2007. [Cited: 3 31, 2012.] http://www.osha.gov/SLTC/etools/evacuation/portable_relation.html#fight.

7. Defintion Fire Extinguisher. *Merriam-Webster.* [Online] Encyclopaedia Britannica Company. [Cited: December 05, 2011.] http://www.merriam-webster.com/dictionary/fire%20extinguisher.

8. The History of Fire Extinguishers. *Atwood Fire & Security.* [Online] [Cited: December 05, 2011.] http://www.atwoodsecurity.com/fire-extinguisher-products-and-services/fire-extinguisher-history.html.

9. History Of The Fire Extinguisher. *Cherwell Fire Safety.* [Online] [Cited: December 05, 2011.] http://www.cherwellfiresafety.co.uk/fireextinguisherhistory.php.

10. History of the Fire Extinguisher. *Fire-RiskAssessment.com - Fire Safety for Businesses.* [Online] 2008. [Cited: December 05, 2011.] http://www.fire-riskassessment.com/fire-extinguishers/history-of-the-fire-extinguisher.html.

11. Fire Protection Handbook, 20th Edition, page 17-16, National Fire Protection Association, 2008

11. History of Fire Extinguishers. *Fire Safety Advice Centre.* [Online] 2011. [Cited: December 05, 2011.] http://www.firesafe.org.uk/history-of-fire-extinguishers/.

12. **Ziemba, Joe and Waters, Steve.** Halon: The Search for Alternatives. *NFPA.* [Online] September 24, 1995. [Cited: December 05, 2011.] http://www.halcyon.com/NAFED/HTML/Halonalt.html.

13. **Harris, Tom.** How Fire Extinguishers Work. *HowStuffWorks.com.* [Online] February 28, 2002. [Cited: December 05, 2011.] http://home.howstuffworks.com/home-improvement/household-safety/fire/fire-extinguisher.htm.

14. Chemistry Labs. *University of Oregon.* [Online] October 17, 2006. [Cited: December 05, 2011.] http://chemlabs.uoregon.edu/Safety/Fire1.html.

15. Classes of Extinguishers. *NYC Fire Department.* [Online] [Cited: December 06, 2011.] http://www.nyc.gov/html/fdny/html/safety/extinguisher/classes.shtml.

16. **BullEx, Inc.** *BullEx Intelligent Training System User's Manual.* Albany : BullEx, Inc. .

17. Facts and Figures. *WPI.* [Online] 2012. [Cited: 3 14, 2012.] http://www.wpi.edu/about/facts.html.

18. Fire Extinguisher: 101. *Fire Extinguisher: 101.* [Online] [Cited: December 05, 2011.] http://www.fire-extinguisher101.com/sitemap.html.

19. Fire Triangle. *PBS.Org.* [Online] [Cited: December 05, 2011.] http://www.pbs.org/wgbh/nova/teachers/viewing/images/2908_firetriangle.jpg.

7.0 Appendix

7.1 Procedure

Protocol for Test Day

1. Set up the BullEx system
    a. See BullEx Quick Reference Manual
2. Fill the BullEx extinguishers for the test subjects with 6 liters of water
    a. This is the 7x Smart Extinguisher (This lasts 3 trials at most)
3. Pressurize the extinguishers to green line
4. Set Hood on the "Low" setting to ventilate area.
5. Mark safety line 8 feet away

   Hello, today you are participating in our study on fire extinguishers. There is a fire extinguisher to your left (POINT TO BULLEX EXTINGUISHER). We will be remotely lighting the fire. When you see the flames from the BullEx ITS (POINT TO BULLEX ITS), we will ask you to grab the extinguisher and use it to extinguish fire we have created. Please stay behind the safety line at all times (Point at safety line). There is a label on the extinguisher to answer any questions. We are now ready to start the study. The BullEx System takes a few seconds to warm up so I will give you a verbal "Go" when you make look at the fire extinguisher and use it to extinguish the fire to the best of your abilities.
6. Double check the test area for safety
7. Fill out date and age for the subject
8. Clear the test area for the test subject to begin
9. Ignite fire and start the timer (for the stop watch)
10. Record time up to water being sprayed
11. Monitor to see if subject puts back to fire
12. Monitor to see if subject reads the label
13. Record how far back from fire the subject stays
14. Monitor to see if the subject aimed at base
15. Monitor to see if subject used a sweeping motion
16. Record if the continued to spray
17. Record total extinguishment time (from BullEx ITS)
18. Turn Hood on the 'Medium' setting after 1st test. If trial lasted for more than 45 seconds, turn Hood on 'High' setting and open door to ventilate area.
19. Investigator briefs the test subject on the correct use of a extinguisher (See Training Sheet)
20. Investigator returns the lab to its original state prior to the first extinguishment
21. Fill the used extinguisher for second trial
22. Turn Hood back to 'Low' as not to interfere with acoustics of system.
23. Test subject is returned to the FPE lab to perform the experiment again

   You have now been briefed on the proper way to extinguish a fire. We ask you now to use the training we have just issued you while you repeat our experiment. We ask you again to be sure to not step over the tape line for your safety. The extinguisher is full and ready for use. We are now ready to begin the second trial of our experiment; we will again be giving you a verbal "Go" for when to begin.

24. Return to STEP 7, repeat all steps until STEP 17
25. Test subject exits, Return to Step 1 to begin the next session

7.2 Hand Out

Training Script for Proper Extinguishment

- TWIST PIN to break seal

- PULL PIN OUT

- Stand back 6 to 8 feet

- AIM and SQUEEZE the lever
    - Aim at base of flame
    - Use a slow sweeping motion

2004-2005 National Sample Survey of Unreported Residential Fires

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July 2009

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Executive Summary

This report provides information from the third national telephone probability sample survey of unreported (and non-fire department-attended) residential fires sponsored by the U. S. Consumer Product Safety Commission (CPSC). The first survey was conducted in 1974 and the second in 1984.[1] All three surveys have had the same objectives, that is, to develop an understanding of the causes of residential fires, the ignition sources, what objects ignited first and the behavioral factors associated with the fires. The surveys also examined how people became aware of the fires, including the role played by smoke alarms and how fires were extinguished.

The three surveys complement the understanding of fire and fire loss from official statistics on reported fires with information on fires that were not attended by or reported to fire departments. All three surveys show that the vast majority of unwanted fires that start in residences were not attended by fire departments.

Statistics on fire department-attended fires have shown that fire incidence and fire loss in general have decreased during the last 20 years. Despite decreases in residential fire losses in recent years, fire is still a serious national problem. For 2005, the most recent year for which data were available when this report was written, there were an estimated 375,100 unintentionally caused fire department-attended residential structure fires, resulting in 2,630 fire deaths, 12,820 fire injuries, and $6.22 billion in property loss.[2]

The current survey, conducted between June 2004 and September 2005, contained data from 916 households that reported to the telephone interviewers that they had experienced at least one fire during the previous 90 days. Households were selected from across the nation as a probability sample using random digit dialing. The sample was stratified by region of the country and demographic composition of the population. Fires were defined in a manner similar to the two previous surveys as

> *… any incident large or small that you have had in or around your home…that resulted in unwanted flames or smoke, and could have caused damage to life or property if left unchecked.*

In addition to the sample of fire households, there was a second probability sample of 2,161 households that did not have a fire during the previous 90 days. These non-fire households were asked questions about their demographic and socioeconomic characteristics. Also, these households were asked about the types of fire defenses in their homes including smoke alarms and fire extinguishers. The purpose for selecting

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[1] U.S. Consumer Product Safety Commission (1978), "Special Report: Results of National Household Fire Survey." HIA Special Report, U.S. Consumer Product Safety Commission, Washington, DC. Audits and Surveys, Inc. (1985), "1984 National Sample Survey of Unreported, Residential Fires." Final Technical Report Prepared for the U.S. Consumer Product Safety Commission. Princeton, NJ.
[2] Chowdhury R, Greene M and Miller D (2008), "2003-2005 Residential Fire Loss Estimates," U.S. Consumer Product Safety Commission, Washington, DC.

this second sample was to compare the fire and non-fire households and to examine the factors that might be associated with the risk of fire.

The response rates in the survey were either 22.5 percent or 31.6 percent, depending on how unknown eligibility was allocated.[3] Unknown eligibility occurs when it could not be determined if the location dialed was a residence (eligible) or a business (not eligible) because the phone was not answered, it was answered by an answering machine, or the call was actually answered and the respondent hung up before identifying the phone line as residential or business.

The first task of the survey, to estimate the number of unreported fires from information reported by survey respondents, required correcting for the possibility that respondents may have forgotten some fire incidents that occurred during the previous 90 days. An analysis in this report showed that recall of fire incidents among fire households decreased with increasing time between interview and fire. Also, incidents that respondents characterized as more severe or involving more fire damage were recalled longer than less severe incidents. Accordingly, estimates of the number of fires (reported and unreported) were made using a 14-day recall period for less severe incidents and a 21-day recall period for the more severe incidents. This was similar to the 1984 survey where fire estimates were based on the previous month although respondents were asked to recall fire incidents over the previous three-month period.

An important finding of the survey is that the number of reported and unreported residential fires declined substantially from the 1984 estimates of 25.2 million fires of which 23.7 million were residential structure fires. This was a rate of 28.3 residential structure fires per 100 households. In the present survey, it was estimated that there were 7.4 million fires in the U. S. (annualized rate for 2004-2005) and a rate of 6.6 residential structure fires per year per 100 households. This was a decrease of 68.7 percent in the number of residential structure fires and a decrease of 76.8 percent in the household fire rate. These decreases were much greater than the 43 percent decrease in the number of residential structure fires that were reported by fire departments over the same period.

According to survey results, about 3.4 percent of residential fires were attended by fire departments. This is essentially unchanged from the 1984 survey, where 3.7 percent of residential fires were attended by fire departments.

Fires involving cooking appliances were associated with the largest single type of fire incident, accounting for 4.7 million fire department-unattended fires (65 percent) in the present survey. This represented a 62 percent decrease from the 1984 survey estimate

[3] The lower response rate is calculated by assuming that all respondents where eligibility is unknown are non-responses, while the higher response rate is calculated by assuming that the non-response rate is the same as the rate among the respondents with known eligibility. The calculations are based on methods developed by the American Association for Public Opinion Research and are in widespread usage. See American Association for Public Opinion Research (2000), "Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys," AAPOR, Ann Arbor, MI.

of 12.3 million fire department-unattended fires. The decrease in cooking fires accounts for much of the decrease in all types of fires during the twenty years between the surveys.

Although fewer in number, fires involving matches, lighters, and smoking materials as the heat sources – collectively non-appliance fires -- decreased by 84 percent between the two surveys. This was a larger percentage decrease than all fires. The decrease in these types of fires may be a result of decreases in the number of smokers over the past 20 years.

A number of comparisons were made between fire and non-fire households. The differences that were statistically significant were type of ownership, where 34 percent of fire households were renters in contrast to 23 percent of non-fire households that were renters. The average size of fire households was significantly larger than non-fire households; and in particular, fire households averaged more people under 18 and fewer members over 65 than non-fire households. Race and ethnicity did not appear to be associated with whether a household was a fire or non-fire household.

Another finding of the survey was that an estimated 97 percent of U.S. households had at least one smoke alarm, an increase from 62 percent in the 1984 survey. Over 80 percent of households had two or more alarms, and 84 percent had alarms on all floors. However, only 31 percent had alarms in all bedrooms, and 19 percent had alarms that were interconnected. Moreover, fire households and non-fire households differed in their alarm configurations. Fire households were significantly less likely than non-fire households to have alarms on all floors, in all bedrooms, and with interconnections.

Overall, people were home and smoke alarms sounded in an estimated 30 percent of fires, alerting residents to the fire in 12 percent of incidents, and providing the only alert of the fire in 10 percent of incidents. People were home and the alarms sounded in 53 percent of incidents for fires in households with interconnected alarms, providing the only alert of the fire in 26 percent of incidents. For fires in households that did not have alarms on all floors, the alarms sounded in 4 percent of incidents, alerting people in 2 percent of incidents, and providing the only alert of the fire in those 2 percent of incidents.

Fires originating on the stove set off the alarm more frequently than other fires, at 41 percent of incidents, providing an alert of the fire in 16 percent of incidents and the only alert in 13 percent of incidents. In fires associated with lighters, cigarettes, and matches, the alarm sounded in 28 percent of incidents, alerting people and providing the only alert to the fire in 8 percent of incidents.

In 55 percent of fires, someone was home when the fire began but the alarm did not sound. In almost all cases, survey respondents attributed the lack of alarm operation to not enough smoke reaching the alarm. When enough smoke had reached the smoke alarm but it still did not operate, almost all respondents reported that they believed that before the fire, the alarm had been in working condition.

The survey also showed that more smoke alarms were better than fewer alarms because in homes with alarms on all levels, residents were alerted to fires more frequently than in homes that did not have alarms on all floors. Interconnected alarms, however, appeared to be the best for warning residents of fires and, in particular, in providing the only alert of the incident.

Residents reported that most fires were put out by using water, turning off power to the equipment, smothering the fire, or separating the burning item from the source of heat. Fire extinguishers were used in 5 percent of incidents and, put out the fire completely in about half the incidents when used. Extinguishers were used most frequently in cooking fires. Fire extinguishers were also more likely to be used if they were in the same room where the fire started (most frequently the kitchen) rather than in a different room.

Acknowledgements

The primary motivation for the survey came from Linda Smith, a staff member of the Division of Hazard Analysis at CPSC, who retired in 2005. Linda was involved in the design and analysis of the 1984 survey and believed that such a survey would provide valuable insights beyond official fire statistics. She proposed conducting this survey, wrote the documents supporting the survey, led the team selecting the survey contractor, participated in the design of the questionnaire and the testing, redesign and retesting. Linda was still at CPSC during the initial phase of the data collection and she provided leadership through that phase.

The CPSC staff study team consisted of Linda Smith during her tenure at CPSC, the two co-authors, and William W. Zamula of the Directorate for Economic Analysis. Drafts of the report were read and commented on by Kathleen A. Stralka, Director, Division of Hazard Analysis, and Russell H. Roegner, Associate Executive Director, Directorate of Epidemiology. Assistance with interpreting fire data was provided by Rohit Khanna, Fire Protection Engineer, Directorate for Engineering Sciences. Erlinda Edwards of the Office of Hazard Identification and Reduction provided extremely helpful editorial comments.

The telephone survey was conducted by Synovate, Inc. Alan Roshwalb designed the sampling plan, the sample weighting, and prepared the SAS®[4] dataset used for the final analysis. Tim Amsbury and John Lavin were instrumental along with CPSC staff in the design of the questionnaire and supervised the data collection. The project was supervised by Corporate Vice President, W. Burleigh “Leigh” Seaver.

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[4] SAS® is a service mark of the SAS Institute, Cary, NC.

In addition to funding from the Consumer Product Safety Commission, survey funding was also provided by the Division of Unintentional Injury Prevention of the National Center for Injury Prevention and Control in the Centers for Disease Control and Prevention (CDC), and the United States Fire Administration, a component agency of the Department of Homeland Security.

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Chapter 1
Introduction to the 2004-2005 Residential Fire Survey

In 2004-2005, U.S. Consumer Product Safety Commission (CPSC) staff conducted a national telephone survey of fire department-attended and unattended residential fires. [5] This is the third such national telephone survey of this type that has been sponsored by CPSC. The first survey was conducted in 1974 and the second in 1984.[6] All three surveys have had the same objective, that is to develop an understanding of the causes of residential fires, especially among fires that are not attended by the fire service and therefore do not enter the official statistics. The three surveys also focused on how people became aware of household fires including the role played by smoke alarms and how such fires were extinguished.

The three surveys complement the understanding of fires and fire losses from official statistics with information on fires that were not attended by or reported to fire departments. Since the 1970s there have been two main national sources of information on fire department-attended fires. These are the National Fire Protection Association's (NFPA) Annual National Fire Experience Survey[7] and the United States Fire Administration's National Fire Incident Reporting System (NFIRS).[8] Information from these surveys on fire department-attended fires is useful in helping CPSC staff devise and evaluate strategies to reduce residential fire deaths, one of the agency's strategic goals. The information is also useful to CPSC's federal partners, the U.S. Fire Administration and the Centers for Disease Control and Prevention, in focusing efforts to reduce fire losses. Information from the NFPA Survey and NFIRS is widely used by other

[5] The U.S. Consumer Product Safety Commission is an independent federal regulatory agency charged with protecting the public from unreasonable risks of serious injury or death from thousands of consumer products. Deaths, injuries, and property damage from consumer product incidents cost the nation more than $800 billion annually. The CPSC is committed to protecting consumers and families from products that pose a fire, electrical, chemical, or mechanical hazard or can injure children. Jurisdictional authority for the CPSC related to fire hazards is from the Consumer Product Safety Act, the Federal Hazardous Substances Act, the Flammable Fabrics Act and the Children's Gasoline Burn Prevention Act. Agency regulations associated with fire prevention include regulations for cigarette and multi-purpose lighters; flammability of mattresses, children's sleepwear and general wearing apparel; and the resistance of portable gasoline containers to children opening them. The agency also works with interested stakeholders to establish and promote voluntary standards.

[6] U.S. Consumer Product Safety Commission (1978), "Special Report: Results of National Household Fire Survey." HIA Special Report, U.S. Consumer Product Safety Commission, Washington, DC. Audits and Surveys, Inc. (1985), "1984 National Sample Survey of Unreported, Residential Fires." Final Technical Report Prepared for the U.S. Consumer Product Safety Commission. Princeton, NJ.

[7] Karter MJ Jr. (2008), "Fire Loss in the United States 2007," National Fire Protection Association, Quincy, MA. This series is published annually. CPSC staff estimates use both NFIRS and the NFPA survey for estimates of residential fire losses. The most recent staff estimates are for 2005 found in Chowdhury R, Greene M and Miller D (2008), "2003-2005 Residential Fire Loss Estimates," U. S. Consumer Product Safety Commission, Washington, DC.

[8] U.S. Fire Administration (1997), "The Many Uses of the National Fire Incident Reporting System." U.S. Fire Administration, Emmitsburg, MD. United States Fire Administration (1997),"Fire in the United States 1985-1994," Ninth Edition. U.S. Fire Administration, Emmitsburg, MD

organizations, and together, these constitute the source of official fire statistics in the United States.

These official statistics have shown that fire incidence and fire loss in general have decreased during the last 20 years. Despite decreases in residential fire losses in recent years, fires are still a serious national problem. For 2005, the most recent year for which the NFPA survey and NFIRS data were available at the time this report was written, CPSC staff estimated that there were 375,100 unintentionally caused fire department-attended residential structure fires, resulting in 2,630 fire deaths, 12,820 fire injuries, and $6.2 billion in property loss.[9] However, fire department-attended fires are not the complete picture. In the 1984 Residential Fire Survey, for example, it was estimated that there were 23.7 million unintentional and unwanted residential structure fires of which 22.9 million (96.7 percent) were not reported to or attended by fire departments.[10]

Like the 1984 survey, the present survey was limited to residential structure fires, including fires that started in the home or, if started outside the home, ultimately spread to the home. Similar to the 1984 survey, fires were defined in the beginning of the survey questionnaire to include *any incident, large or small, that occurred in or around the home, resulted in unwanted flames or smoke, and that could have caused damage to life and property if left unchecked.* This definition included cooking and other types of fire incidents that took some action to extinguish, but excluded “friendly fires” such as barbecues and bonfires unless those fires got out of control. Also excluded were motor vehicle fires and brush fires unless they spread to the home.

One of the reasons for studying fires that were not attended by the fire department is to try to understand the process of how residents became aware of an unwanted fire and ultimately brought it under control without requiring fire department involvement. All fires begin small from contact between a heat source and a fuel; some fires are controlled, while others grow causing injury and property damage. The survey can reveal the role of smoke alarms in alerting people to the fire as the fire develops, as related to the type of fire and the location of the smoke alarms. Also such a study can describe how household fire extinguishers were used among other methods for putting out fires.

A second reason to study unattended fires is to help explain the decrease in reported fires over the period between the two surveys. In 1980, there were an estimated 655,500 fire department-attended residential structure fires; thus, fire department-attended fires decreased by 43 percent between 1980 and 2005.[11] Some have conjectured that the total number of fires (i.e., both attended and unattended) has not decreased, but that earlier warning of the incidents provided by smoke alarms, which surveys have

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[9] Chowdhury R, Greene M and Miller D (2008), “2003-2005 Residential Fire Loss Estimates,” U.S. Consumer Product Safety Commission, Washington, DC, page 1.
[10] Audits and Surveys, Inc. (1985), *op cit.,* page 22.
[11] Mah J (2001), “1998 Residential Fire Loss Estimates: U.S. National Estimates of Fires, Deaths and Property Losses from Non-Incendiary, Non-Suspicious Fires.” U.S. Consumer Product Safety Commission, Washington, DC, Table 6. Data for 2004 from Chowdhury, et al, (2008), *op cit.*

shown to have become almost universal, has allowed residents to extinguish fires before they got out of control and required fire department assistance.[12] If this conjecture is true, it would suggest that the percentage decrease in fire department-attended fires would have been greater than unattended fires in the 20 year period between the surveys.

Third, official statistics show that the largest single category of fires begins in the kitchen and involves cooking equipment. For example, 2005 statistics show there were 137,500 residential cooking fires, involving 210 fatalities, 3,250 injuries, and $412.7 million in property loss.[13] Cooking fires account for the largest percentage of fires. A study of unattended fires should also be dominated by cooking fires and should provide additional insights into these incidents, especially those that are able to be controlled by household residents. Because there are so many of these fires, reducing the total number of fires involves reducing the number of cooking fires.

Fourth, during the past 20 years, there have been substantial changes in the types of appliances in homes. Computers and home office equipment, home entertainment systems, multiple televisions per household, electric heat pumps and central air conditioning, microwave ovens, batteries of all kinds and sizes, and other small kitchen appliances are new and, for the most part, have not resulted in substantial numbers of fire department-attended fires. It is not known if they have resulted in substantial numbers of unattended fires.

Fifth, smoke alarms are now almost universal in residences.[14] This may also have altered the ratio of attended to unattended fires.

Finally, such a study can contribute to the knowledge of household fire risk. All previous surveys and the current survey collected data on a comparison group of households that did not report fires during the previous three months. Such a comparison includes differences in housing and demographic characteristics, the presence or absence of smokers, young or older household members, and other factors.

Four sections follow in this chapter. The next section describes the two previous surveys. It is followed by some background information on how the 2004-05 survey was developed. Major findings of the survey are discussed next. The last section outlines the chapters and describes the organization of the report.

Previous Surveys

The first survey was conducted by the U.S. Bureau of the Census on April 15, 1974 as part of the monthly Current Population Survey. The survey report was delivered in February 1978. The sample consisted of respondents from 33,856 households in the

[12] See Audits and Surveys, Inc., (1985), *op cit.,* page 20.
[13] Fire losses from Chowdhury R, Greene M and Miller D (2008), *op cit.,* pages 5-8.
[14] For example, see Ahrens M (2007b), "U.S. Experience with Smoke Alarms and Other Fire Detection/Alarm Equipment." National Fire Protection Association, Quincy, MA.

U.S. In face-to-face interviews, Census Bureau staff asked respondents if a fire had occurred in or around their home, or whether a household member had been killed or injured by fire at any location between April 1, 1973 and April 15, 1974.[15] 2,233 respondents indicated that at least one fire occurred during that period. These respondents were then asked a series of questions including the location of the fire, characteristics of the fire, consumer products involved, fire losses, and other details. After applying survey weights to the responses, it was estimated that there were 4.5 million residential fire incidents during the 54-week survey period from April 1, 1973 to April 15, 1974.[16]

In 1977, the Statistics Department of the University of Wisconsin was asked to reanalyze the survey. It had been suspected that the survey underestimated the number of residential fires because there was some evidence in the survey that respondents did not remember all the fires during the 12-month recall period, especially those fires occurring many months before the interview. This suspicion was borne out by the analysis of the data. The University of Wisconsin report, issued in November 1977, made adjustments for the lack of recall. As a result of those adjustments, they estimated the number of unreported residential fires at 11.8 million, more than double the original estimate.[17] Using this corrected number of fires, they estimated that 91 percent of residential fires were not reported to U.S. fire departments.[18]

The 1984 survey was developed on the basis of the 1974 survey, but with some important distinctions. These were as follows: (1) there was a small difference in the definition of a fire,[19] (2) the 1984 survey was conducted by telephone rather than with face-to-face interviews, (3) the length of the recall period was different between the two surveys (three months rather than one year), and (4) the 1974 survey was conducted during a single month (April), while the 1984 survey was conducted during 12 consecutive months. Of these differences, probably the most important distinction between the surveys was the length of the recall period. It is also the most important distinction between the 1984 survey and the present survey.

The 1984 survey also collected information on a sample of households that had not had a fire during the three-month period. These non-fire households were used to compare various demographic factors and other factors with fire households.

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[15] In all three surveys, the term "their home" refers to where people are living regardless of whether the home is owned or rented by the residents.
[16] U.S. Consumer Product Safety Commission (1978), *op cit.,* pages 2-7.
[17] Audits and Surveys (1985), *op cit.,* page 11.
[18] *Ibid.,* page iii.
[19] Audits and Surveys (1985), *op cit.,* page 3. Page 67 of the 1974 survey (U.S. Consumer Product Safety Commission, 1978, *op cit.)* shows that the initial screening questions about whether a fire had occurred were similar between the two surveys. Respondents in the 1974 survey were asked, "We are interested in all types of fires, no matter how small they might have been…" Respondents who did not indicate that a fire had occurred were then prompted with types of fires such as "Grease or something else flaming on the stove or oven, Burning Clothing," etc. The screening questions in the 1984 survey were similar but defined the residence to include home, vacation home, or on the respondent's property.

In the 1984 survey, telephone interviews were conducted between December 1983 and November 1984. Respondents were interviewed during the first two weeks of the month and asked about fires that occurred in the past three calendar months. The three-month period was chosen because the University of Wisconsin analysis of the 1974 survey had demonstrated that one year was too long a period for respondents to recall fire incidents. However, when the 1984 survey data became available, an analysis of the number of incidents reported by month from the interview showed that the most fires were reported for the month before the interview and the fewest fires were reported for the month three months before the interview. From this finding, it appeared that even three months was too long a period for recall of fire incidents. This led the authors of the 1984 survey to estimate fire incidence using only those incidents that occurred during the month before the interview.

Accordingly, using this one-month recall period, it was estimated that in 1984 there were 25.2 million residential fires, of which 24.3 million (96.4 percent) were not reported to U.S. fire departments.[20] This was an incidence rate of about 30 unattended fires per hundred U.S. households per year. This represented more than a doubling in the number of fire incidents from the 1974 survey. Thus, one key finding from both surveys was that the vast majority of unwanted residential fires was not reported to fire departments and therefore was not reflected in official fire statistics.

Before the 1984 survey was conducted, other surveys had shown that the proportion of U.S. households with smoke alarms was steadily increasing and, in particular, had increased from 5 percent or less in 1974 to more than half the U.S. households by 1984.[21] The authors of the 1984 survey conjectured that if fires were detected earlier as the result of a smoke alarm sounding, residents would discover the fire in a smaller, more manageable state and could extinguish such fires without needing to call the fire department. That would then lead to an increasing proportion of all fires not being reported to fire departments.[22] This was one explanation offered by the authors of the 1984 survey for the more than doubling of the number of unattended residential fires between the 1974 and 1984 surveys. The other explanations were the 20 percent increase in the number of households from 1974 to 1984, and the increased rigor of the 1984 survey methodology.[23]

It is unknown as to the extent that the University of Wisconsin adjusted 1974 survey underestimated fire incidence, but it is very likely that the 1984 survey was an underestimate. This is because of the way that the questions were posed about residential

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[20] Although denoted as Residential Fires in Table 3-4, Audits and Surveys (1985), page 18, these include fires in a personal motor vehicle. Contemporary procedures for fire data analysis would count motor vehicle fires separately. Removing the motor vehicle fires leaves 23.7 million residential structural fires of which 22.9 million (96.7 percent) were not reported to U.S. fire departments (*ibid.,* page 22). On a per household basis, using the 23.7 million fires and an estimate of 83.8 million households, there were 28.3 fires per 100 households.

[21] Audits and Surveys (1985), *op cit.,* page 1.

[22] Audits and Surveys (1985), *loc cit*.

[23] Audits and Surveys (1985), *op cit.,* page 22.

fires. During the first two weeks of each month beginning in December 1983 and ending in November 1984, respondents were asked the following question:

> *Have you had a fire in or around your home, vacation home or your property during the past 3 months – that is during _______, ________ or _______?*

where the telephone interviewers filled in the blanks with the names of the previous three months.[24] Fires occurring between the beginning of the month of the interview and the interview, a period of up to two weeks, were not captured in the survey. As shown in Chapter 3 of this report and in the growing literature on recall of injury incidents, survey respondents tend to forget incidents that occurred more than a few weeks before the interview. Had the 1984 survey interviewers asked about incidents that occurred during the interview month, without doubt, the estimated number of fire incidents would have been higher than estimated in the survey report.

Even though the 1984 survey asked about fires over a period of three months, it used only the first month before the interview to estimate fire incidence. However, the remainder of the 1984 report used fire incidence estimates differently. In analyses that drew contrasts between fire and non-fire households, the 1984 survey defined households as fire households if a fire occurred any time during the three-month period. In later chapters examining fires in consumer products, fires over the entire three- month period were used again, but the estimates were scaled to the annual estimates from the one-month fire incidence estimates.[25]

Some of the major findings of the 1984 survey were as follows:

- There were 25.2 million residential fires of which about 3 percent (925,000) were reported to fire departments. Of the residential fires, 23.7 million were residential structure fires; the remaining incidents were vehicle or outside fires. This was more than a doubling of the number of residential structure fires from the 1974 survey.

- The survey identified fire risk factors by comparing fire and non-fire households. Non-fire households (households that did not have a fire in

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[24] *Ibid.,* page 5 for the interviewing plan. The survey instrument is in the Appendix of that document.

[25] There are a number of methodological issues associated with the samples occurring from different length survey periods that are discussed in some detail in Chapters 3, 4, and 6 of this report. First, since it is logical to assume that people are more likely to recall incidents of greater seriousness (however defined) for a longer time, a sample based on a three-month recall period is likely to contain a larger proportion of serious incidents than one based on a one-month recall period. Consequently, even though the 1984 report scaled the three-month estimates to the one-month estimates, the distribution of the types of fires was biased toward more severe incidents than actually occurred. Second, identifying fire households as those with fires in the three-month period is certainly correct, but it is likely that some of the non-fire households may have had fires during the three-month period that they were unable to recall. This contaminates the comparison between fire and non-fire households, making the distinctions less sharp. Third, while it is desirable to use as short a recall period as possible, short recall periods result in smaller sample sizes, which among other things would increase the amount of sampling error in various estimates.

the previous three months) did not differ significantly from fire households in the type of area where the household was located (urban or rural), region of the country, type of dwelling, home ownership as compared with rental occupancy, age of the structure, household income or whether or not smoke alarms were present. Significantly different attributes were as follows: fire households had more members, more members under the age of 18, more smokers, and the heads of households tended to have higher educational levels.

- More residential fires (43 percent) occurred between 1 and 6 pm than any other time, fewer occurred between midnight and 6 am.

- The majority of residential fires (69 percent) were associated with human carelessness. A minority (20 percent) were attributed to equipment failure.

- Fires produced illness or injury in 6 percent of the cases.

- Household appliances were involved in 68 percent of incidents; 78 percent of these appliance-related fires occurred in the kitchen and 78 percent involved cooking or kitchen appliances. Other consumer products involved in fires included electrical components such as wiring, lamps, cords or plugs (6 percent); heating appliances (4 percent); and miscellaneous other appliances (13 percent).

- Electrical wiring fires resulted in some property damage in 80 percent of the incidents, heating appliances in 61 percent of the incidents, and kitchen/cooking fires in 36 percent of the incidents. Most of the property damage was valued by respondents as less than $100. Injury or illness resulted from 5 percent of the cooking fires, 3 percent of the heating fires, and 2 percent of the electrical wiring fires.

- About 62 percent of U.S. households were estimated to have smoke alarms; more households were likely to have them in the Northeast and fewer were likely in the West.

Development of the 2004-2005 Residential Fire Survey

CPSC staff began designing the survey in 2002. Staff prepared a request for proposal for a survey contractor in May 2002 and staff evaluated bids selecting Synovate, Inc. of McLean, Virginia as the survey contractor in Fall 2002. Between that time and June 2004, agency staff and Synovate staff designed the survey questionnaire, building upon the 1984 Residential Fire Survey; pilot tested survey questions; prepared the documents for Office of Management and Budget clearance; trained the telephone interviewers; and designed the Computer-Assisted Telephone Interviewing (CATI) system for collecting the results. During that period, Synovate staff also conducted cognitive tests of the survey questions, to discover if respondents understood the questions to mean the same as the survey designers intended. Following revisions to the survey questionnaire that were informed by the cognitive testing, telephone interviewing began in June 2004 and was completed in September 2005. Later that year, Synovate delivered a SAS® dataset containing the raw survey result to CPSC staff.[26] Synovate also provided sampling weights for each case.

The final survey dataset contained more than 1600 variables. CPSC staff wrote the computer programs for analyzing the survey data and performed the statistical analyses and interpretations that are found in this report.

The sampling design had a requirement for both fire and non-fire households so that comparisons could be made between the two. The design involved a Random Digit Dialing (RDD) probability sample of the United States, with oversampling of selected areas to obtain adequate sample sizes in order to characterize the fire problem among subsets of the population that were considered to be high-risk. These included rural households and low socioeconomic households and households with minority ethnic and racial group members.

Like the 1984 survey, the design specified selecting all the households with a qualifying fire in the previous three months. Respondents were asked at the very beginning of the survey:

> *We are interested in learning about any fires – large or small – that you have had in or around your home. By "fire" I mean any incident – large or small – that resulted in unwanted flames or smoke, and could have caused damage to life or property if left unchecked.*

If the respondent was unsure of what was meant by "home," the interviewer was instructed to continue as follows:

> *By "home," I mean your house, apartment, or other residence where you live.*

To provide a better definition of fires, respondents were then asked if any of the following incidents occurred during the past three months.[27]

> *Unwanted flaming or smoking on the stove or another cooking appliance*
> *A smoldering electrical appliance*
> *Burning or smoldering clothing, either being worn or not being worn*
> *Smoldering fabric, mattress, rug or upholstered furniture*
> *A child igniting something with a match or lighter*

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[26] SAS® is a service mark of the SAS Institute, Inc., Cary, NC.
[27] The actual date of the beginning of the three-month period was read to the respondent. For example, if the survey was being taken on July 15, 2005, the three-month period would have extended back to April 15, 2005.

A candle igniting something
A fire that started outside your home, and spread to the home
Any other fire – large or small – that produced unwanted flames or smoke

Respondents answering any of these affirmatively were then defined as "fire households," and the full questionnaire was then administered. Fire households were asked about the type of the fire, the cause of the fire, the products involved in starting the fire, and the items that burned. Also asked were questions about injuries and deaths, medical treatment required for fire victims, property damage, and if the fire was attended by the fire service. Fire households were also asked about the performance of smoke alarms, fire extinguishers, and sprinklers during the fire.

For the respondents who did not have a fire in the past three months, 1/40th were randomly selected as a comparison group. This was similar to the 1984 survey. An abbreviated form of the questionnaire was administered that included demographic questions in order to be able to compare fire risk by demographic group. Non-fire households were also asked about the number, type, and location of smoke alarms, and the availability of fire extinguishers and home sprinkler systems.

Chapter Outline

This report contains 8 chapters. This section briefly describes the content of Chapters 2-8.

Chapter 2 Survey Methodology

This chapter is a technical description of the sample design, management, and weighting of the survey. It does not deal with fire incidence or other substantive issues. The reader can skip this chapter on the first reading and return later to learn more about the survey design.

The chapter begins with a description of how the sample was designed. This includes information about how the survey was stratified, the use of the GENESYS® system to generate samples of telephone numbers, the anticipated sample size and allocation by stratum, and estimated sampling error for that design. The chapter continues with how the telephone interviewing process was managed including interviewer training, data collection, qualifying respondents, and procedures utilized to maximize response rates.

During the telephone interview, more than a half million telephone numbers were dialed. Using the formulas developed by the American Association for Public Opinion Research (AAPOR), the response rate was either 22.5 percent or 31.6 percent depending on how phone numbers with unknown eligibility were allocated.

The next section of Chapter 2 presents the number of survey responses actually obtained in the survey, by stratum, race, ethnicity, and demographic group. This is followed by a discussion of how sample weights were calculated. Those weights were used in all analyses found in subsequent chapters. An appendix to this chapter provides details on the AAPOR procedures.

Chapter 3 Fire Incidence

The purpose of this chapter is to develop and explain the methodology for estimating the annual number of residential fires, including both fire department-attended and unattended fires and to present those estimates.

The chapter begins with a review of the methods used to make fire estimates in the 1974 and 1984 surveys, in particular, concerning how memory recall issues were handled. The surveys asked respondents to recall fire incidents up to one year from the interview (1974 survey) and up to three months from the interview (1984 survey). The analyses in both surveys clearly indicated that respondents did not recall fire incidents and, as expected, recall decreased with increasing time from the interview. This is then followed by a review of the literature on retrospective recall of illness and injury incidents, especially on methods for estimating injury and incident rates in such studies.

In addition to completely forgetting incidents that occurred, respondents may have remembered that a fire occurred, but may not have been able to remember the date it occurred. While many respondents in this survey were able to provide the interviewers with the date of the fire, some were able to identify only the month, and others could not recall either the month or day, but asserted that the incident occurred during the 91-day recall period. These missing dates must be allocated to the 91-day recall period using a statistical procedure (imputation). The methodology for imputing missing fire dates and estimation is outlined in this chapter. Part of the methodology involved classifying fires on the basis of characteristics associated with the severity of the fire incident. Using fire severity in the imputation process took into account that respondents would be more likely to remember dates when more severe fire incidents occurred.

Following imputation of the missing dates, the chapter applies a statistical procedure for selection of the most appropriate recall period. Various possibilities for the recall period were examined leading to selection of the recall period as that with the smallest amount of statistical error. Separate analyses by incident severity were conducted with the result that a 14-day recall period was chosen for the less severe incidents and a 21-day period for more severe incidents. In this chapter, then, household fire incident rates were computed using only the incidents that fell into the 14- or 21-day period.

Results for the number of attended and unattended fires are then presented. It was estimated that there were 7.43 million residential fires annually of which 7.18 million were not reported to fire departments. Reported and unreported fires amounted to 6.6

attended fires per 100 households. These estimates represented a decrease of 71 percent in the number of fires from the 1984 survey estimates, and a decrease of 78 percent in the per household fire incident rate from the 1984 survey. Between 1980 and 2005, official statistics on fire department-attended residential structure fires showed that such fires decreased by 43 percent.

One of the questions motivating the present survey was to compare the decrease in fire department-attended fires with the decrease in fires not attended by fire departments. As mentioned earlier in this chapter, it has been suggested that the almost universal adoption of household smoke alarms in the last 20 years has resulted in people becoming aware of fires at an earlier point in the fire development. This would allow them to extinguish the fire without notifying the fire department. The implication is that over the past 20 years, fire department-attended fires would have decreased much faster than unattended fires. As that was not found in the survey, there does not seem to be support for this conjecture.

Chapter 4 Comparison of Fire and Non-Fire Households

This chapter evaluates fire risk factors by comparing characteristics of fire households with non-fire households. As mentioned above, fire households were defined as the survey respondents who had at least one fire during the three-month recall period, while non-fire households were the households that did not so indicate.

Some of the factors analyzed in the chapter include region of residence, type of housing unit, ownership versus renting, house age, household size, age composition, presence of smokers, income, education, race, and ethnicity. Factors that were significantly different between fire and non-fire households were as follows:

- Fire households were more likely to be renters and less likely to be owners
- Fire households had on average more members and, in particular, more people under 18 but fewer people over 65
- The head of fire households tended to have a higher educational level than the head of non-fire households.

Different from the 1984 survey, the presence of at least one smoker in the household did not appear to differ significantly between fire and non-fire households. The difference in the average number of smokers in fire and non-fire households was borderline significant. In this present survey, the percent of households with smokers was lower than in the 1984 survey.

Chapter 5 Characteristics of Households with Smoke Alarms and Fire Extinguishers

The purpose of Chapter 5 is to compare characteristics of survey respondents that had (1) different smoke alarm installations (including alarm location and alarm interconnection) and (2) fire extinguishers. Fire and non-fire households were compared as well as households with and without risk factors that were suggested by the analysis in Chapter 4.

In contrast to the 1984 survey where 62 percent of households had smoke alarms, 96.7 percent of households had at least one smoke alarm in the present survey. With that large a proportion having smoke alarms, it would be unlikely to find significant differences in the presence of smoke alarms by many household characteristics, but both region variables (South with the lowest proportion of households with alarms) and community type (non-urban with fewer alarms) were significant.

More than 75 percent of households had at least one fire extinguisher. There were significant differences in the percent having at least one extinguisher by type of dwelling (mobile homes and multifamily less likely to have fire extinguishers) and also renters were less likely to have at least one extinguisher in the residence than homeowners.

The chapter then examines the differences in smoke alarms between fire and non-fire households. Non-fire households were significantly more likely to have smoke alarms than fire households, and the difference in the average number of smoke alarms between fire and non-fire households was statistically significant. Controlling for the difference in the size of the dwelling showed that non-fire households had more smoke alarms per floor on average than fire households. In addition, non-fire households were more likely to have smoke alarms on all floors, in all bedrooms, and alarms that were interconnected.

Non-fire households had a larger number of extinguishers than fire households, on average.

The chapter concludes by comparing the two recommended smoke alarm configurations, smoke alarms on all floors and smoke alarms in all bedrooms by some of the risk factors developed in Chapter 4. Non-urban households were significantly less likely to have smoke alarms on all floors, while households with at least one person under 18 were significantly more likely to have smoke alarms on all floors. Non-urban households, households with smokers, and households with at least one person over 65 were less likely to have smoke alarms in all bedrooms, while households with at least one person under 18 were significantly more likely to have alarms in all bedrooms.

Chapter 6 Characteristics of Residential Fires

Chapter 6 returns to the same dataset used in Chapter 3, the fire incidents from the 14- and 21-day recall periods. This chapter and Chapter 7 examine the types of fires, the characteristics of households where they occurred, and the associated fire losses. A particular focus in this chapter is the ratio of unattended to attended fires, in order to shed some light on the differences in fire and household characteristics where attended and unattended incidents occur.

The chapter begins with the demographic breakdown of the estimated 7.4 million attended and unattended fires. Fires are broken down by region of the country, showing that the West region had the highest per household fire incidence and the lowest ratio of unattended to attended incidents. The chapter continues comparing fires in owner occupied and rental housing, single family and other types of housing, urban and non-urban regions, and other characteristics. One important finding noted in this chapter is that the per household fire incidence rate increased with an increasing number of members in the household. Also, households with at least one member under 18 had almost twice as many fires per household as those without a family member under 18. Although households with members 65 and over had a lower household fire incidence rate than households with only younger members, when fires occurred in households with older members, it was more likely to result in fire department attendance than a fire in a household with only younger members.

The chapter continues with descriptions of the fire characteristics, showing that most fires (4.8 million fires or 64 percent of the total) involved cooking appliances. The next largest source of heat was small open flames, such as candles, matches, lighters and other devices (783,000 fires or 10.7 percent). Consistent with the number of cooking fires, most fires were found to start in the kitchen (68 percent), followed by the bedroom (7.5 percent). The highest hourly fire rate was between 5 and 9 pm, which is the time when many cooking fires happen.

The remainder of the chapter focuses on fire losses. Substantial property damage, injuries to household members, and other fire consequences tended to be the exception in these incidents. For example, in 74 percent of incidents there was no smoke damage, in 93 percent of incidents there was no flame damage or flame damage only to the item first ignited, and in 81 percent of incidents the property damage was under $100. In less than 1 percent of incidents, the conditions after the fire required families to stay out of the household for one day or longer.

The chapter also develops an approximate method for determining the uncertainty associated with any of the estimates presented in this chapter, Chapter 7 and Chapter 8. This method, a generalized coefficient of variation, is described in the appendix of Chapter 6.

Chapter 7 Consumer Products Involved in Unattended Residential Fires

Chapter 7 treats some of the same issues as Chapter 6, but the focus in this chapter is unattended fires and consumer products. In Chapter 3, it was estimated that 3.4 percent of total fires were attended by fire departments. As a result, almost all analyses of both attended and unattended fires taken together will be the same as analyses of unattended fires. The exceptions are in any measures associated with the severity of the incident because fire department-attended fires tend to have much larger fire losses than unattended incidents. To develop a better understanding of unattended fires, fire losses and consumer products, the analyses in this chapter only consider unattended incidents.

Another reason to focus on unattended incidents is to be able to compare the results with the 1984 survey. More specifically, one of the main objectives in Chapter 7 is to account for the 69 percent decrease from an estimated 22.9 million unattended fires in 1984 to 7.2 million unattended fires in the current survey. A key issue is if the decrease occurred in all types of fires or just certain types of fires.

One unique feature of this chapter is an estimate of the percentage decrease in the number of unattended fires from the 1984 survey by various characteristics of the fire. This comparison requires modifying the estimation method for the current data to match the 1984 survey. The statistical approach is outlined in the chapter and presented in some detail in an appendix.

Like Chapter 6, Chapter 7 analyzes the room where the fire incident began, the source of heat, item first ignited, damage, injury, and property loss. The analysis focuses on appliance (synonymous with equipment) fires, distinguishing them from non-appliance fires by time of day and item first ignited. Then specific types of fires are studied. These include cooking fires by type of cooking appliance, electrical lighting and wiring fires, heating and cooling appliance fires, other household appliances, and small open flame and cigarette fires.

With respect to the item first ignited, most cooking-related fires (83 percent) involved cooking materials. The second largest category involved linens, probably kitchen towels, and napkins. Most cooking-related fires (81.2 percent) involved ranges, with about twice as many electric ranges involved in fires than gas ranges. The third highest ranking appliance involved in cooking-related fires was microwave ovens (7 percent). Electrical lighting-related and wiring-related fires were most likely to involve light fixtures (23 percent) or lamps (11 percent); the item first ignited most frequently was bedding (24 percent), none reported (22 percent), or electrical wire (21 percent). Heating and cooling appliance-related fires were most often associated with fixed heaters (30 percent of heating fires) and portable heaters (35 percent), and ignited electrical wire (41 percent) or the appliance itself (29 percent).

When the heat source was cigarettes or small open flames, the largest single source was candles (52 percent of cigarette/open flame incidents). When cigarettes were involved, bedding was the most frequently ignited item, while with other open flame incidents, paper was the most frequent item first ignited.

In comparison with the results of the 1984 survey, cooking fires and heating and cooling equipment associated fires decreased at about the same rate as all incidents, other household appliances decreased by a larger percent, and electrical lighting/wiring fires declined less. Non-appliance fires decreased more than the overall decrease, at 84 percent. As the most frequently occurring heat source for non-appliance fires was fires with cigarettes and small open flames, this decline in non-appliance fires probably reflects an overall decrease in smoking-related incidents.

Chapter 8 Operation and Effectiveness of Smoke Alarms and Fire Extinguishers

To examine how smoke alarms and extinguishers reduce fire losses, this chapter uses the fire incidents from the 14/21-day recall period. For the most part, only unattended fires are considered in this chapter.

The chapter opens with a discussion of different ways to characterize the operation of smoke alarms. Smoke alarm operation is described as follows: (1) the alarm sounded, but did not alert anyone to the fire, (2) the sounding alarm alerted residents to the fire, and (3) the alarm provided the only alert of the fire. When residents reported that they were not alerted when the alarm sounded because they were already aware of the fire, the sounding alarm may provide some benefit by confirming the seriousness of the fire or the location of the fire. An alarm that alerts people to the fire first is of greater benefit in providing them with an early warning. If the sounding alarm provides the only alert, a situation that may occur when residents are not near to the fire, this is of even greater benefit.

In the chapter, it was estimated that from the survey data that smoke alarms sounded in 30 percent of the fire incidents (40 percent of attended fires), alerted residents in 11.8 percent of the incidents, and provided the only alert in 9.8 percent of incidents.

Why did the alarm not sound or alert residents more frequently? The main explanation for the alarm not sounding provided by survey respondents was that insufficient smoke reached the alarm. This not only involves the characteristics of the fire but also where alarms were located in the residence. In most cases when the alarm did not sound, residents reported that before the fire, they believed that the alarm was working.

Some highlights of the chapter are as follows. In fires starting in the kitchen, the alarm sounded in 36.9 percent of incidents, alerted residents in 14.9 percent of incidents, and provided the only alert in 12.0 percent of incidents. In fires starting in the bedroom, the alarm sounded in 16.7 percent of incidents, alerting people and providing the only alert in 11.6 percent of fires. In fires involving heating and cooling equipment, the alarm sounded in 17.9 percent of incidents, alerting residents in 4.1 percent and providing the only alert in less than 1 percent of incidents. The alarm sounded in 19.5 percent of candle fires and 27.7 percent of lighter, cigarette, and match fires; alerting people in 6.9 percent of candle fires and 7.9 percent of lighter, cigarette, and match fires; and providing the only alert in 6.2 percent of candle fires and 7.9 percent of lighter, cigarette, and match fires.

Another aspect of this chapter was to analyze alarm operation by how the alarms were configured in the residence. Interconnected alarms sounded in 53.3 percent of incidents as compared with 27.0 percent with non-interconnected alarms, alerted people in 26.0 percent of incidents as compared with 10.0 percent with non-interconnected alarms, and interconnected alarms provided the only alert in 26.0 percent of incidents as compared with 7.6 percent with non-interconnected alarms. Most fires occurred in residences that did not have interconnected alarms.

There also were large differences between alarm responses in residences where the alarms were on all floors in contrast to alarms not on all floors. As shown in Chapter 5, 82 percent of fire households had alarms on all floors. Overall the alarms sounded in 37.1 percent of incidents when the alarms were on all floors as compared with 4.1 percent in residences without alarms on all floors. With alarms on all floors, people were alerted in 14.5 percent of incidents and this was the only alert in 11.9 percent of incidents. In contrast, in residences without alarms on all floors, people were alerted in 1.9 percent of incidents and in each case, this was the only alert.

The other issue considered in the chapter is the use and effectiveness of fire extinguishers. Fire extinguishers were used in 4.5 percent of unattended fire incidents and 17.7 percent of attended fires, often in combination with other methods. Most unattended fires were put out by removing power, putting water on the fire, separating the fuel from the heat source, or other such actions. The most frequent use of extinguishers was in unattended bedroom fires (8.6 percent of incidents), kitchen fires (5.2 percent), candle fires (9.5 percent), and fires in cooking equipment other than stoves (9.9 percent of incidents). There was a somewhat higher chance of the extinguisher being used when it was in the room where the fire started.

Appendix

The survey questionnaire is reprinted in the Appendix at the end of this report.

Chapter 2
Survey Methodology[28]

This chapter describes the technical aspects of how the survey was designed and conducted.

The chapter is organized into five sections. The first section, Sampling Plan, discusses the survey design (including construction of strata), sample size and allocation, sample selection, and collapsing the strata. The second section, Questionnaire Design, briefly describes the development and testing of the survey questionnaire. This is followed by a section on Survey Management, including interviewer training, data collection, determining respondent eligibility, and maximizing response rates. The next section, Responses to the Survey, describes the characteristics of the actual sample and the construction of the weights used in analyzing the data. The last section describes the response rate methodology and presents the response rates.

Sampling Plan

The sampling frame for this survey consisted of all U.S. residential telephone numbers, i.e., all U.S. households with at least one land-line telephone in the home. The frame was developed using the GENESYS[29] sampling system.

GENESYS is a computer program and data system that is used to create random digit dialing (RDD) single-stage probability samples of telephone numbers. It generates each random telephone number by first randomly selecting a block of telephone numbers. A block consists of the area code and the first five digits of the phone numbers. Then a number from 01 to 99 is computer generated and appended to the end of the block number for the full specification of the phone number to be called.

One of the advantages of using this system is that much is known about each block of telephone numbers. This includes whether it contains at least one residential telephone number, so that blocks of phone numbers assigned exclusively to businesses or not-yet assigned blocks will not be called. Additionally, the GENESYS system contains telephone exchange level estimates for over 48 demographic variables such as age, income, home ownership, education, race, whether the block belongs to a metropolitan (urban) or non-metropolitan (non-urban) region, etc. This feature then allows designing a sample that can be stratified to over- or under-sample households along certain demographic variables.

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[28] This chapter was drafted by Synovate, Inc, then edited and reformatted by CPSC staff. Under contract Number GS-23F-8039H and Order Number CPSC-F-02-1316, Synovate participated in the design of the survey questionnaire, tested the questionnaire, and conducted the telephone survey. Synovate also designed the sampling plan.

[29] GENESYS is a product of the Marketing Systems Group, Fort Washington, PA.

The sampling frame of households was stratified to meet the goals of the sampling plan. The strata were constructed such that the resulting sample would accomplish the following:

- Provide a nationally representative probability sample of U.S. households in the 50 states and the District of Columbia.

- Provide sufficient representation of key demographic subgroups including but not limited to: Native Americans, African Americans, households in rural areas, households of Hispanic origin, and the elderly. Race and ethnicity in this report refer to the head of the household only.

- Provide sufficient representation of other demographic and housing characteristics, such as: type of dwelling, age of dwelling, rental versus owned properties, household income, education of head of household, cause of fire and room of origin, and age of occupants.

Sufficient representation meant that there would be adequate numbers of respondents within these subgroups to make comparisons along two important dimensions as follows: (1) if there were differences in fire incidence by subgroup, that is, if the risk of fire was elevated in certain subgroups above the population risk and (2) to determine if there were differences in the number and types of smoke alarms and fire extinguishers by subgroup.

Synovate, Inc., the survey contractor, with the help of Marketing Systems Group, compiled area code and exchange combinations along with key population statistics updated from the 2000 U.S. Census. All area codes/combinations were assigned to 16 strata that were defined and compiled by geographic region of the country, incidence of ethnic/racial categories, and urban/non-urban designations.

Specifically, the sampling design uses these definitions:

- The urban/non-urban strata are determined by whether or not counties are assigned to a Metropolitan Statistical Area (MSA). MSAs are a geographic entity used by federal statistical agencies for collecting, tabulating, and publishing statistical information. MSAs contain a core urban area of at least 50,000 people with at least one county and includes the surrounding counties that have a high degree of geographic or social interaction with the urban core.[30]
- The Native American strata have at least a 25% incidence of Native Americans in this small area definition as reported in the 2000 Census.[31]
- The African American strata have at least a 50% incidence of African Americans in this small area definition as reported in the 2000 Census.

[30] For more information including the formal definition of Metropolitan Statistical Areas (MSAs), see www.census.gov/population/www/estimates/metroarea.html.
[31] The sampling plan was based on the U.S. Census Bureau's ZCTA—ZIP Code Tabulation Areas. These are approximately equivalent to the definition of U.S. Postal Service ZIP Codes. The final sample was drawn from a frame of area code and telephone exchanges mapped to Census blocks.

- The Asian American strata have at least a 25% incidence of Asian Americans in this small area definition as reported in the 2000 Census.
- The Hispanic American strata have at least a 30% incidence of Hispanic Americans in this small area definition as reported in the 2000 Census.

On the basis of these definitions, 16 strata were defined. Eight of these were defined by race or ethnicity (Native American, African American, Hispanic American, and Asian American) of the head of household and whether the stratum was an urban or non-urban region. The other eight strata were defined by region (East, Midwest, South, and West) crossed with urban/non-urban region.[32] Strata that satisfied two or more of the above regional, ethnic, or racial criteria were defined in the following order: Native American, Asian American, Hispanic American, African American, and then region of the country. This meant that the eight region strata (the East, Midwest, South, and West strata by urban/non-urban) represented area code/exchanges (telephone blocks) that did not have high incidence of the four ethnic/racial groups.

Table 2-1 shows the definition of the strata.

32 Regions were defined as follows: Northeast: CT, MA, ME, NH, NJ, NY, PA, RI, VT; South: AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV; Midwest: IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI; West: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY.

Table 2-1
Stratum Definitions and Incidence of Population Subgroups

Stratum Number and Definition			Number of Households	Percent of Population in Stratum	Percent Composition by Race or Ethnicity of Head of Household: White	African American	Asian American	Native American	Hispanic American
	All		105,475,618	100.00	75.14	12.32	3.78	0.88	12.54
1	Native Amer.	Urban	31,717	0.04	32.17	0.81	0.25	62.45	5.79
2	Native Amer.	Non-urban	224,938	0.26	27.37	3.13	0.37	68.02	4.21
3	African Amer.	Urban	5,937,032	5.77	19.76	74.03	1.41	0.24	5.47
4	African Amer.	Non-urban	694,098	0.70	35.63	62.48	0.30	0.28	1.69
5	Hispanic Amer.	Urban	10,532,587	11.79	54.29	10.21	4.72	0.51	55.05
6	Hispanic Amer.	Non-urban	796,905	0.86	69.53	3.38	0.91	0.69	53.95
7	Asian American	Urban	1,654,980	1.69	39.66	6.25	41.2	0.24	12.94
8	Asian American	Non-urban	109,739	0.11	30.48	0.47	42.0	0.40	8.88
9	East	Urban	15,277,910	14.16	84.49	6.69	3.98	0.18	6.34
10	East	Non-urban	2,132,718	1.96	95.38	1.86	0.76	0.30	1.81
11	Midwest	Urban	15,976,528	14.63	87.62	6.34	2.37	0.36	3.88
12	Midwest	Non-urban	6,457,380	5.92	95.06	1.72	0.55	0.65	2.13
13	South	Urban	22,257,623	20.37	79.13	13.29	2.65	0.50	6.81
14	South	Non-urban	8,197,684	7.56	81.56	14.04	0.51	0.94	3.65
15	West	Urban	12,736,284	11.87	78.74	3.87	6.91	0.82	13.02
16	West	Non-urban	2,457,495	2.31	88.94	0.80	1.12	2.32	7.93

Notes: Source: 2000 Census Data Note that although the first eight strata are defined by race, ethnicity, and urban/non-urban communities, they contain members of all races, ethnicities, urban locations, and non-urban locations. Racial groups are mutually exclusive. Two other race categories are not included: Native Hawaiian or Other Pacific Islander and Some Other Race. Race categories do not add to 100 percent because of the two omitted race categories and also because, in some cases, respondents did not specify their race to the census interviewers. Also, note that Hispanic ethnicity overlaps racial groups.

Table 2-1 shows the distribution of U.S. households for the 16 strata along with the incidence of each group within each stratum. The goal of the stratification is to increase the sample incidence of key population subgroups as well as to reduce sampling variance. For example, the incidence of Native American-headed households is approximately 65 percent in the Native American strata, compared to 0.88 percent in the U.S. population overall. The incidence of African American-headed households is 74 percent in urban areas and 62 percent in non-urban high incidence African American strata, compared to 12 percent overall. Thus, within each stratum, one or more race or ethnic group is represented at a rate that is higher than their representation in the U.S., but each stratum contributes people from all racial and ethnic groups. The stratum definitions cover the entire United States and District of Columbia.

Sample Design Fundamentals

Stratified sample designs are efficient because they have lower sampling variance for the same number of survey respondents as simple random samples or cluster samples. Using population information compiled from the Census Bureau and commercial demographic sources, and mapping Census blocks to area code and telephone exchange areas, the strata were constructed to over-sample African American, Native American, and Hispanic American households. Stratified designs developed using these procedures have the following characteristics:

- Known probabilities of selection
- Single-stage design without clustering
- Well defined formulas for estimating parameters and variances

Each stratified sample is a collection of simple random samples – one simple random sample within each stratum.

Sample Size and Allocation

The sample design specified screening approximately 76,650 households for occurrences of fire incidents during the previous 90 days. The plan was designed to provide approximately 1,810 interviews of households that had at least one fire. This estimate was made by assuming an average incidence of 2.36 fires per 100 households during the previous 90 days, an assumption that was based on the 1984 survey.[33] An abbreviated interview was to be administered to a 1/40th (2.5 percent) random selected subset of non-fire households to obtain a sample of about 1,500 households. The purpose of the interview with non-fire households was to capture information on demographics, housing characteristics, and numbers and types of smoke alarms and fire extinguishers of non-fire households for comparison with fire households.

The final anticipated sample specifications were as follows:

[33] In the 1984 survey, it was estimated that there were 28.3 (fire department-attended and unattended) residential structure fires per 100 households per year, or approximately 7.1 fires per 100 households per 90 days (Audits and Surveys (1985), *op cit.,* page 18). The estimate of 2.36 fires per 100 households took into account that respondents would not recall some incidents during the 90-day recall period and also that there was a decrease in household fires between 1984 and 2004 that was somewhat commensurate with the decrease in reported fires. For more details on household fire incidence rates and recall issues, see Chapter 3.

- Brief screening interviews with 76,650 households
- Extensive interviews with 1,810 fire households
- Abbreviated interviews with 1,500 non-fire households

The demographic distribution of the final sample was based on the actual heads of households that were contacted and, as a result, could not be known until the completion of the study. The anticipated demographic distribution was calculated using Census data. Table 2-2 provides the anticipated sample sizes for the key demographic groups. These numbers were calculated by first allocating the number of households in the sample to each stratum (see Table 2-3) to provide an estimate as to how many households would be in each stratum. Then the number of households in each stratum was multiplied by the percent incidence of each demographic subgroup in that stratum (as shown in Table 2-1). Finally, the number of households in each demographic group was then added across the strata to provide an estimate for the number of households in the sample by demographic, ethnic, or racial group membership.

Table 2-2

Target Sample Number and Percent of Fire Households
by Race, Ethnicity or Demographic Group

Racial, Ethnicity or Demographic Group	Sample Size	Percent
All	1,810	100.0
White	1,093	60.4
African American	224	12.4
Asian American	174	9.6
Native American	176	9.7
Hispanic	203	11.2
Urban	1,336	73.8
Non-urban	474	26.2
Household Income under $25,000	569	31.4
Households with at Least One Member		
Age 65 and over	215	11.9
Age 18 and under	280	15.5
Home Owner	1,249	69.0
Renter	561	31.0
Single Family	1,265	69.9
Multiple Family	422	23.3
Mobile Homes	123	6.8

Notes: Race and ethnicity characterize only the head of the household; income is defined as household income and may involve more than one family member; age characteristics mean that a household contains at least one member in that age group. The target sample sizes for racial categories do not add to 1,810 households because they are based on Table 2-1, where the percentage composition by race does not add to 100 percent. That was because some people did not specify their race in the Decennial Census and also because two race categories are not included in Table 2-2. See the notes for Table 2-1. The Hispanic category overlaps all races.

It is important to understand that this was not a quota sample in the sense that the sample was designed to select exactly 224 African American-headed households, 203 Hispanic American-headed households, etc. In a quota sample, sampling of each ethnic group would stop as soon as the desired number of households was obtained. The procedure here was different. The sample sizes were defined based on the allocation of the total number of households to strata as shown below in Table 2-3. That allocation was designed to yield the samples sizes specified in Table 2-2. However, the actual number of households in the sample in each particular race, ethnicity, or demographic group would be likely to differ from the targets in Table 2-2 because of sampling variability.

Table 2-3
Allocation of Total Sample to Strata

Stratum Number	Stratum Definitions Race/Ethnicity	Urban/Non-urban	Sample Size
	All	All	1,810
1	Native American	Urban	31
2	Native American	Non-urban	219
3	African American	Urban	134
4	African American	Non-urban	16
5	Hispanic	Urban	139
6	Hispanic	Non-urban	11
7	Asian American	Urban	309
8	Asian American	Non-urban	21
9	East	Urban	167
10	East	Non-urban	23
11	Midwest	Urban	171
12	Midwest	Non-urban	69
13	South	Urban	238
14	South	Non-urban	87
15	West	Urban	147
16	West	Non-urban	28

Notes: Race, ethnicity, and urban/non-urban characteristics predominate in each stratum, but each stratum contains households with all races, ethnicities, urban and non-urban locations. See Table 2-1 for details.

Sample Selection

The sample was designed to be selected using random digit dialing. Telephone numbers were generated using the GENESYS sampling system. The GENESYS system produces equal probability selection method samples without a clustering effect.

As mentioned above, the GENESYS system constructs a frame of all known telephone area codes, exchanges, and blocks of telephone numbers with at least one listed telephone number. The frame was then mapped onto Census Blocks, and the known Census information was used to assign blocks of telephone numbers to the strata. Samples were then able to be generated from telephone blocks associated with those Census Blocks.

Before starting the telephone interviews, Synovate staff pointed out that it would be difficult to manage telephone interviewing for the strata where the desired sample sizes were very small. As a result, the urban and non-urban strata for the Native American, African American, Hispanic, Asian American, and East strata were collapsed together. By collapsing the strata, the urban/non-urban mix in the final sample was likely to be proportional to the distribution of urban and non-urban households in the collapsed strata. Table 2-4 shows the final sampling plan for the resulting 11 strata.

Table 2-4
Final Sample Allocation

Stratum Number	Stratum Definition Race/Ethnicity	Urban/Non-urban	Sample Size
	All	All	1,810
1	Native American	Both	250
2	African American	Both	150
3	Hispanic	Both	150
4	Asian American	Both	330
5	East	Both	190
6	Midwest	Urban	171
7	Midwest	Non-urban	69
8	South	Urban	238
9	South	Non-urban	87
10	West	Urban	147
11	West	Non-urban	28

Questionnaire Design

Early drafts of the survey instrument were based on the 1984 survey and designed to be similar enough to permit comparisons of results. Pilot testing of the instrument and procedures took place in four phases. The first two phases of pilot testing were conducted prior to Office of Management and Budget (OMB) clearance, and the last two were completed after clearance.[34]

In the first phase of pilot testing, the survey instrument was tested using staff from Synovate and CPSC. The purpose of this pretest was to evaluate question wording, logic flow, prompts, and the list of responses to some questions that would be read to survey respondents. The interview length was estimated during the pretest. Staff members with

[34] U.S. Government agencies initiating a new survey or developing a major revision of an existing survey that will ask identical questions, or have identical record keeping or disclosure requirements imposed on 10 or more respondents are required to submit information clearance requests describing the anticipated survey to the Office of Management and Budget for clearance.

recent fires in their homes were recruited by letter. Persons identified through public sources as having experienced recent fires were also asked to participate in the pretest.

During the second phase of testing, cognitive interviews took place to assess whether respondents understood the questions as intended and if the alternatives presented supported valid responses. Nine in-depth telephone interviews were completed with respondents from low-income areas who had experienced recent residential fire events. The interviews were conducted by telephone to reflect the telephone interviewing method during the actual survey.

Synovate's TeleNation omnibus was used for the third phase of the survey pretest. The purpose was to test a number of different approaches to asking the key screening questions about whether the respondents had experienced a fire event in the previous three months. Because respondents may not remember such events, different versions of the screening questions were tried to test how well the form of the question elicited recall of fire events.[35] Synovate staff interviewed 2,000 persons who were randomly assigned to one of up to four versions of the screening questions.

To assure that all aspects of the survey instrument and protocol were working as designed, the final phase of pilot testing involved trained interviewers and the fully developed survey instrument programmed into Synovate's Computer Assisted Telephone Interviewing System (CATI). The pilot test involved a random digit dialing sampling frame from the general population.

The final survey questionnaire was also translated into Spanish. A copy of the English language questionnaire appears at the end of this report.

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[35] Both the 1974 and 1984 surveys displayed problems with people recalling fire events. See Audits and Surveys (1985), *op cit.*, pages 11-16 and Chapter 3 of this report.

Survey Management

Interviewer Training

Synovate staff trained a group of interviewers at their facility in Fresno, California. Interviewers were briefed extensively on the content and format of the survey, including the use of skips and prompts. In addition, interviewers were supplied with a manual that provided information about CPSC and the purpose of the study. A list of answers to commonly asked questions and objections was provided. Also, each interviewer was provided with a list of reasons explaining why respondents may refuse to participate and detailed ways to gain the respondent's cooperation. The briefing was conducted in an interactive manner, allowing interviewers to raise questions and make suggestions for the successful completion of the survey.

The interviewing effort was managed by data collection supervisors. They maintained records on the sample and the numbers of completed interviews, callbacks, and refusal conversions, and they managed the staffing requirements. All interviewers were monitored throughout the project by quality control supervisors. If an interviewer had a high refusal rate, corrective measures were taken, and interviewers with a low refusal rate were selected for refusal conversion calls.

Telephone Data Collection

Interviewing began on June 4, 2004 and continued through September 7, 2005. Interviews were conducted from Synovate's Fresno, California facility. Respondents were called between 9:00 a.m. and 9:00 p.m. Monday through Friday, between 10:00 a.m. and 9:00 p.m. on Saturdays, and between 11:00 a.m. and 9:00 p.m. on Sundays (all times were local to the area telephoned). Weekday dialing was limited so there would not be an over-representation of homemakers or retirees. Each month a sample was drawn for each stratum, and the monthly sample was divided into equal sized groups by stratum (replicates) to allow managers to control release of the sample in response to differences in response rates by strata.

Interviewers were monitored for the quality of the information elicited from respondents, and provided with guidance and correction when necessary. In addition, project management reports were generated by computer on a daily basis in order to track sample disposition and production rates.

Synovate's Computer Assisted Telephone Interviewing (CATI) system was used for data collection. Questionnaires were programmed into the system, and telephone interviewers read questions as they were logically fed in predetermined order from the computer to a viewing screen. The answers were sent back to the computer through the keyboard. This system reduced interviewer error, such as not adhering to skip patterns, thus enhancing the quality of the data.

Respondent Eligibility

To be eligible to participate in the study as a fire household, the respondent had to be 18 years of age or older and to have reported an eligible fire within the past 90 days. Eligible fires were defined in a question in the beginning of the survey as follows:

> *We are interested in learning about any fires – large or small—that you have had in or around your home. By "fire" I mean any incident – large or small—that resulted in unwanted flame or smoke and could have caused damage to life or property if left unchecked.*[36]

Home was further defined to mean "… house, apartment or other residence where you [the respondent] live…" Respondents who answered that they did not have a fire were then asked if they had at least one or more of common fire type incidents such as unwanted flaming or smoking on the stove or another cooking appliance, a smoking electrical appliance, burning or smoldering clothing, etc.

Of the households screened that did not report having a fire in the past 90 days, a subset of 2.5 percent (1 in 40) were selected randomly for an abbreviated interview that captured information on demographics, housing characteristics, and fire defenses.

If the household had more than one adult aged 18 or older, the "head of the household" was selected for the interview. This required that the person answering the phone know which adult was responsible for the home and be willing to pass the telephone to him/her. Those households that failed to identify the "head of the household" were called at different times in order to maximize the chance of reaching an individual who could identify the correct person within the household.

Procedures to Maximize Response Rates

Several procedures were undertaken in order to increase the response rates as much as possible and reduce the chance of interpretive error or bias associated with low response rates. The procedures were as follows:

- Highly experienced interviewers were assigned to the project. Interviewers with experience conducting interviews for government studies received extensive training and were used for this study.

- Telephone interviews were conducted at different times of the day and days of the week in order to increase the likelihood of locating available respondents at times convenient for them. When possible, callbacks were scheduled at specific times requested by respondents.

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[36] See page 1 of the survey instrument in the Appendix to this report.

- Several interviewers had the ability to conduct interviews in Spanish using a Spanish language version of the questionnaire.

- Every telephone number that did not result in contact with a respondent (excluding disconnects, fax numbers, and modems) was dialed up to 40 attempts on successive days in order to increase the chances of finding a potential respondent.

- Production rates, interview length, and sample dispositions were monitored closely every other day to detect potential problems with the sample so they could be addressed and resolved immediately.

- Project management personnel received weekly reports containing the number of refusals received and hours dialed by each interviewer. These reports were closely monitored by supervisory staff. Interviewers with a high refusal to hours-dialed ratio were removed from dialing or provided corrective feedback and monitored more closely. In addition, those who demonstrated the lowest refusal to hours-dialed ratio were selected for refusal conversion interviewing. These interviewers called households that had on previous calls refused to participate.

Non-response Follow-up Results

All non-respondents were re-contacted by telephone one to two weeks following the initial contact in order to secure their cooperation. Those respondents who requested that they not be contacted again were excluded from this effort. The contact was made by more experienced interviewers, who were specially trained in refusal avoidance techniques.

In order to assess the extent of any bias due to non-response, a random subset of those who refused for a second time during the conversion attempt answered a few key demographic questions. This allowed the characterization of any differences between respondents and those who chose not to participate.

Responses to the Survey

Table 2-5 provides the actual number of survey fire households compared with the projections from the sample design.

Table 2-5
Projected and Actual Number of Fire Households in the Survey

Stratum Definition (Stratum Number)	Projected		Actual	
	Responses	Percent	Responses	Percent
All	1,810	100.0	916	100.0
Native American (1)	250	13.8	152	16.6
African American (2)	150	8.3	70	7.6
Hispanic (3)	150	8.3	60	6.6
Asian American (4)	330	18.2	161	17.6
East (5)	190	10.5	105	11.5
Midwest - Urban (6)	171	9.4	67	7.3
Midwest – Non-urban (7)	69	3.8	39	4.3
South – Urban (8)	238	13.1	113	12.3
South – Non-urban (9)	87	4.8	38	4.1
West - Urban (10)	147	8.1	93	10.2
West – Non-urban (11)	28	1.5	18	2.0

As shown in the table, there were 916 actual fire households in the survey compared with a projected 1,810 fire households from the survey design. That projection, as noted previously, was based on a fire incidence rate of 2.36 fires per 100 households in a three-month period (approximately 9.5 fires per 100 households per year) developed on the basis of the 1984 survey. The projection was about twice as high as what was found in the data, resulting in an actual sample of fire households that was about half that projected.

Despite the difference between the actual and projected sample sizes, the proportional distribution of the sample among strata was maintained in the sample, indicating that the racial, ethnic, and demographic distribution would be likely to be as planned. That distribution is shown in Table 2-6 below.

Table 2-6
Projected and Actual Demographic Distribution of the Fire Households in the Survey

Demographic Factor	Projected Number	Projected Percent	Actual Number	Actual Percent
Total	1,810	100.0	916	100.0
White	1,093	60.4	601	65.6
African American	224	12.4	99	10.8
Asian American	174	9.6	37	4.0
Native American	176	9.7	98	10.7
Hispanic	203	11.2	106	11.6
Urban	1,336	73.8	646	70.5
Non-urban	474	26.2	270	29.5
Household Income under $25,000	569	31.4	198	21.6
At Least One Household Member				
Age 65 and over	215	11.9	42	4.6
Age 18 and under	280	15.5	488	53.3
Home Owner	1,249	69.0	571	62.3
Renter	561	31.0	334	36.5
Single Family	1,265	69.9	552	60.3
Multiple Family	422	23.3	255	27.8
Mobile Homes	123	6.8	93	10.2

Notes: The survey question about annual household income had different categories than in the planning documents. The estimated survey proportion for the number and percent of households with income under $25,000 is estimated as all responding households with income under $15,000 plus half the households who reported income between $15,000 and $35,000. Detail lines may not add to totals because of non-response, omitted categories, or in the case of race and ethnicity, that a household head may specify membership in more than one race or ethnic group or no race or ethnic group.

Table 2-6 shows that the sample met the survey design projections in percentage terms by the race and ethnicity breakdowns, except that there were fewer households headed by Asian Americans than expected. The distribution of urban/non-urban households, owners and renters, and dwelling types were fairly close to the projections.

The survey sample was different from the projections in that there was a smaller proportion of households with members 65 or older and more households with members 18 years or younger. The survey also had relatively fewer households with household income under $25,000.

Sample Weighting

Samples are weighted to be able to extrapolate to a target population, in this case all U.S. households. The procedure followed the standard approach of constructing weights that are the inverse of the probability of selecting an element in the sample. Weights were constructed as follows:

The initial weight w_{ih} was defined as the weight associated with the screening process for household *i* in stratum *h.* It was defined as follows:

$w_{ih} = 1/L_{ih}$ if household *i* in stratum *h* was a fire household,
$= [(T_h)/(V_h)] * 1/L_{ih}$ if household *i* was a non-fire household in stratum *h*.

where

L_{ih} was the number of telephone lines receiving calls in household *i,* stratum *h* (i.e., distinct telephone numbers ringing in the household). This corrects for the fact that households with more lines have a higher probability of being selected for the survey.
T_h was the total number of non-fire households (households with no eligible fires) in stratum *h*, and
V_h was the sample number of non-fire households in stratum *h*.

The initial weights are proportional to the inverse of the sampling probability, but are not yet the inverse of the sampling probability. The next stage was to make them scale to the total sample size. This was called the design weight, as follows:

$$DesignWeight_{ih} = K_h \, w_{ih}$$

where K_h was a constant assigned to stratum *h* to bring the sum of the initial weights into proportion across the strata, i.e.,

$$K_h = \frac{N_h}{\sum_{h=1}^{H} N_h} \Bigg/ \frac{\sum_{i \in h} w_{ih}}{\sum_{h=1}^{H} \sum_{i \in h} w_{ih}}.$$

In the above equation N_h is the number of households in the U.S. in stratum *h.*

The design weights are intended to sum to the sample size, which in this study was the 3,077 households (916 fire households and 2,161 non-fire households).

The final step was to calculate the expansion weight, the weight that would be applied to the survey responses to make estimates. The expansion weight allows the results to represent the total number of households in the United States. The formula for the expansion weight is

$$ExpansionWeight_{ih} = \frac{N}{\sum_{i \in h} DesignWeight_{ih}} DesignWeight_{ih},$$

where N is the total number of households in the United States (113,343,000).[37]

Table 2-7 presents descriptive statistics on the expansion weights. On average, each fire household in the survey represents 1,409 U.S. households and each non-fire household represents 51,852 households.

[37] The estimated number of households is from the U.S. Bureau of the Census. See www.census.gov/population/socdemo/hh-fam/cps2005/tabH2-all.csv. Note that this differs from the estimated number of households shown in Table 2-1 from the 2000 Census that was used to design the sample.

Table 2-7

Descriptive Statistics for Expansion Weights

	Fire Households	Non-fire Households
Mean	1,409	51,852
Median	1,242	45,408
Standard Deviation	1,193	52,036
Sum	1,290,329	112,052,669
Minimum	11	14
Maximum	3,443	149,742
Number of Households	916	2,161

Response Rate Computations

Final Sample Dispositions and Response Rates

As mentioned previously, the final sample size was 916 fire households and 2,161 non-fire households. The number of fire households was about half the projected number. The difference was a result of lower household fire incidence rates than the rate of 2.36 fires per hundred households that had been projected based on the 1984 survey.

Table 2-8 shows the final dispositions for the entire survey sample. Response rates, shown in that table, were computed using the method proposed by the American Association for Public Opinion Research (AAPOR).[38]

[38] American Association for Public Opinion Research (2000), "Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys," AAPOR, Ann Arbor, MI, pp. 35-37.

In computing the response rates, people who were telephoned were classified as follows:

- Interview
- Eligible/non-interview
- Unknown eligibility
- Not eligible

The interview category included all who were screened, both with full and partial interviews. The eligible/non-interview category was the non-respondents (i.e., those who refused to be interviewed). Unknown eligibility includes telephone lines that were always busy, never answered, or were always answered by answering machines, and those interviews with respondents where it was impossible to complete the screening part of the questionnaire in order to determine eligibility. Not eligible includes fax and data lines, business lines, disconnected numbers, nobody living in the home 18 years old or older, and other such categories. Table 2-8 contains a complete list of these categories.

The formulas for calculation of the response rates specify a fraction where the numerator is the number of screening interviews and the denominator is the number of phone numbers associated with eligible respondents. The four different response rate calculations construct numerators and denominators slightly differently. The formulas are as follows (with RR indicating response rate):

$$RR\ 1 = \frac{Completed\ Screening\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews + UnknownEligibility}$$

$$RR\ 2 = \frac{Completed\ Screening\ Interviews + Partial\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews + UnknownEligibility}$$

$$RR\ 3 = \frac{Completed\ Screening\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews + e * UnknownEligibility}$$

$$RR\ 4 = \frac{Completed\ Screening\ Interviews + Partial\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews + e * UnknownEligibility}$$

where

$$e = \frac{Completed\ Screening\ Interviews + Partial\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews}$$

RR1 and RR3 use Completed Screening Interviews as the numerator, while RR2 and RR4 use Completed and Partial Interviews as the numerator. In this survey, as shown in Table 2-8, there were very few partial responses, so that the difference between RR1 and RR2 was negligible as was the differences between RR3 and RR4.

RR1 and RR2 differ from RR3 and RR4 in the way that unknown eligibility was handled. RR1 and RR2 assume that unknown eligible responses were non-responses (non-interviews). RR3 and RR4 consider the possibility that some of the cases with unknown eligibility may have been business lines or other ineligible categories. RR3 and RR4 estimate the proportion of unknown eligible responses from the known responses and non-responses and then apply that proportion to the unknown eligibility category. That proportion is symbolized in the formulas above as e.

Table 2-8 contains the distribution of the responses and the response rate calculations.

Table 2-8
Overall Sample Disposition

Response Category	Number of Responses	Percent
Interview		
Completed Screening Interviews	76,826	**13.2**
Partial Interviews	66	0.0
Total	**76,892**	**13.2**
Eligible/Non-interview		
Refusal and Break Off	95,604	16.5
Total	**95,604**	**16.5**
Unknown Eligibility/Non-interview		
Always Busy	2,526	0.4
No Answer	65,405	11.3
Answering Machine-Don’t Know if Household	22,160	3.8
Call Blocking	4,580	0.8
Housing Unit, Unknown if Eligible Respondent	486	0.1
No Screening Interview Completed	73,851	12.7
Total	**169,008**	**29.1**
Not Eligible		
Fax/Data Line	21,416	3.7
Disconnected Number	130,674	22.5
Non-working Number	21,788	3.8
Temporarily Out of Service	3,428	0.6
Number Changed	10	0.0
Cell Phone	1,091	0.2
Business, Gov’t Office, Other Organization	48,315	8.3
Group Quarters	1,449	0.2
No Eligible Respondent	10,665	1.8
Total	**238,836**	**41.2**
TOTAL PHONE NUMBERS USED	**580,340**	**100.0**
AAPOR Response Rates		
Response Rate 1		22.5
Response Rate 2		22.5
Response Rate 3		31.6
Response Rate 4		31.6

Table 2-8 shows that more than one-half million telephone numbers were called for the survey. There were 76,892 interviews; most of which were with non-fire households, and most were in the 39/40th group that were not used for the survey. More than 95,000 households who were contacted began the interview, were determined to be eligible from the initial screening questions, but then decided against participation. Slightly more than 169,000 households were not able to be reached for various reasons; these count as being of unknown eligibility. Finally, almost half the numbers contacted were ineligible because they were disconnected, business lines, non-working numbers, fax or data lines, or in some other way did not represent a household.

Using this data, it was possible to compute the response rates as 22.5 percent for Response Rates 1 and 2, which consider unknown eligibility as non-responses, and 31.6 percent for Response Rates 3 and 4, where it was estimated that 42 percent of those with unknown eligibility would have been eligible.

Response Rate 3 and Response Rate 4 were considerably lower than the 80 percent response rate for the 1984 survey calculated in the same way.[39] That decline was not unexpected given the decline in response rates to random digit dialing (RDD) telephone surveys over the past 20 years.[40]

Conclusion

This chapter has outlined the construction and management of the survey. The basis for the survey was the 1984 survey. Questions were designed from that survey and then modified after pretesting and cognitive testing. An important aspect of the questionnaire design process was to refine the screening questions to help respondents recall if they had a fire in the previous 90 days.

The survey sample was developed from the GENESYS sampling system and census data. The strata were designed to over-sample ethnic and racial groups to provide reasonable estimates from households. The sample also contained an urban/non-urban breakdown. Sample size was allocated to strata on the basis of expected numbers of cases in the ethnic, racial, and geographic breakdowns.

The sample of fire households was about half the number expected. This was because the planning factor for fire households assumed 2.86 fires per 100 households, whereas in fact, there were about half as many households with fires. The smaller number of fire households signaled that the household fire rate had dropped substantially from 1984. Estimates of the household fire rates are presented in the next chapter.

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[39] Audits and Surveys (1985), *op cit.,* Appendix A.

[40] There is an extensive literature on the decreasing response rates. Some authors believe that the decline is probably associated also with caller id, answering machines, and the response to telemarketing. See for example Khare, M (2006), “Sample Design and Issues with Telephone Multi-Mode Surveys.” Paper presented at the National Center for Health Statistics Data Users Conference, Washington, DC.

Chapter 3
Fire Incidence

This chapter presents the methods used to estimate fire incidence and then presents the estimates using data from the survey. The methods are examples of techniques for adjusting for lack of recall that is present in many retrospective surveys. The literature indicates that people are often unable to recall recent events. As a result, rates (i.e. incidents divided by time) estimated from retrospective surveys tend to decrease with increasing recall periods. Short recall periods, on the other hand, have smaller sample sizes, with larger sampling variance in the rate estimates. An important decision in these analyses is how much of the recall period to use for making estimates. This chapter applies a method for finding the length of the recall period that balances the bias from the underestimates associated with longer recall periods with the increased variance associated with smaller sample sizes from shorter recall periods.[41]

Following the discussion of the methods for making estimates from recalled events, the chapter presents the annual fire incidence estimates. From the survey, it was estimated that there were 7.4 million annual household fires in 2004-2005, of which 254,441 (97 percent) were fire department-attended and 7.2 million were unattended. This was 6.56 fires per 100 households.

This chapter begins with a discussion of the analytical methods followed by the results of the survey and the CPSC staff's conclusion. Of particular interest in this chapter is the decrease in residential structure fires between this survey and the 1984 residential fire survey.

Methods

Memory and Recall Issues

The analysis of fire incidence rates was based on a series of questions designed to prompt the respondent to recall all home fire incidents that occurred up to 90 days before the interview. The questionnaire defined "fire" as

> *…any incident large or small that resulted in unwanted flames or smoke and could have caused damage to life or property if left unchecked...*

Home was defined as

> *…house, apartment or other residence where you live…*

[41] This tradeoff between bias and variance is described in Warner M, Schenker N, Heinen MA and Fingerhut LA (2005), "The Effects of Recall on Reporting Injury and Poisoning Episodes in the National Health Interview Survey," *Injury Prevention*, 11, pp. 282-287.

The survey respondent was then offered a series of examples of fire incidents such as

unwanted flaming or smoking on the stove or another cooking appliance
a smoking electrical appliance
burning or smoldering clothing, either being worn or not worn
smoldering fabric, mattress, rug or upholstered furniture
a child igniting something with a match or lighter
a candle igniting something
a fire that started outside your home, and spread to the home
any other fire – large or small – that produced unwanted flames or smoke

If the respondent said there was one or more such incidents in the past three months, the next question asked how many incidents occurred. This was then followed by a request for the date and time of the fire. Finally, the respondent was again prompted to answer if the fire involved the home.[42]

The purpose of these questions was to elicit information on residential fires, attended by fire departments or unattended by fire departments, that occurred in a 91-day period.[43] If respondents had perfect recall of incidents then, as a 91-day period covers one-fourth of the year, an estimate of annual fire incidence would be approximately four times the weighted number of incidents reported by the respondents. As anticipated, respondents did not have perfect recall. Of the 961 fire incidents cited as occurring up to 90 days before the interview, respondents could recall the month and day of the incident for 668 incidents (70 percent). This raised the concern that there might have been other incidents that the respondents could not recall at all.

Memory and recall problems are among the most common non-sampling errors encountered in surveys.[44] In addition to recall delay, where respondents forget the incident and/or believe it occurred earlier than the end of the recall period, there is also telescoping. Telescoping is the opposite error of putting the incident into the recall period when it actually happened before the recall period.

Previous Residential Fire Surveys

The authors of the 1984 National Sample Survey of Unreported, Residential Fires were aware of problems associated with memory decay, i.e., recall of fire incidents

[42] For details, see the survey questionnaire in Appendix, question 2-10.
[43] The period is 91 days because fires occurring on the day of the interview also count. Recall that in Chapter 2, respondents were called as late as 9:00 p.m. The data contains fires that were reported to have occurred on the day of the interview. The recall period will occasionally be described as three months in the text, but it is almost 91 days long, and covers up to 90 days before the day of the interview.
[44] For example see Tourangeau R, Rips U and Rasinski K (2000), Chapter 4, "The Role of Memory in Survey Responding" in *The Psychology of Survey Response,* New York, Cambridge University Press.

during the period covered by the survey.[45] They raised this issue in the context of the 1974 National Household Survey, the first survey of household fires that included fires not reported to fire departments.[46] In the 1974 survey, respondents were asked to provide information on all fire events occurring up to 12 months before the interview. From these data, estimates were made of 5.6 million annual household fires using the full 12-month recall period. A reanalysis of this study was conducted by the University of Wisconsin, several years later.[47] In the reanalysis, they concluded that respondents were likely to have failed to recall fire incidents and that failure to recall increased with increasing time from the interview. For example, in reviewing the number of fire events reported for each of 12 months, they estimated that one fire in eight that had occurred 12 months before the interview was reported by the respondent to the interviewer. Correcting the estimates for memory issues led to an estimate of 13 million annual household fires in 1974, more than twice the original estimate.[48]

The 1984 survey interviewed respondents in the first two weeks of the month and asked for information on all fire incidents occurring during the previous three calendar months.[49] The authors analyzed the number of incidents by calendar month and by the number of months from the interview. They found that the number of incidents reported as occurring two calendar months before the interview was about two-thirds of the number reported for the calendar month before the interview. Also, the number of incidents reported in the third calendar month before the interview was about half of the number of incidents reported in the first month. As a result, the authors of the survey made estimates of annual household fire incidence only using incidents reported to have occurred in the calendar month before the interview and scaled to a calendar year.[50]

In addition, in the 1984 survey, there were 106 incidents (5.8 percent of the 1,819 total incidents) where the respondents knew that the incident had occurred in the three-month period before the interview, but did not remember in which month the incident occurred. To make estimates, the authors allocated one-third of these incidents to each month before the interview.[51] As only the first month was used in the estimates, only

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[45] Audits and Surveys (1985), *op cit.,* pages 6-9.
[46] U. S. Consumer Product Safety Commission (1978), *op cit.* The University of Wisconsin reanalysis is in Department of Statistics, University of Wisconsin (1977), "Statistical Analysis of the National Household Fire Survey," Madison, WI.
[47] Ibid.
[48] Quoted in Audits and Surveys (1985), *op cit*., page 11.
[49] The question was, "*Have you had a fire in or around your home, vacation home, or your property during the past 3 months—that is during ________, __________, or _________?"* The interviewer filled in the blanks with the names of the past three months. Incidents occurring during the same month as the interview were not included in the survey. For example, if the interview took place on July 10, the blanks would be filled in as May, April or March. Incidents occurring between July 1 and July 10 would not be included. See Audits and Surveys (1985), *op cit*., Appendix B, page 2.
[50] *Ibid*., page 12-17.
[51] *Ibid*., page 15. The usual strategy would be to allocate the unknown incidents in proportion to the known incidents, which would have put 46 percent of these incidents in the first month. The survey authors reasoned that since the first month was least subject to memory decay, incidents where the date was not recalled would be less likely to be in the first month. Putting 46 percent of the unknown incidents in the first month would then overestimate the number of incidents in that month.

one-third of the incidents with unknown months were used in the calculations for the estimated annual incidence rates.

Thus, like in the 1984 survey, in the 2004-2005 survey there were two problems to be solved before estimating fire incidence rates. These were as follows: (1) how to impute missing fire dates, where the respondent knew that an incident had occurred during the recall period but did not know the actual date, and (2) what length recall period to use for estimating annual fire incidence rates. The fire date problem was somewhat more complicated in the present survey, because respondents were asked about the day as well as the month of the fire, not just the month as in the 1984 survey. Both day and month could be missing in the present survey and would need to be imputed.

Issues in Imputation and Estimation

Because retrospective household surveys are the main source of information on events occurring in households that are not reported in official statistics, there is an emerging literature about how to deal with memory issues, specifically about the length of recall periods, imputation of missing dates, and factors associated with failure to recall actual events. Some examples follow.

Harel et al (1994) compared childhood injury estimates from the National Health Interview Survey (NHIS) with estimates from the Child Health Supplement (CHS). The NHIS used estimates from a two-week recall period, while the CHS asked about incidents occurring during the previous year. Annual estimates were made by scaling the estimates obtained by the inverse of the fraction of the year represented by that period. The analysis showed that estimates of annual injuries declined with increasing length of the recall period, clear evidence that incidents occurring further from the date of the interview were less likely to be remembered. When separating injuries by severity, injuries involving surgery or hospitalization, and injuries resulting in at least one full bed day or one school day loss showed almost no change in estimates with length of recall period, suggesting that more serious injuries were more likely to be remembered.[52]

In another study of injuries to children, Cummings et al (2005) telephoned a sample of parents of children under 6 years of age. The sample was drawn from members of a Health Maintenance Organization (HMO) in Washington State from children who had at least one injury in the last year. Parents were asked to recall injuries during the year before the interview, and the injuries were compared with the HMO's computerized records. The authors found that recall decreased with time from the

[52] Harel Y, Overpeck MD, Jones DH, Scheidt PC, Bijur PE, Trumble AC and Anderson J (1994), "The Effects of Recall on Estimating Annual Nonfatal Injury Rates for Children and Adolescents," *American Journal of Public Health,* 84,4, 599-605. Massey and Gonzales found a similar result using injuries in the 1975 Health Interview Survey (HIS). They recommended the HIS use a 2-4 week recall period. See Massey JT and Gonzalez JF (1976), "Optimum Recall Periods for Estimating Accidental Injuries in the National Health Interview Survey." Proceedings of the American Statistical Association, Social Statistics Section, Boston, MA, pp. 584-588.

interview. As in other analyses, more severe injuries were recalled better than less severe injuries.[53]

Landen and Hendricks (1995) compared different length recall periods for estimates of annual at-work injuries in the 1988 Occupational Health Supplement of the National Health Interview Survey. They found that estimates based on a four-week recall period were 32 percent higher than estimates based on a one year-period. Injuries with lost workdays were less likely to be under-reported than those with no lost workdays.[54] In a similar project in Ghana, Mock et al (1999) concluded that longer recall periods resulted in underestimates of injury rates for non-fatal injuries, but periods of 12 months may be used for reliable estimates of severe injuries.[55] Moshiro et al (1999), in another study about recall of injuries, concluded that long recall periods underestimated injury rates as compared with shorter periods, but for severe injuries a recall period of up to 12 months could be used. They recommended a recall period of no more than 3 months for non-severe injuries.[56]

While a shorter recall period results in more accurate recall, according to the literature above, there is a tradeoff. As longer observations are discarded from the data, the sample size goes down and the sampling variance increases. Moshiro et al (2005), in recommending a shorter recall period, called for larger sample sizes to reduce the amount of sampling error.[57]

Warner, Schenker, Heinen and Fingerhut (2005, hereafter WSHF) formalized the tradeoff between the increased sampling error (sampling variance) associated with short recall periods and the memory decay associated with the longer periods into a single quantity, the Mean Square Error (MSE).[58] Defining the loss due to recall delay as the "bias," the MSE is the sum of the square of the bias and the sampling variance. They recommended that the recall period be selected to minimize the MSE.

Using the National Health Interview Survey, WSHF estimated the annual number of injury episodes using different length recall periods between one and 13 weeks. Estimates were made by weighting the sample and then scaling to annual totals by

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[53] Cummings P, Rivara FP, Thompson RS and Reid RJ (2005), "Ability of Parents to Recall the Injuries of Their Young Children," *Injury Prevention*, 11, pp. 43-47.
[54] Landen DD and Hendricks S (1995), "Effect of Recall on Reporting of At-Work Injuries," *Public Health Reports,* 110:3, pp. 350-354.
[55] Mock C, Acheampong F, Adei S and Koepsell T (1999), "The Effect of Recall on Estimation of Incidence Rates for Injury in Ghana," *International Journal of Epidemiology*, 28, 4, pp. 750-755.
[56] Moshiro C, Heuch I, Astrom AN, Setel P and Kvale G (2005), "Effect of Recall on Estimation of Non-Fatal Injury Rates: A Community Based Study in Tanzania," *Injury Prevention,* 11, pp 48-52.
[57] Moshiro (2005), *op cit*., page 52. The sampling error increases because the sample size decreases. For example, suppose a sample of size n is collected to estimate a sample mean. Assuming simple random sampling with replacement, the standard error of the sample mean is $\sigma/\sqrt{n}$. If the sample size is reduced from n to n/a ($a>1$), then the standard error of the mean is then $\sqrt{a}(\sigma/\sqrt{n})$, i.e., it is increased by a factor of $\sqrt{a}$. For example, if ¼ of the sample is used, the standard error is doubled.
[58] Warner M, Schenker N, Heinen MA and Fingerhut LA (2005), *op cit.*

multiplying by the inverse of the fraction of the year covered by the recall period.[59] As expected, the estimates of annual injuries decreased with increasing length recall periods, but there were occasional small increases in the estimate as the period increased. To smooth out this fluctuation, the authors fit a regression line to the estimates. The fitted value (i.e., the point on the regression line) was used in place of the estimated values. The fitted value for two weeks was defined as the reference value, essentially as "the truth."[60] To estimate the loss due to recall delay, the fitted value for any particular recall period was subtracted from the reference value. The result, the difference in estimates from a particular recall period and from the two week fitted reference value was defined as the bias for the particular recall period.

The variance of the period was estimated using standard statistical software programs that correct for the survey design.[61] The sum of the variance and the square of the bias was computed as the estimated MSE. A recall period of five weeks was selected because it had the lowest estimated MSE.

WSHF addressed another problem found in retrospective surveys, that of missing incident days. In their study, 75 percent of the incidents had the date fully specified, 22 percent had only month specified, and respondents could not recall the day or month for 3 percent of the incidents. Incident days needed to be imputed (i.e., estimated) to complete the recall period analysis. WSHF adopted a two-stage imputation strategy as follows:

- Stage 1: For the 22 percent of incidents with month but not day specified, the day was chosen randomly in that month so that the elapsed time from the interview to the injury was no greater than 91 days.
- Stage 2: For the 3 percent of incidents with missing month and day, elapsed times between interviews and incidents were randomly selected from the stage 1 imputed elapsed times stratified by year of incident and hospitalization status.

WSHF pointed out that the stage 2 imputations followed the theory that the distribution of missing days would look more like the partially specified days in stage 1 than the completely specified days in the rest of the sample.

Another innovation in the WSHF paper was the use of a multiple imputation procedure. Five datasets were made using the complete cases and stage 1 or stage 2 imputed dates. The imputed dates varied in each dataset because of the random selection of days in the month (stage 1) or the random selection from the stage 1 imputations (stage

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[59] For example, if the recall period was 1 week, the estimates would be multiplied by 52, two weeks 26, 3 weeks 17.3, etc.

[60] The first week was disqualified as the reference value because it was "…estimated to be affected the most by the possible discrepancy between the recorded interview date and the date the respondent completed the injury section…" Warner M, Schenker N, Heinen MA and Fingerhut LA, (2005), *op cit.*, page 283.

[61] Warner M, Schenker N, Heinen MA and Fingerhut LA , (2005), *op cit.,* page 283. SUDAAN® is described in Shah BV, Barnwell BG, Bieler GS (1996), *Sudaan User's Manual, Release 7.0*, Research Triangle Park, NC). Similar routines are found in the SAS® System.

2). This allowed including the variance associated with imputation along with the sampling variance in computation of the MSE.

To summarize the literature, most of the articles point out that respondents cannot be expected to remember all incidents during retrospective recall periods, and in particular, earlier incidents are more difficult to recall than more recent incidents. Recall delay also varies with incident severity, where more severe incidents are more likely to be recalled. Finally, some of the authors pointed to the other source of inaccuracy in making estimates in addition to bias, i.e., greater sampling variation was associated with smaller samples when short recall periods were used.

Imputation and Estimation Methods for the 2004-2005 Residential Fire Survey

A modified form of the approach in WSHF was used in this report for imputation of missing days and for selection of the recall period. The imputation procedure was as follows:

1. To assess if there was a different recall pattern associated with incidents with different characteristics, the fire incident records with month and date of incident specified were separated into two categories, those fires with characteristics that were thought to make it more likely that the incident would be recalled and those with characteristics that were thought to make it less likely that the incident would be recalled. As a shorthand description, the more likely to be recalled category was defined as "high severity" and the less likely as "low severity." A variety of different indicators was examined. The final set of indicators that distinguished high severity from low severity was that at least one of the following events occurred at a fire: a smoke alarm sounded, somebody attempted to put out the fire using a fire extinguisher, people left or tried to leave the residence during the fire, the fire department attended the incident, or there was any flame damage.

2. Missing fire dates were imputed by selecting an elapsed time between interview and fire date and then computing the fire date from the possible elapsed times. Similar to WSHF (2005), a two stage strategy was used as follows:

    a. <u>Stage 1</u>. When respondents reported a single fire where the month but not the day of fire was known, the elapsed time between interview and fire date was selected randomly (i.e., following a uniform distribution) out of the possible elapsed times between the beginning of the month (or the day of the interview, whichever was closer) and the end of the month (or the end of the 91-day recall period, again whichever was closer). The imputed fire date was then calculated by subtracting the imputed elapsed time from the interview date. These imputed dates were classified as belonging to high or low severity incidents based on the definition above, but severity did not play a role in this stage of imputation.

b. Stage 2. For respondents who reported a single fire where the month and day were unknown, imputed elapsed times were selected at random with replacement by severity level from the imputed elapsed times in stage 1. The imputed fire date was then also calculated by subtracting the elapsed time from the interview date.

c. Special Handling for Exceptions. Six survey respondents reported two fires with neither month nor day specified for either fire. Missing fire dates were imputed by sampling from the uniform distribution from the possible elapsed times. The shortest elapsed time from the date of interview that was sampled was used in computing the date of the most recently occurring fire, and the second shortest elapsed time was used for the earlier fire.[62]

The imputation process described above was repeated 15 times, producing 15 datasets with imputed dates. The literature suggests a minimum of five imputation datasets, but more datasets are useful when the imputation variance might be large.[63] The dataset with non-missing dates was attached to each imputation dataset, to produce 15 datasets with complete dates. Only the imputed dates differed between datasets, and that difference was used to compute the imputation variance, a part of the overall sampling variance. The imputation software described above was written in the R language.[64]

Analysis of the multiple imputation data sets then proceeded by computing the Mean Squared Error (MSE) for various recall periods and then selecting the recall periods with the lowest value of the MSE. Separate computations were made for the two different severity levels, to allow the possibility of different recall periods for high and low severity incidents. Annual estimates were made by recall period and severity level by adding the weighted estimates where the elapsed time between interview and fire date fell into the recall period, then scaling by the proportion of the year in the recall period. A cubic smoothing spline with four degrees of freedom was fit to the plot of annual fires against recall period length.[65] The fitted value of the smoothing spline for the 14-day recall period was used as the reference value for making the bias estimate. The choice of the 14 day reference period was in keeping with WSHF and much of the literature. The use of the smoothing spline instead of a linear regression was a departure from WSHF.

The MSE was then calculated from the bias estimate and the variance (including both the sampling variance and the imputation variance). Calculations for annual estimates and the sampling variance were made in SAS® using Proc Surveymeans. The

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[62] These 12 missing fire dates were about 3.8 percent of the missing dates and about 1.2 percent of the total dates. There were more complicated imputation approaches available for imputation of these dates, but they did not seem warranted because of the small number of cases involved.

[63] See Schaefer JL (1997), *Analysis of Incomplete Multivariate Data*, Chapman and Hall, New York, pp. 134-135.

[64] R is a freely available language and environment for statistics and statistical computing. See http://www.r-project.org/.

[65] Hastie TJ and Tibshirani RJ (1990), *Generalized Additive Models,* Chapman and Hall, NY.

total variance, including the imputation variance was calculated in SAS® using Proc MIAnalyze.[66]

Results

The data consisted of 3,077 survey responses, where 916 households reported a total of 961 fire incidents and 2,161 non-fire households had abbreviated interviews. Of the fire incidents, complete fire dates were provided for 649 incidents (67.5 percent). Month but not day was specified for 230 incidents and neither day nor month in 82 incidents. Respondents were interviewed between June 4, 2004 and September 7, 2005.

Of the 312 incidents with incomplete fire dates, 293 were from households that reported a single fire incident. The remaining 19 missing dates were from households that had two fire incidents.

Using the definition of severity from the previous section, 671 fire incidents (70 percent) were classified as high severity and 290 fire incidents (30 percent) were classified as low severity.

Pre-imputation Analysis

Figures 3-1 and 3-2 show the weighted number of fires reported by survey respondents by week from the time of the interview. Both figures use only the 649 incidents with complete fire dates. Week 1 includes all fires reported on the day of the interview up to day 7 from the interview, week 2 covers days 8-14, week 3 covers days 15- 21, etc. In both figures, the dotted line illustrates the average number of estimated weekly incidents. The solid line in both figures is a smoothing spline, a smoothed line that is useful to help the eye follow the trend in the data.

If there were no issues about memory recall, the solid lines in both Figures 3-1 and 3-2 would be flat. That is, there is no reason to expect a fire would be more likely in the first week before the interview than the twentieth week before the interview. However, this is not the case in either figure.

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[66] SAS Institute Inc. (2004), *SAS/STAT® 9.1 Users Guide.* SAS Institute, Cary, NC.

Figure 3-1 shows the estimated number of high severity fire incidents. The weighted average number of fires per week was 46,769 (Standard Deviation = 15,002, Range 25,505 – 86,135, Coefficient of Variation = 32.1 percent). This is shown by the dashed line. The solid line shows the smoothing spline. The largest estimated number of fires was 86,135 was estimated from the data from the first week after the interview. It then declined to 49,201 in using the data from weeks 1 and 2, then back up to 56,379 with data from weeks 1-3. After reaching the minimum in week 6, the points then tend to oscillate around 40,000 fires per week.

Figure 3-1 Estimated High Severity Fires by Weeks from the Interview

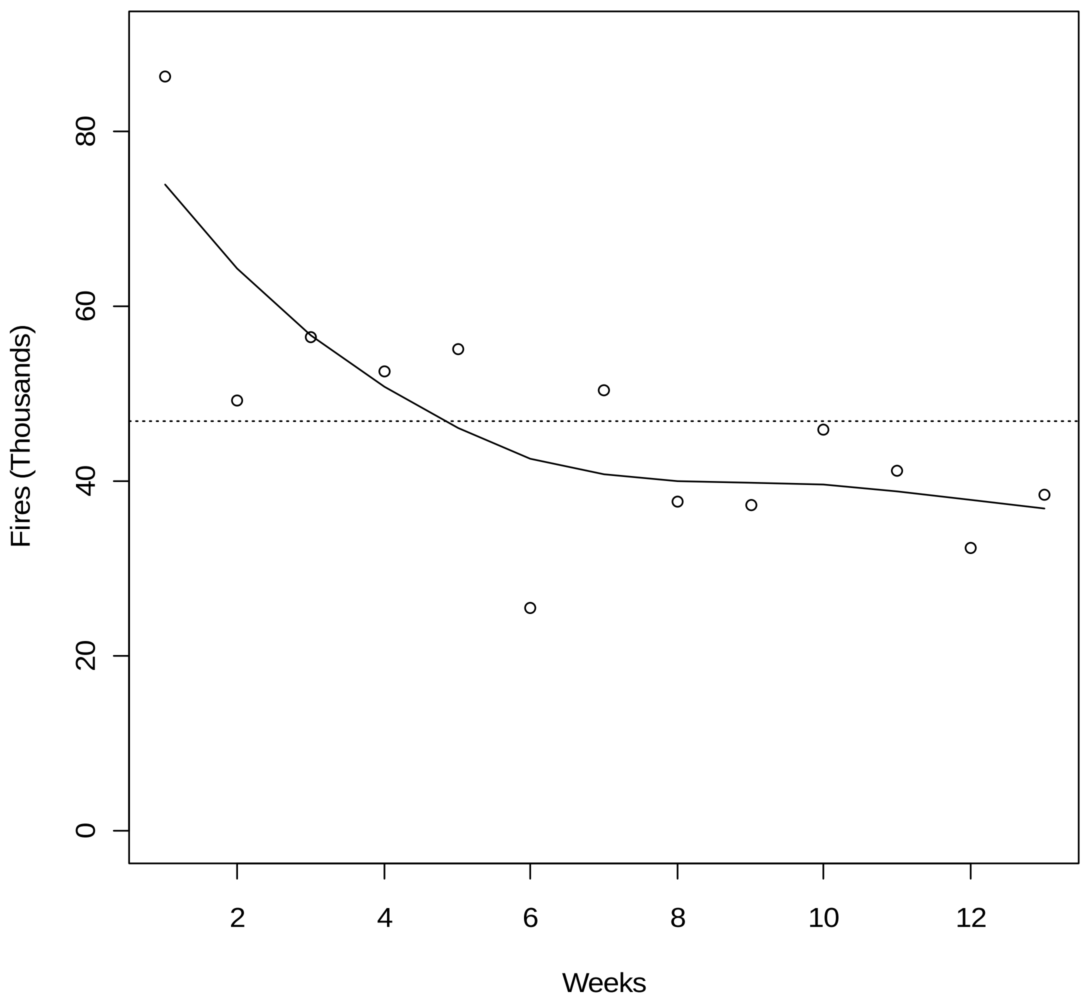
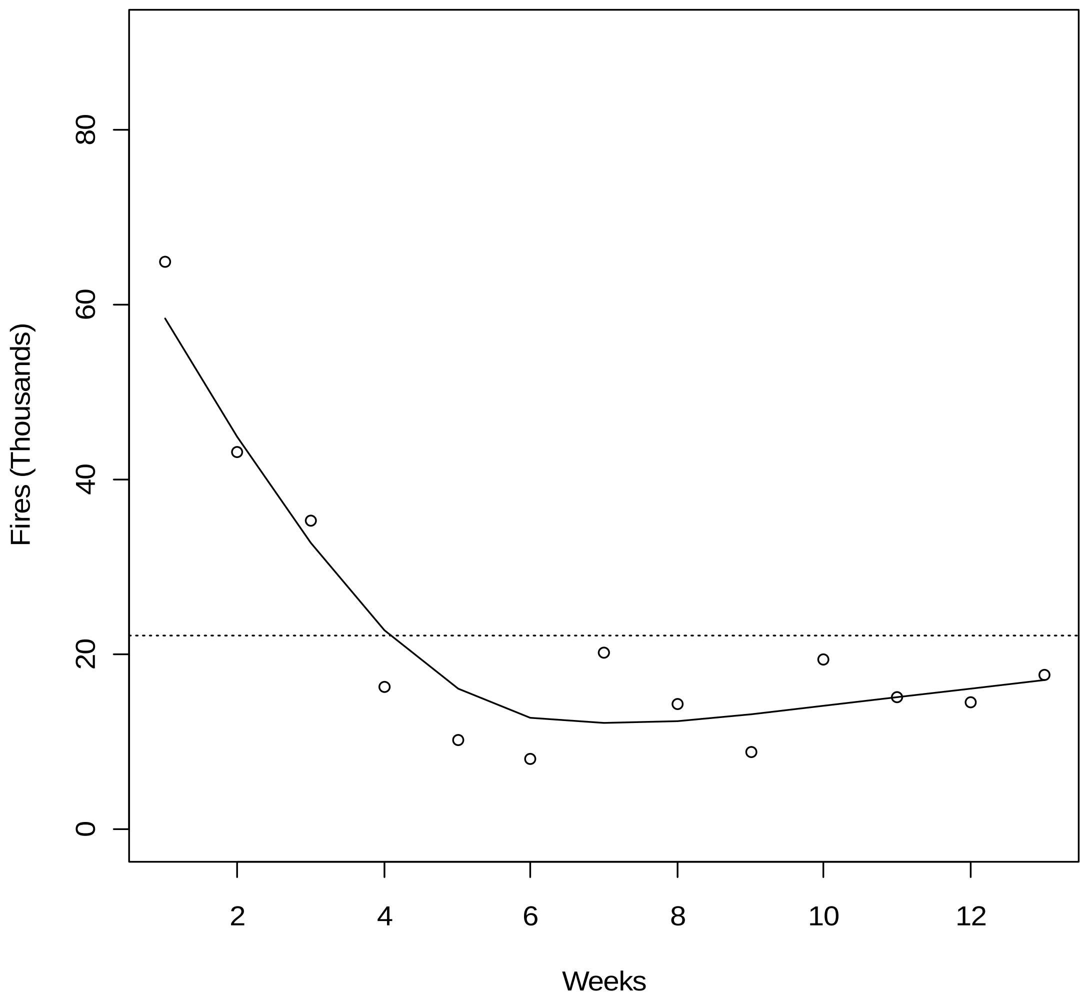


Figure 3-2 shows the same plot for the low severity fires. The estimated weighted average number of fires was 22,150, about 47 percent of the average of the high severity fires (Standard Deviation = 16,290, Range 8,143 – 64,774, Coefficient of Variation = 73.5 percent). Like Figure 3-1, the largest number of incidents, 64,774, was reported for the data from week 1 (one week from the interview). The plot descends steeply for weeks 2 and 3, then the plot oscillates around 15,000 from week 4 on.

Figure 3-2 Estimated Low Severity Fires by Weeks from the Interview



Both plots illustrate the existence of problems with retrospective recall of incidents, that is, if recall were perfect both plots would have been flat all the way out to week 13. The low severity plot decreases more steeply, suggesting that low severity incidents are less likely to be recalled than high severity incidents.

Mean Square Error Analysis

Following the imputation procedure, a mean square analysis was conducted separately for high and low severity incidents. As discussed in the methods section of this chapter, the variance calculation combines both the sampling variance and the variance from the multiple imputations. The bias was calculated under three different specifications of the reference period, i.e., the particular week or group of weeks that provided the "true rate." These were week 1 alone, weeks 1-2, or weeks 1-3. Data are provided in the tables below as the square roots of the variance (the Standard Error or SE) and the root mean square error (RMSE), respectively. These are in the original units, i.e., fires, rather than the square of fires.

Table 3-1
Estimated Annual High Severity Fire Incidents, Bias, and Root Mean Square Error by Cumulative Weeks from the Interview and Reference Period
(Thousands of Fires)

Cumulative				Reference Period					
Weeks from	Fire Incidents			1 week		1-2 weeks		1-3 weeks	
Interview	Estimated	Fitted	SE	Bias	RMSE	Bias	RMSE	Bias	RMSE
1	5418	5094	851	0	851	365	926	676	1087
1-2	4507	4728	552	-365	**662**	0	552	310	633
1-3	4268	4418	434	-676	803	-310	**534**	0	**434**
1-4	4112	4184	377	-910	985	-544	662	-234	444
1-5	4098	4021	324	-1073	1121	-708	779	-397	513
1-6	3861	3909	280	-1185	1217	-819	866	-509	581
1-7	3884	3838	260	-1256	1283	-891	928	-580	636
1-8	3809	3792	241	-1301	1324	-936	967	-626	670
1-9	3753	3763	221	-1330	1349	-965	990	-655	691
1-10	3770	3745	209	-1349	1365	-984	1006	-673	705
1-11	3754	3730	197	-1363	1378	-998	1017	-688	715
1-12	3690	3718	186	-1376	1388	-1010	1027	-700	724
1-13	3725	3708	176	-1386	1397	-1020	1036	-710	732

Notes: The number of fires was estimated by applying the sampling weights, including imputed missing days, and scaled to a calendar year. Those values are in the column labeled "Estimated." The column labeled "Fitted" contains values resulting from applying a smoothing spline to the values in the "Estimated" column. The RMSE values in **bold** are the respective minimum RMSE values for each reference period. Data may not add due to rounding.

As noted previously, the estimated fire incidents (column 2 of the table) were derived from the actual data with both known and imputed fire dates, using the sampling weights. A smoothing spline was fitted to those values and is shown in the third column. The fitted values are then used as the reference values and in the bias calculations. Thus for example, 5094 (5,094,000 estimated fires) is the reference value for the week 1 fire estimate. Details of the calculation are found in the footnote.[67]

In Table 3-1, the RMSE is U-shaped, decreasing with increasing cumulative weeks from the date of the interview, and then usually increasing again. The point where it turns around is one week later than the reference period in the first three periods shown. This is the result of the SE of the fire incidence estimate decreasing with increasing sample size and the bias increasing with increasing weeks from the reference week.

Note that the minimum RMSE occurs in the 1-3 week reference period (434), but additional calculations with reference periods of 1-4 weeks and higher show that the minimum RMSE usually occurs either at the week defined by the reference period or the next week. This is a result of relatively small changes in the SE that are not offset by the increase in bias. To put it another way, of the two factors that contribute to the RMSE, sampling variance and bias, bias is the greater contributor.

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[67] For example, 5094 is the reference value for the week 1 estimate. The bias in the first week is zero, for the second week is 4728-5094 = -365, and for the third week is 4418-5094 = -676. (The calculations occasionally appear to be off by 1 due to rounding.) Bias estimates are shown in the fifth column. Using the 1-2 week fire estimate (4728) as the reference period shows a bias of 5094-4728=365 for week 1 (column 7). The root mean square error calculation uses the bias and the standard error (SE), which also includes the variance associated with multiple imputation. So for example, using a week 1 reference period and testing 1-3 weeks, the RMSE estimate is the square root of $(676^2 + 434^2) = 803$. This is shown in column 6.

Table 3-2
Estimated Annual Low Severity Fire Incidents, Bias, and Root Mean Square Error by Cumulative Weeks from the Interview and Reference Period
(Thousands of Fires)

Cumulative Weeks from Interview	Fire Incidents			Reference Period 1 week		1-2 weeks		1-3 weeks	
	Estimated	Fitted	SE	Bias	RMSE	Bias	RMSE	Bias	RMSE
1	3701	3574	704	0	704	367	794	711	1001
1-2	3162	3207	462	-367	**590**	0	**462**	344	576
1-3	2855	2863	358	-711	796	-344	496	0	**358**
1-4	2508	2558	294	-1015	1057	-648	712	-304	423
1-5	2250	2307	241	-1266	1289	-899	931	-555	606
1-6	2066	2113	208	-1460	1475	-1093	1113	-749	777
1-7	1998	1971	189	-1602	1614	-1235	1250	-891	911
1-8	1891	1868	170	-1706	1714	-1339	1350	-995	1009
1-9	1778	1792	156	-1781	1788	-1414	1423	-1070	1082
1-10	1751	1739	147	-1835	1841	-1468	1475	-1124	1134
1-11	1706	1699	138	-1875	1880	-1508	1514	-1164	1172
1-12	1676	1667	131	-1906	1911	-1540	1545	-1195	1203
1-13	1654	1639	124	-1935	1939	-1568	1573	-1224	1230

Notes: See Table 3-1.

Table 3-2 shows that, aside from week 1, the optimum estimation period is the reference period week. The bias tends to be larger (in absolute value) than the high severity incidents in Table 3-1. This indicates that the low severity incidents were more difficult to recall than high severity incidents, as also shown in comparing Figures 3-1 (high severity) and 3-2 (low severity).

In analyzing Tables 3-1 and 3-2, it is clear that one can only choose a recall period after having chosen a reference period. The choice of 1-2 weeks as a reference period was made in keeping with WSHF. Using the lowest value of the RMSE for the high and low severity incidents resulted in a 1-3 week recall period for the high severity fire incidents and a 1-2 week recall period for the low severity incidents.

Annual Residential Fire Estimates

Table 3-3 shows the annual fire estimates based on the recall periods from the last section.

Table 3-3
2004-2005 Fire Estimates by Fire Department Attendance

Fire Department Attendance	Estimated Fires per Year (95% Confidence Interval)	Fires per 100 Households (95% Confidence Interval)
Both	7,430,069 (6,195,938 - 8,664,199)	6.56 (5.46 - 7.64)
Attended Only	254,441 (65,165 - 443,716)	0.22 (0.06 - 0.39)
Unattended Only	7,175,628 (5,933,397 - 8,417,859)	6.33 (5.23 - 7.42)

Notes: Number of fires per household based on 113,343,000 households. Household estimates from http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH2-all.csv.

Table 3-3 shows that there were an estimated 7.4 million household fires per year, which translates to 6.56 fires per 100 households per year. Of these fires, 7.2 million fires were not fire department-attended, according to the survey respondents, and 254,000 were fire department-attended. The NFPA estimates of 410,000 fire department-attended residential structure fires in 2004 and 396,000 in 2005 are within the 95 percent confidence interval for the number of fire department-attended fires.[68] Note that 3.4 percent of fires, or one in 29.2 fires was fire department-attended.

Table 3-4 shows the distribution of estimated total residential fires and per household fire rates by region of the country.[69]

[68] Karter MJ (2005), "Fire Loss in the United States in 2004," National Fire Protection Association, Quincy, MA, and Karter MJ (2006), "Fire Loss in the United States in 2005," National Fire Protection Association, Quincy, MA. The NFPA survey is a probability sample of all U.S. fire departments and typically samples more than 2,500 departments. It is considered the most accurate national sample of fire department-attended fires.

[69] Regions were defined as follows: Northeast: CT, MA, ME, NH, NJ, NY, PA, RI, VT; South: AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV; Midwest: IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI; West: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY.

Table 3-4
2004-2005 Fire Estimates by U.S. Region

Region	Estimated Fires per Year (95% Confidence Interval)	Fires per 100 Households (95% Confidence Interval)
All	7,430,069 (6,195,938 - 8,664,199)	6.56 (5.46 - 7.64)
West	2,271.425 (1,911,500 - 2,631,350)	9.09 (7.65 - 10.53)
South	2,822,345 (2,436.329 - 3,208,362)	6.85 (5.91 -7.78)
Midwest	1,065,578 (837,943 - 1,293,212)	4.11 (3.23 - 4.99)
Northeast	1,270,721 (1,063.596 - 1,477,845)	6.00 (5.02 - 6.98)

Notes: Number of fires per household based on 113,343,000 households. Household estimates from http://www.census.gov/population /socdemo/hh-fam/cps2005/tabH2-all.csv.

Table 3-4 shows the distribution of fires by region of the country. The West region is shown to have the highest per household fire rate at 9.09 fires per 100 households, followed by the South, Northeast, and Midwest. Interestingly, this differs from fire department-attended fires. NFPA statistics, based on their probability sample of U.S. fire departments, show the West has the lowest per capita fire incidence and the South has the highest.[70]

One of the objectives for the 2004-2005 survey was to compare the decrease in unreported fire incidence with the decrease in reported fire incidence. Some have suggested that newer technology, such as more and better smoke alarms, would make it possible for residents to detect and extinguish fires when the fire was smaller, thus reducing or eliminating the need for fire department assistance.[71] This would then result in a greater decrease in fire department-attended fires than unattended fires. The results from the survey suggest that this conjecture may not be true. In 1980, using estimates based on the NFPA survey and NFIRS, CPSC staff estimated there were 655,500 fire department-attended residential structure fires, while in 2005, there were 375,100

[70] Karter MJ (2003), "U.S. Fire Experience by Region." National Fire Protection Association, Quincy, MA, Table 3, page 8.
[71] This conjecture has appeared in a number of places. For example, see Audits and Surveys (1985), *op cit.*, page 20.

unintentional residential structure fires.[72] This is a decrease of 43 percent. On the other hand, the number of unreported fires has dropped from 22.9 million in the 1984 survey to 7.2 million, a decrease of 68.7 percent.[73]

The decrease in the number of unreported fires is even more interesting because the number of households has increased from 84 million to 113.3 million, an almost one-third increase in the number of households in the last 20 years.[74] Taking this into account with rates, the 1984 survey estimated an annual household incidence rate of 28.3 (reported and unreported) fires per 100 households per year. The 2004-2005 survey showed that the household fire incidence estimate dropped by 76.8 percent to 6.6 fires per 100 households per year.

Conclusion

Estimation of events from retrospective surveys immediately confronts the analyst with problems associated with recall. This occurred in the 1974 survey, with a one-year recall period and the 1984 survey where the recall period was three months. In the 1984 survey, because of recall problems, fire incidence rates were estimated only from the previous month's data. To determine the length of the recall period for the current survey, a method was adapted from WSHF that involved a tradeoff between sampling variance and recall bias.

The tradeoff is as follows: lower sampling variance is associated with longer recall periods, but longer recall periods have fewer events recalled per week leading to a downward bias in the estimate of annual fire incidence rates. In keeping with WSHF, the two-week period was defined as the reference period. Applying the WSHF method required finding the recall period with the smallest mean square error, defined as the sum of the square of the bias and the sampling variance.

The particular refinement of the WSHF method involved stratifying the recall period by the severity of fire incidents. It seemed plausible that incidents that were more severe would be remembered more easily. A severity indicator was developed that defined higher severity cases as those where a smoke detector operated, an attempt was made to extinguish the fire, there was obvious flame damage, the fire department-attended, or people had to leave the residence during the fire. The analysis showed that

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[72]The 1980 estimates are in Mah J (2001), *op cit.*, Table 6. 2005 estimates from Chowdhury R, Greene M and Miller D (2007), *loc cit.* page 21. Statistics for 1984 were not available. As fires have been decreasing over time, the number of fires in 1984 were likely to have been less than in 1980, and as a result, the percentage decrease in reported fires had we been able to use the 1984 estimates, would have been lower than reported above.

[73] The most appropriate comparison in the 1984 survey was unreported residential structure fires. That excludes brush fires and motor vehicle fires that were sampled in the 1984 survey, but were not in the 2004-2005 survey. See Audits and Surveys, *op cit.,* page 22.

[74] The 1984 survey was based on a population of 83,815,800 households and on 23.7 million (reported and unreported) residential structure fires in the 1984 survey. See Audits and Surveys, *op cit.,* page 22. The increase from 1984 to 2004-2005 was 35 percent.

the best (lowest mean square error) recall period was 21 days for these higher severity incidents. For the other, lower severity incidents, a 14-day recall period was best. This made sense because one would expect lower severity incidents to be more difficult to recall.

Using the 14-day low severity and 21-day high severity recall periods, annual fire incidence was estimated at 7.4 million fires, of which 7.2 million were unattended by fire departments and 254,000 were fire department-attended. The estimate of fire department-attended was lower than the comparable estimate from the NFPA annual survey, but the sample size for attended fires in the Residential Fire Survey was small and the confidence interval was large. On a per household basis, the estimates were 6.56 total fires per 100 households. When broken down by region, the West had the highest per household fire incidence rate and the Midwest had the lowest.

The estimates in this survey are substantially lower than the "recall adjusted" 1984 survey. The earlier survey estimated 25.2 million total residential fires (23.7 million residential structural fires) on an estimated U.S. population of 83.8 million households. This was a household incidence rate of 28.3 residential structure fires per 100 households per year. The current survey shows that to have decreased to 7.4 million residential structural fires, a decrease of 76.8 percent.

Although the 1984 survey and the present survey differ in the estimation methodology and in some of the survey questions, the difference in the household fire incidence estimates is too large to be explained by differences in methodology or survey questions. As a result, it seems safe to conclude that there has been a substantial change in the number of household fires. Factors associated with those changes are the explored in Chapter 6 and Chapter 7 of this report.

Chapter 4
Comparisons of Fire and Non-fire Households

In Chapter 3, it was estimated that the annual household fire incidence rate was 6.56 fires per 100 households per year. The purpose of Chapter 4 is to identify the socioeconomic characteristics that differ between fire and non-fire households. Previous research has identified presence of smokers, mobile home housing type, presence of young and old household members, minority status, low income, and alcohol use as more likely to characterize fire households, that is, these characteristics are risk factors for fires.[75]

Fire households are defined in this chapter and in Chapter 5 as households with at least one fire in the 91-day recall period. This definition is somewhat different from the definition used in Chapters 3, 6, 7, and 8 where only fires occurring in the 14- and 21-day recall periods were used in the analysis. The 1984 survey in comparing fire and non-fire households also used the full three-month period in the comparisons even though fire incidence rates were estimated from a one-month recall period. Reasons for this different definition are discussed in the next section.

The tables in this chapter contrast fire and non-fire households according to region of residence, housing characteristics, household size and age distribution, number of smokers, and other demographic characteristics.

Some of the differences between fire and non-fire households in the present survey were as follows:

- Fire households were more likely to be renters and less likely to be owners of their residences than non-fire households.
- Fire households had more members than non-fire households. In comparing household sizes by age group (under 18, 18-64, 65 and over), fire households had more members under 18 and between 18 and 64 than non-fire households. Non-fire households had more people 65 and over.
- The heads of fire households tended to have higher educational levels than heads of non-fire households.

The following variables differed significantly between fire and non-fire households: type of dwelling, age of residence, race or ethnicity, whether or not there was at least one smoker in the household, and household income. On average, there were a larger number of smokers in fire households than non-fire households, with a difference that was almost

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[75] For example, see Runyan CW, Bangdiwala SI, Linzer MA, Sacks JJ and Butts J (1992), "Risk Factors for Fatal Residential Fires," *New England Journal of Medicine, 12,* 327: 859-863. Mobley C, Sugarman JR, Deam C and Giles L (1994), "Prevalence of Risk Factors for Residential Fire and Burn Injuries in an American Indian Community," *Public Health Reports, 109,* 5, 702-705. Warda L, Tenenbein M, Moffatt MEK (1999), "House Fire Injury Prevention Update. Part I. A Review of Risk Factors for Fatal and Non-fatal House Fire Injury." *Injury Prevention* 5: 145-150.

statistically significant. This is different from the 1984 survey, where there was a significant difference in the proportion of fire households with smokers than non-fire households. The newer finding about smokers might reflect the overall decline in smoking rates in the U.S. over the past 20 years.

The next section describes the methods used in this chapter. The results and conclusion sections follow.

Methods

Defining Fire Households

An issue arising in this chapter and in Chapter 5 is how to define fire and non-fire households. In Chapter 3, in estimating the annual household fire incidence rate, the only fires that were counted were those low severity fires in the 14-day recall period and the high severity fires in the 21-day recall period. Extending this idea would result in defining households with fires in the 14 or 21 days before the interview as fire households and all other households as non-fire households. This would have resulted in defining 257 households as fire households.[76] The issue, then, is how to assign the remaining 659 households that had fires between 22 and 91 days before the interview. The following choices were considered:

- Include these cases with the non-fire households
- Exclude the cases from the analysis, that is, treat them neither as fire households nor non-fire households
- Include the cases with the fire households.

The last choice, to include these cases with the fire households, was selected. The reasons are discussed below.

The analyses in Chapter 3 suggested that some of the non-fire households may actually have had fires during the 14/21-day recall period but were unable to remember them. Thus, it seems extremely likely that there were non-fire households that actually had fires but were unable to recall them. The effect of these apparent misclassifications is to blur the differences in characteristics between fire and non-fire households. This meant that stronger differences in characteristics would be necessary in order to find them in the data. Therefore, including the 22-91 day fire households with the non-fire households would further contaminate the non-fire households with households known to have had fires, further weakening the ability to identify factors that distinguished between fire and non-fire households.

[76] Recall that in Chapter 3, missing dates were imputed for some fire incidents. For a given household with a missing fire date to be imputed, in one of the imputations, a fire date could fall in the 14- or 21-day recall period, while on another imputation, that same fire date might fall outside the recall period. Thus, the number of fire households would depend on the particular imputation.

The second option of discarding these cases was rejected because it reduced the size of the sample without providing any substantive benefit. There would still be non-fire households that actually had fires. The third option of including the 22-91 day fire households with the other fire households seemed to be the best option because these households were known to have had fires and, as a result, were more likely to resemble the fire households than the non-fire households.[77]

Another reason for grouping the 22-91 day fire households with the fire households was for consistency with the 1984 survey. Aware of recall issues, the authors of the 1984 survey used a one-month period for estimating fire incidence rates, but the full three-month period was used for comparing factors that differed between fire and non-fire households.[78] Using the same definition of fire households facilitates making comparisons between the two surveys.

Statistical Analyses

The tables in this chapter were prepared using Proc Surveyfreq, averages were computed with Proc Surveymeans, and differences between averages were estimated using Proc Surveyreg, all in the SAS® software system.[79] Two-way tables were tested for independence between the particular survey variable measuring some household characteristic and whether the household was a fire or non-fire household, i.e., whether there was an association between household fire status and the characteristic tested. The test statistic used was the Rao-Scott Likelihood Ratio F statistic, a test statistic that is corrected for the survey design.[80] This was different from the test statistic and the procedure used in the 1984 survey.[81]

Statistical tests were applied to the actual table shown or, when cell counts were small, to a collapsed version of the table. Table notes indicate whether the test statistic came from the original table or a collapsed version. Data in tables are shown in percentages. Missing data (not associated with survey skip patterns), responses of "don't

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[77] In view of the analysis of fire severity in Chapter 3, it is likely that the fires recalled in the 22-91 day period among households that only had fires in that period would be of greater severity than those in the 14- and 21-day recall periods.
[78] Audits and Surveys (1985), *op cit.,* p. 12. The recall period for estimating fire incidence rates was the calendar month before the month of the interview. All respondents were interviewed in the first two weeks of the month.
[79] SAS Institute Inc. (2004), *SAS/STAT®, 9.1 User's Guide.* Cary, NC: SAS Institute Inc.
[80] *Ibid*., volume 9, pages 4219-4221. See also Rao, JNK and Scott, AJ (1984), "On Chi-Squared Tests for Multiway Contingency Tables with Cell Properties Estimated from Survey Data," *The Annals of Statistics,* 12, 46-60 and Rao, JNK and Scott, AJ (1987), "On Simple Adjustments to Chi-Square Tests with Survey Data," *The Annals of Statistics*, 15, 385-397. The correction for the survey design involves the proportions under the null hypothesis of independence. The F test is recommended as a better approximation.
[81] The 1984 survey used unweighted chi square hypothesis tests. The text does not explain the computational details, but it is likely that the chi square test was applied to the original survey data before weighting. This was a reasonable practice in the 1980s before the advent of modern sample survey software, but is no longer common practice.

know," and refusals to respond were excluded before the computation of percentages -- a procedure that essentially allocates non-responses in proportion to the responses.

Results

Region of Residence

Table 4-1 shows the distribution of region of residence for fire and non-fire households.

Table 4-1
U. S. Region of Residence by Fire and Non-fire Households (Percent)

U. S. Region	Fire Households	Non-fire Households
Northeast	18.9	19.3
South	35.3	36.8
Midwest	18.8	23.2
West	26.9	20.8

Notes: Based on n = 3077 observations. Test statistics for the table contrasting fire and non-fire households by region, F =3.1390, p = 0.0243. Weighted distribution of the survey (i.e., fire and non-fire households) was as follows: *Northeast* 19.3 percent, *South* 36.7 percent, *Midwest* 23.2 percent, and *West* 20.8 percent. Census data by region are as follows: *Northeast* 18.7 percent, *South* 36.4 percent, *Midwest* 22.9 percent, and *West* 22.0 percent. Source: U.S. Bureau of the Census, Table H2. Households, by Type, Age of Members, Region of Residence, and Age, Race and Hispanic Origin of Householder for 2005, are available at http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH2-all.csv. Regions are defined in the footnote below.[82]

In comparing fire and non-fire households by region, note that there were relatively more fire households than non-fire households in the West (i.e., 26.9 percent vs. 20.8 percent), about the same balance between fire and non-fire households in the South and Northeast, and fewer fire households than non-fire households in the Midwest. The difference between fire and non-fire households by region was statistically significant. This pattern is similar to the difference in per capita household fire rates shown in Table 3-4 of Chapter 3, where the West had the highest rates, the Midwest had the lowest rates, and the South and Northeast were in the middle. As noted in Chapter 3, the regional distribution was different from statistics on fire department-attended fires as reported by the NFPA, where the West had the lowest per capita rates.[83]

[82] Regions were defined as follows: Northeast: CT, MA, ME, NH, NJ, NY, PA, RI, VT; South: AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV; Midwest: IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI; West: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY. The same definitions were used in Table 3-4.
[83] See Karter MJ (2003), *op cit.*

As noted in Chapter 2, the definition of urban and non-urban in this survey is from the 16 original strata, eight that were defined as urban, and eight as non-urban. Among fire households, 82 percent were in urban strata and 18 percent were in non-urban strata. The distribution of non-fire households was 80 percent urban and 20 percent non-urban, just about the same as fire households.[84] These results are different from the NFPA survey that shows, for communities below 50,000 people, per capita fire department-attended fires increase with decreasing community size.[85] It may be that the urban/non-urban difference applies primarily to fire department-attended fires, or it may be that the distinction between urban and non-urban areas in this survey is not sharp enough to find differences.

The 1984 survey showed a slightly larger proportion of fire than non-fire households in the West, but the differences between regions in that survey were not statistically significant. That survey also contrasted the distribution of fire and non-fire households by city, suburb, small town, and "the country." The differences were also not statistically significant.[86]

Housing Characteristics

Table 4-2 shows the distribution of the percentage of fire and non-fire households by type of dwelling. While detached single family homes were the largest category of dwelling type in the survey, a smaller proportion of fire households lived in this type of housing than non-fire households. For all dwelling types other than single family homes and condominiums, the proportion of fire households exceeded the proportion of non-fire households, but the differences were not statistically significant.

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[84] The difference between the proportion of fire and non-fire households by urban/non-urban region was not statistically significant (F = 0.6943, p=0.4048).

[85] For example, communities of 25,000 to 49,999 had 4.9 fires per thousand people; communities of 10,000 to 24,999 had 5.8 fires per thousand; communities 5,000 to 9,999 had 6.9 fires per thousand; 2,500 to 4,999 had 8.3 fires per thousand; and under 2,500 had 12.2 fires per thousand people. For details see Karter MJ (2003), *op cit.,* page 20.

[86] Audits and Surveys (1985), *op cit.,* pages 23-24.

Table 4-2
Fire and Non-fire Households by Dwelling Type (Percent)

Type of Dwelling	Fire Households	Non-fire Households
Detached single family home	65.1	71.1
Mobile or manufactured home	8.7	6.1
Two family dwelling	4.0	3.4
Apartment building	15.2	12.6
Townhouse or row house	5.9	5.2
Condo	0.8	1.4
Other	0.3	0.3

Notes: Based on n = 3013 respondents. Test of independence of household status and dwelling type was based on the following categories: (1) *Detached single family home*, (2) *Mobile or manufactured home*, (3) *Townhouse or row house*, (4) multifamily (*Two family dwelling*, *Apartment building*, *Condo*, and *Other*). Test statistic $F = 2.0657$, $p = 0.1025$.

The categories of dwelling types in the 1984 survey were slightly different from the present survey categories, but in that survey, there was almost no difference in the distribution of dwelling types between fire and non-fire households. For example, in the 1984 survey, 66.2 percent of fire households were in single family dwellings, while 67.1 percent of non-fire households were in single family dwellings. Townhouses, row houses, and condos were not listed as dwelling categories in the 1984 report.[87]

Table 4-3 shows that fire households were less likely to own their residences than non-fire households. The difference in tenure patterns was statistically significant.

[87] Audits and Surveys (1985), *op cit.,* page 24.

Table 4-3
Type of Ownership by Fire and Non-fire Households (Percent)

Type of Ownership	Fire Households	Non-fire Households
Owner	65.8	77.5
Renter	34.2	22.5

Notes: Based on n = 3010 respondents. Three responses of *Other* were included with *Renter*. Test of independence of household status and type of ownership, F =19.6608, $p < 0.0001$.

Table 4-3 shows that renters accounted for a larger proportion of fire households than non-fire households. The results in the 1984 survey appear to be different. That survey showed no significant difference in the composition of fire and non-fire households by type of ownership. In the 1984 survey, 65.0 percent of fire households were owners and 66.4 percent of non-fire households were owners.[88]

Table 4-4 compares the age of residential structures by fire and non-fire households.

Table 4-4
Age of Dwelling by Fire and Non-fire Households (Percent)

Age of Dwelling	Fire Households	Non-fire Households
5 years old or less	12.2	13.5
6 to 15 years old	22.6	19.5
16 to 25 years old	14.6	16.4
26 to 35 years old	12.1	13.5
36 to 45 years old	13.3	10.1
46 years or older	25.1	27.0

Notes: Based on n = 2940 respondents. Test of independence of household status and age of residence, F = 1.3603, p = 0.2359.

Table 4-4 shows that there were no significant differences in the distribution of the ages of housing for fire and non-fire households. The average age of dwelling units for fire

[88] *Loc cit.*

households was 27.5 years (95 percent confidence interval 26.0 – 29.0), and for non-fire households was 27.7 years (95 percent confidence interval 26.6 – 28.7). The difference in average dwelling ages was not statistically significant (t=0.17, p=0.8617). These findings were in agreement with the 1984 survey, which also did not show any significant difference in the age distribution of dwellings.[89]

Household Composition

Table 4-5 shows the distribution of the number of household members by fire and non-fire household.

Table 4-5
Household Size by Fire and Non-fire Households (Percent)

Number of People in Household	Fire Households	Non-fire Households
One	11.3	16.4
Two	23.7	34.1
Three	22.9	18.9
Four	22.1	17.5
Five	13.0	8.9
Six	4.1	3.0
Seven	1.7	0.9
Eight or More	1.2	0.3

Notes: Based on n = 3006 respondents. Test of independence of household status and household size, F =4.2735, p < 0.0001.

Table 4-5 shows that fire households tended to have more people than non-fire households. The difference in the distribution of household size between fire and non-fire households was statistically significant. The average household size for fire households was 3.27 people (95 percent confidence interval 3.14 – 3.40) as compared with 2.83 for non-fire households (95 percent confidence interval 2.74 – 2.91). Not surprisingly given the difference in distribution, the difference in average household size was statistically significant (t=5.70, p < 0.0001). In the 1984 survey, fire households also tended to be larger than non-fire households.[90]

The age distribution of members of fire and non-fire households is shown in Table 4-6a, Table 4-6b, and Table 4-6c. In addition to fire households having more

[89] *Ibid*., page 25.
[90] *Loc cit*.

members than non-fire households, these three tables show that the members of fire households tended to be younger than members of non-fire households.

Table 4-6a
Number of People Under 18 Years Old by Fire and Non-fire Households (Percent)

Number of People	Fire Households	Non-fire Households
None	45.4	60.6
One	18.9	15.5
Two	21.1	16.2
Three	9.1	5.4
Four or More	5.4	2.3

Notes: Based on n = 2957 respondents. Test of independence of household status and number of people under 18, $F = 7.0578$, $p < 0.0001$.

Table 4-6a shows that fire households had more people under 18 years old than non-fire households. The average number of people under 18 in fire households was 1.13 (95 percent confidence interval 1.02 – 1.24) as compared with 0.74 in non-fire households (95 percent confidence interval 0.67 – 0.81). The difference in averages was statistically significant (t=5.83, $p < 0.0001$).

Table 4-6b shows the distribution of the number of people between 18 and 64 years old by fire and non-fire households.

Table 4-6b
Number of People Between 18 and 64 Years Old by Fire and Non-fire Households (Percent)

Number of People	Fire Households	Non-fire Households
None	2.5	13.0
One	19.3	17.8
Two	57.3	51.8
Three	14.0	12.1
Four or More	6.9	5.3

Notes: Based on n = 2957 respondents. Test of independence of household status and number of people between 18 and 64, $F = 13.2379$, $p < 0.0001$.

Table 4-6b again shows the effect of larger household sizes for fire households, i.e., as fire households had on average more members, it would be expected that fire households would have more members between 18 and 64 years old. The average fire household had 2.05 people between 18 and 64 years old (95 percent confidence interval 1.98 - 2.13), while the non-fire households averaged 1.82 people between 18 and 64 (95 percent confidence interval 1.75 – 1.88). The difference was statistically significant (t=4.76, p < 0.0001).

Table 4-6c shows the number of people 65 and over by fire and non-fire households.

Table 4-6c
Number of People 65 Years Old and Older by Fire and Non-fire Households (Percent)

Number of People	Fire Households	Non-fire Households
None	94.5	81.2
One	3.5	10.1
Two or More	2.0	8.7

Notes: Based on n = 2957 respondents. Test of independence of household status and number of people 65 and over on collapsed table for *None* and *One* and *Two or More*, F = 79.5634, p < 0.0001.

Table 4-6c shows that fire households had relatively fewer people 65 and over than non-fire households. The average number of people 65 and over in fire households was 0.08 (95 percent confidence interval 0.05 – 0.10), while the average number of people 65 and over in non-fire households was 0.28 (95 percent confidence interval 0.24 – 0.31). This difference in averages was statistically significant (t = 8.31, p < 0.0001).

The results shown above are similar to the findings in the 1984 survey. In that survey, fire households were significantly larger than non-fire households, and fire households had significantly more people under 18 than non-fire households. The 1984 survey did not tabulate the 18-64 age group or the 65 and over age group.[91]

Smokers

Table 4-7 shows the proportion of fire and non-fire households by number of smokers in the household.

[91] *Ibid.,* pages 25-26.

Table 4-7
Number of Smokers by Fire and Non-fire Household (Percent)

Number of Smokers	Fire Households	Non-fire Households
None	68.5	70.8
One or More	31.5	29.2

Notes: Based on n = 3029 responses. Test of independence of household status and number of smokers, $F = 0.8949$, $p = 0.3442$.

Table 4-7 shows that there was almost the same percentage of smokers in fire and non-fire households.[92] Fire households had an average of 0.52 smokers (95 percent confidence interval 0.43 – 0.60), while non-fire households averaged 0.42 smokers (95 percent confidence interval 0.38 – 0.47). The difference between averages by type of household was almost statistically significant ($t = 1.89$, $p = 0.0586$).

The percentage of smokers by household fire status differed between the current survey and the 1984 survey. In the 1984 survey, 50.4 percent of fire households had smokers in contrast to 35.0 percent of non-fire households, a difference that was statistically significant.[93] Some decrease in proportions of both fire and non-fire households with smokers should be expected because smoking rates have decreased in the last 20 years. In 1985, according to the U.S. Centers for Disease Control and Prevention, 30.1 percent of the adult U.S. population were smokers, while in 2004, 20.9 percent were smokers, a decrease of 31 percent. Both adult male and adult female smoking rates decreased over the past 20 years.[94]

An additional reason why the results may have been significant in the 1984 survey but not the current survey is that the two surveys differ in the distribution of the types of fires. In the 1984 survey, 31.6 percent of fires were non-appliance fires (associated with candles, matches, lighters, and smoking materials), in contrast to 12.6

[92] The exact question for the fire households was, "At the time of the fire, how many people in your household smoked tobacco at least once a day." For non-fire households the question was, "How many people in your household smoke tobacco at least once a day." For households that had more than one fire, this question was asked for each fire. All except two households reported the same number of smokers by fire. Of the two households with different numbers of smokers, one had four smokers at the most recent fire and five at the previous fire; while the other had four, one, and seven, respectively. To use a single number to characterize those households, the average number of smokers was used in both cases.
[93] Audits and Surveys (1985), *op cit.*, page 26.
[94] U. S. Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Prevention (2005), "Smoking Prevalence Among U.S. Adults," available at www.cdc.gov/tobacco /research_data /adults_prev/prevali.htm. CDC(2007), "Cigarette Smoking Among Adults." *Morbidity and Mortality Weekly*, 56(4), 1157-1161. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml /mm5644a2.htm, See also http://www.cdc.gov/nccdphp /publications/aag /osh_text.htm#2.

percent of the present survey. With fewer smoking-related fires in the present survey to classify households as fire or non-fire households, it seems reasonable that the presence of smokers would make less of a difference.[95]

The results in Table 4-7 and the comparison of the average number of smokers by household type raise but do not settle the question as to whether the presence of smokers is still a risk factor for fires. The role of smoking materials as associated with fires losses has been well documented.[96] Smoking may continue to be a risk factor for fire department-attended fires, types of fires such as upholstered furniture and mattress fires, or for fatal fires in general, but for the larger category of unattended fires, there seems to be less evidence than in the 1984 survey that smoking is a fire risk factor.

Other Demographic and Socioeconomic Characteristics

Table 4-8 compares household income between fire and non-fire households. Fire households tended to have fewer families in the $35,000 - $75,000 group than non-fire households and more in the under $35,000 group, but the differences were not statistically significant. The 1984 survey also did not show a significant difference in household income between fire and non-fire households.[97]

Table 4-8
Household Income by Fire and Non-fire Households (Percent)

Income	Fire Households	Non-fire Households
Less than $15,000	10.4	8.4
$15,000 - $35,000	25.7	22.4
Less than $35,000	36.1	30.8
$35,000 - $75,000	31.9	36.6
$75,000 or more	32.0	32.6
$35,000 or more	63.9	69.2

Notes: Based on n = 2,565 respondents. Income classes do not include the right endpoint, i.e., $15,000 - $35,000 is actually $15,000 - $34,999. Two categories:*Less than $15,000* and *$15,000 - $35,000* were collapsed together for the test of independence of income and household status. Test statistics, $F = 2.2612$, $p = 0.1043$.

[95] More information on the characteristics of fires in the present survey is in Chapter 7. The 1984 survey results are from Audits and Surveys (1985), *op cit*., page 36.
[96] Hall JR Jr. (2004), "The Smoking-Material Fire Problem." National Fire Protection Association, Quincy, MA.
[97] Audits and Surveys (1985), *op cit.,* page 28.

Table 4-9 shows the educational levels attained by the heads of households by household status. There was a statistically significant association between household status and educational level. In particular, heads of fire households tended to have higher educational levels than heads of non-fire households. This was also found in the 1984 survey.[98]

Table 4-9
Household Head Educational Levels by Fire and Non-fire Households (Percent)

Educational Level	Fire Household	Non-fire Household
Less than High School	1.5	1.6
Some High School	2.0	3.2
High School Graduate	18.9	27.0
Technical/Vocational School	2.3	2.3
Some College	18.2	18.4
College Graduate	36.9	31.9
Postgraduate Work	20.1	15.6

Notes: Based on n = 2967 responses. Table collapsed to the following categories for statistical testing: (1) *Less than High School*, *Some High School*, *High School Graduate*, and *Technical/Vocational School*, (2) *Some College*, (3) *College Graduate*, and (4) *Postgraduate Work*. Test of independence of household status and educational level, $F = 5.2935$, $p = 0.0012$.

Table 4-10 shows race and ethnicity of household head by fire and non-fire households. The responses were the result of two questions. The first question asked respondents if the head of household was of Hispanic or Latino descent. The second question provided respondents with a choice of racial/ethnic groups, allowing them to choose all applicable categories. Some respondents chose more than one category. The second question permitted respondents to specify a non-listed category. Some respondents mentioned Hispanic or Latin American as a category.

The table shows that fire households were headed by relatively more Black or African Americans, American Indians, or Hispanic or Latin Americans. Fire households had relatively fewer White heads of households. However, the differences were not statistically significant.

[98] *Loc cit.*

Table 4-10
Race and Ethnicity by Fire and Non-fire Households (Percent)

Race or Ethnicity	Fire Households	Non-fire Households
Hispanic or Latino Descent	11.5	9.4
Not Hispanic or Latino Descent	88.5	90.6
White	79.7	83.0
Black or African American	9.8	9.1
Hispanic or Latin American	6.0	4.8
American Indian	3.1	2.5
Asian	2.0	1.7
Native Hawaiian or Pacific Islander	0.9	0.3
American/European/Canadian	0.8	0.8
Mixed Race or Multi-Racial	0.6	0.5
Alaskan Native	0.4	0.1
Some Other Race	0.2	0.4

Notes: *Hispanic or Latino Descent* based on n = 2,948 responses; other designations based on n = 2879 survey respondents who indicated membership in at least one race or national origin. Percentages add to more than 100 percent because some respondents indicated membership in more than one group. Statistical tests were conducted one group at a time, e.g., *White* vs. Non-white, or *Black or African American* vs. Non-black or African American. No test of association between race or ethnicity and whether the household was a fire or non-fire household was found to be statistically significant.

Tests of the association between ethnicity/race and fire or non-fire household were also computed from a table that was collapsed into two categories as follows: (1) White, Asian, American/European/Canadian and (2) Black or African American, Hispanic or Latin American, American Indian, Native Hawaiian or Pacific Islander, Mixed Race or Multi-Racial, Alaskan Native, and Some Other Race. This was an attempt to separate possible low- and high-risk ethnic groups. The differences were not statistically significant.

How do these weighted estimates compare with the U.S. population for 2004? The comparison is inexact because we do not have national data for households broken down by the race of the head of the household. Taking the population as a whole, however, 14 percent of the population identified themselves as Hispanic or Latino, 80 percent as White, 13 percent as Black, 4 percent as Asian, and 1 percent as American

Indian or Alaskan Native.[99] As a result, it appears that the composition of the survey and the U.S. population agree fairly closely.

Conclusion

Fire households were more likely to be renters and less likely to be owners than non-fire households. In addition, fire households had a larger number of people and the heads of fire households had more years of schooling than non-fire households. Fire households tended to be more likely to have people under 18 years old and were less likely to have people 65 years old and older. The survey also showed a regional association with household fire status. Relatively more fire households than non-fire households were in the West and relatively fewer were in the Midwest. In the 1984 survey, these differences were also found to be statistically significant, except for the renter/owner difference.

Like the 1984 survey, this survey showed no statistically significant association between household fire status and type of dwelling, age of dwelling, household income, or urban/non-urban location. Additionally, the present survey did not show any significant statistical association between household fire status and race/ethnicity.

The two surveys differed in the results regarding the presence of smokers. In the 1984 survey, fire households were more likely than non-fire households to have at least one member who smoked, while in the present survey, there was no significant difference in the prevalence of smokers in fire and non-fire households. However, the difference in the average number of smokers between fire and non-fire households was almost statistically significant. That there appears to be less evidence for smoking as a risk factor in the 2004 survey is probably a result of the large decrease in smoking nationwide during the 20 years between the surveys. As shown later in Chapter 7 of this report, a much smaller percentage of fires in the present survey involved smoking materials than in the 1984 survey. That does not mean that smoking is no longer a risk factor for fires in general. The role of smoking materials in fire department-attended fires, especially those involving upholstered furniture and mattresses, has been well documented, especially in fires that produce injury and death.[100]

[99] U.S. Bureau of the Census (2006a), "Table 3: Annual Estimates of the Population by Sex, Race and Hispanic or Latino Origin for the United States: April 1, 2000 to July 1, 2005." Available from http://www.census.gov/popest/national/asrh/NC-EST2005-srh.html
[100] Hall JR Jr. (2004), *op cit.*

Chapter 5
Characteristics of Households with Smoke Alarms and Fire Extinguishers

This chapter compares the characteristics of households that have smoke alarms and fire extinguishers with households that do not have these devices. The chapter is organized into four sections. The first section contains survey estimates for the proportion of households that have smoke alarms and fire extinguishers by household characteristics. The second section compares presence and absence of these devices among fire and non-fire households. Section three focuses on high-risk households, comparing the presence and absence of these devices by race and ethnicity, presence of young children or older adults, presence of smokers, and some socioeconomic characteristics. The last section draws conclusions from the analyses.

The survey included a number of questions about smoke alarms, sprinklers, and fire extinguishers. Respondents were asked if they had smoke alarms on every level in the residence, in all the bedrooms, the type of power source for these alarms, if the smoke alarms were interconnected, and if they were connected to a home security system. Respondents were also asked if they had an installed sprinkler system and about the number of fire extinguishers in their homes.

The role of smoke alarms in alerting people to fires and the effectiveness of alarms in reducing fire losses are discussed in Chapter 8.

Like Chapter 4, households are the unit of comparison in this chapter. For the most part, results are provided as percentages and thus apply to the estimated 1.3 million U.S. fire households and the 112.1 million non-fire households or, collectively, to the 113.3 million U.S. households.[101]

Some of the findings in this chapter are as follows:

- Similar to other recent surveys, 96.7 percent of U.S. households were estimated to have at least one smoke alarm in their residence. This was a major change from the 1984 survey where 62 percent of households had smoke alarms.[102]
- The breakdown by fire and non-fire households was that 92.7 percent of fire households and 96.8 percent of non-fire households had at least one smoke alarm. Fire households had an average of 2.92 alarms per household while non-fire households had an average of 3.54 alarms.

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[101] Total U.S. households from the Bureau of the Census. See http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH2-all.csv. Estimates for the number of fire and non-fire households in the U.S. are found in Chapter 3 of this report.
[102] Audits and Surveys (1985), *op cit*., page 53. Information on recent surveys of smoke alarms is in Ahrens M (2007b), *op cit.*

- About 30 percent of the alarms in both fire and non-fire households used house current or house current with battery backup. The remaining 70 percent of alarms were battery powered.
- Among fire households, 13 percent had interconnected alarms while 19 percent of non-fire households had interconnected alarms. About 8 percent of fire households and 14 percent of non-fire households had alarms that were connected to home security systems.
- Fire households were less likely to have smoke alarms on all floors and in all bedrooms than non-fire households.
- In comparing households that had various fire risk factors with those that did not, the following were observed:
    - Households with at least one family member under 18 years old were more likely to have smoke alarms on all floors and in all bedrooms than households without a family member under 18.
    - Urban households were more likely than non-urban households to have smoke alarms on all floors and in all bedrooms.
    - Households with at least one person 65 years old or older and households with at least one smoker were less likely to have smoke alarms in all bedrooms.
- Non-fire households were more likely than fire households to have at least one fire extinguisher in the house.

Although originally intended to be included in this chapter, results for home sprinkler systems are not included because it appeared that survey respondents had not answered the question accurately. Households were asked, "Do you currently have a sprinkler system installed in your home?" According to the survey data, 6.7 percent of households answered that their homes had installed sprinkler systems. This was composed of 15.1 percent of households in townhouses or row houses, 16.1 percent in multifamily houses, 13.1 percent in rental occupancies, 11.9 percent of households in buildings 0-5 years old, and 12.2 percent in buildings 6-15 years old. These statistics conflict with what is known about the number of homes with sprinklers.[103] It is possible that some people in multifamily dwellings answered yes to the sprinkler question when the buildings had sprinklers in public areas, but not in apartments. Also, it is possible that some households may have confused home sprinkler systems with installed lawn sprinkler systems.

Methods

Similar to Chapter 4, the tables in this chapter were prepared using Proc Surveyfreq, averages were computed with Proc Surveymeans, and differences between

[103] According to the National Residential Fire Sprinkler Initiative Meeting at the U.S. Fire Administration in 2003, no more than 2 percent of new residences are built with sprinkler systems. See Rohr K and Hall JR Jr. (2005), "U.S. Experience with Sprinklers and Other Fire Extinguishing Equipment," National Fire Protection Association, Quincy, MA, page 1.

averages were tested using Proc Surveyreg, all in the SAS® software system.[104] Two-way tables were tested for independence between the particular survey variable and whether the household was a fire or non-fire household, i.e., whether there was an association between household fire status and the characteristic tested. The test statistic used was the Rao-Scott Likelihood Ratio *F* statistic, a test statistic that is corrected for the survey design.

Statistical tests were applied to the actual table shown, or, when cell counts were small, to a collapsed version of the table. Table notes indicate when the test statistic came from a collapsed version. Data in tables are shown in percentages. Missing data, responses of "don't know," and refusals to respond were excluded before the computation of percentages. That procedure allocates non-responses in proportion to the responses.

Households with at least one fire were asked questions about the presence of smoke alarms and fire extinguishers immediately before each fire and if they had changed the number of these devices after the fire. If respondents said they had changed the number of smoke alarms or extinguishers after the fire, then the number of smoke alarms or extinguishers reflect those changes; otherwise they are the number of smoke alarms present before the most recent fire.

Results

Household Characteristics

Smoke Alarms. From the survey, it was estimated that 96.7 percent of U.S. households (95 percent confidence interval 95.8 – 97.7 percent) had smoke alarms.[105] Survey households averaged 3.53 smoke alarms in their households (95 percent confidence interval 3.36 – 3.70). As expected, the proportion of households with alarms was much larger than that from the 1984 survey, where 62 percent of households (52 million households) were estimated to have had smoke alarms.[106]

Table 5-1 contains additional information on the characteristics of households with smoke alarms.

[104] SAS Institute Inc. (2004), *SAS/STAT®, 9.1 User's Guide.* Cary, NC: SAS Institute Inc. See Chapter 4 for details on the statistical procedure.
[105] This equates to 109.6 million households. Percentages and household estimates are based on $n = 3030$ respondents who indicated the presence or absence of smoke alarms.
[106] Audits and Surveys (1985), *op cit*., page 53.

Table 5-1
Characteristics of Households with Smoke Alarms

Household Characteristic	Percent with Smoke Alarms
All	96.7
Type of dwelling	
Detached single family home	97.0
Mobile or manufactured home	90.9
Townhouse or row house	97.9
Multifamily	97.0
Type of ownership	
Owner	97.0
Renter/Other	95.7
Region	
Northeast	97.1
South	95.4
Midwest	98.9
West	96.3
Community type	
Urban	98.0
Non-urban	91.4
Age of dwelling	
5 years old or less	95.2
6 to 15 years old	97.4
16 to 25 years old	97.8
26 to 35 years old	96.1
36 to 45 years old	95.4
46 years or older	97.3

Notes: *Type of dwelling* based on n = 3,004 respondents, $F = 2.3056$, $p = 0.0747$; *Type of ownership*, n = 3,003, $F = 0.9761$, $p = 0.3232$; *Region*, n = 3,030, $F = 2.9022$, $p = 0.0335$; *Community type*, n = 3,030, $F = 22.4274$, $p < 0.0001$; *Age of dwelling*, n = 2,937, $F = 0.7023$, $p = 0.6217$. Multifamily housing includes two family dwelling, apartment, condo, and other dwelling categories.

Although the differences in the proportions of households with smoke alarms were not statistically significant by dwelling type, Table 5-1 shows mobile or manufactured homes had a smaller proportion with smoke alarms than other types of residences. A significantly larger proportion of households in urban communities had smoke alarms than households in non-urban communities. The differences in the proportions of households with smoke alarms by region were statistically significant, with the South having the smallest percentage and the Midwest having the highest.

Table 5-1 shows that there were no statistically significant associations between ownership type and presence of alarms and age of residence and presence of alarms.

Fire Extinguishers. It was estimated that 76.4 percent of households had at least one fire extinguisher (95 percent confidence interval 73.8 percent – 78.9 percent). Households averaged 1.35 extinguishers (95 percent confidence interval 1.28 – 1.42).[107]

Table 5-2 contains additional information on households with fire extinguishers.

[107] Based on n = 3015 respondents. This equates to 86.6 million households with extinguishers.

Table 5-2
Characteristics of Households with Fire Extinguishers

Household Characteristic	Percent with Extinguishers
All	76.4
Type of dwelling	
Detached single family home	81.2
Mobile or manufactured home	71.7
Townhouse or row house	77.2
Multifamily	59.3
Type of ownership	
Owner	81.0
Renter/Other	61.1
Region	
Northeast	76.7
South	78.4
Midwest	75.3
West	73.8
Community type	
Urban	76.1
Non-urban	77.6
Age of dwelling	
5 years old or less	76.8
6 to 15 years old	76.1
16 to 25 years old	77.2
26 to 35 years old	81.6
36 to 45 years old	79.9
46 years or older	76.7

Notes: *Type of dwelling* based on n = 2,988 respondents, $F = 11.2566$, $p < 0.0001$; *Type of ownership*, n = 2,994, $F = 30.0116$, $p < 0.0001$; *Region*, n = 3,016, $F = 0.6277$, $p = 0.5971$; *Community type*, n = 3,016, $F = 0.2669$, $p = 0.6054$, *Age of dwelling*, n = 2,923, $F = 0.4308$, $p = 0.8275$.

Table 5-2 shows that townhouses, row houses, and detached single family homes were most likely to have had at least one fire extinguisher, while multifamily homes were least likely. The differences were statistically significant. With respect to the type of ownership, renters were less likely to have fire extinguishers than owners, also a statistically significant difference.

There were no statistically significant differences in the proportions of households with fire extinguishers by region of the country, community type, or by the age of the dwelling.

Fire and Non-fire Households

Smoke Alarms. Table 5-3 shows that 92.7 percent of fire households had smoke alarms while 96.8 percent of non-fire households had smoke alarms. The difference was statistically significant.[108] There were relatively more fire households with no alarms or one alarm than non-fire households, while there were more non-fire households with two or more alarms. Further details are shown in Table 5-3.

[108] $n = 3{,}030$, $F = 7.8523$, $p = 0.0051$. This is essentially the same result as Table 5-3 collapsed to two rows, None and One or more. 95 percent confidence intervals for the proportion of fire households with smoke alarms 90.5 – 94.9; non-fire households with alarms 95.8 – 97.7.

Table 5-3
Number of Smoke Alarms by Fire and Non-fire Households (Percent)

Number of Smoke Alarms[109]	All Households	Fire Households	Non-fire Households
None	3.3	7.3	3.2
One	15.8	19.5	15.7
Two	23.6	24.7	23.5
Three	19.3	19.9	19.3
Four	13.0	11.8	13.1
Five or more	25.1	16.8	25.2
At least one alarm	96.7	92.7	96.8

Notes: Based on n = 3,030 respondents. Test of independence of number of alarms and household status $F = 4.8618$, $p = 0.0002$. Percentages computed using survey weights. Because the weights are much larger for the Non-fire Households (i.e., each Non-fire Household represents a larger number of households than each Fire Household), the Non-fire Households column in this table and the next few tables will differ from the All Households column only by a small amount.

Fire households averaged 2.92 smoke alarms (95 percent confidence interval 2.72 – 3.11) while non-fire households averaged 3.54 alarms (95 percent confidence interval 3.37 – 3.71). The difference was statistically significant (t=4.67, $p < 0.0001$).

The difference in the average number of smoke alarms may have resulted from differences in housing characteristics between fire and non-fire households. Fire households had, on average, fewer floors (or levels) in their residences than non-fire households (1.75 as compared with 1.86).[110] Moreover, fire households had fewer smoke alarms per floor with an average of 1.86 (95 percent confidence interval 1.87 – 2.09) than non-fire households, which averaged 2.20 (95 percent confidence interval 2.10 – 2.30).[111]

[109] Responses in this table were constructed from several survey questions. First, respondents were asked if they had any smoke alarms. A response of *None* was recorded if they responded "No" to the question. If they responded "Yes" to having at least one smoke alarm, the next question asked about the number of levels in the home. Respondents who said that they had smoke alarms but didn't specify the number of floors in the home were assumed to have one smoke alarm. Respondents were then asked about the number of alarms on each level, and these were added to produce the results in the table. If a respondent said they did not know or refused to supply the number of alarms on any particular level, the number of alarms on that floor was counted as zero. As a result, Table 5-3 may understate the number of alarms in U.S. households.

[110] The difference in the number of levels between fire and non-fire households was statistically significant, n = 2,899, $t = 2.39$, $p = 0.0171$.

[111] The difference in the average number of alarms per floor was also statistically significant, n = 2,899, $t = 2.94$, $p = 0.0033$.

Table 5-4 shows that a larger proportion of non-fire households had smoke alarms on some or all floors than fire households did. For example, 84.0 percent of non-fire households had alarms on all floors in contrast to 82.4 percent of fire households.

Table 5-4
Levels in the Home with Smoke Alarms by Fire and Non-fire Households (Percent)

Floors with Alarms	All Households	Fire Households	Non-fire Households
No alarms	3.3	7.3	3.2
Some floors	12.7	10.3	12.8
All floors	84.0	82.4	84.0

Notes: Based on n = 3,030 respondents. Test of independence of number of floors with alarms and household status $F = 5.6875$, $p = 0.0034$.

In addition to having a smoke alarm on all floors of the home, it is also recommended that there are smoke alarms in all rooms where people sleep.[112] Table 5-5 compares fire and non-fire household as to whether all or some bedrooms in the home had smoke alarms.

[112] Ahrens M (2007b), *op cit.*, page xii.

Table 5-5
Alarm Locations by Fire and Non-fire Households (Percent)

Location of Alarms	All Households	Fire Households	Non-fire Households
No alarms	3.3	7.4	3.2
In home but not in respondent's bedroom	51.0	57.2	51.0
Only in respondent's bedroom	15.0	13.7	15.0
In all bedrooms	30.7	21.7	30.8

Notes: Based on n = 3,008 responses. Test of independence of alarm location and household status $F = 7.3859$, $p < 0.0001$. The responses in the table were constructed from two questions as follows: (1) Is there a smoke alarm in the bedroom where you sleep and (2) Do you have a smoke alarm in every bedroom in your home or apartment. A positive response to both questions was counted as *In all bedrooms*. The category *Only in respondent's bedroom* was derived from a negative response to every bedroom and a positive response to the bedroom where you sleep. Negative responses to both questions for survey respondents who indicated the presence of alarms in other questions were counted in the category *In home but not in respondent's bedroom*. The percent of households with *No alarms* in this table is different from other tables because of non-response to the question about location in bedrooms.

Table 5-5 shows that less than one-third of non-fire households and less than one-quarter of fire households had smoke alarms in all bedrooms. About 15 percent of each group had one alarm that was located in the respondent's bedroom.

The location of the smoke alarms is an issue because sleeping occupants in the home may not have adequate warning when a fire starts in a different area of the home. In 1993, the National Fire Protection Association recommended that in new construction smoke alarms be placed in all bedrooms.[113]

Another way to alert occupants who are remote from the origin of a fire is to have all smoke alarms connected so that when one alarm sounds, all sound. Table 5-6 shows the proportion of fire and non-fire households with interconnecting smoke alarm systems. The table includes only households that had two or more smoke alarms.

[113] See Public/Private Fire Safety Council (2006), "Home Smoke Alarms." Washington, DC. Available at http://www.firesafety.gov/programs/alarms.shtm. The NFPA requirement is in NFPA 72, National Fire Alarm Code. See NFPA (2007), National Fire Alarm Code, 2007 Edition. National Fire Protection Association, Quincy, MA.

Table 5-6
Interconnected Alarms by Fire and Non-fire Households (Percent)

Type of Connection	All Households	Fire Households	Non-fire Households
No alarms	3.6	8.1	3.6
One alarm	17.4	21.5	17.3
Stand alone	59.9	57.6	59.9
Interconnected	19.1	12.9	19.2

Notes: Based on n = 2797 responses. The sample for this table excludes households that did not know if they had smoke alarms or did not know if the alarms were interconnected. Test of independence of household status and type of connections in collapsed table includes only *Stand alone* and *Interconnected* alarms, n = 2,045, $F = 5.5018$, $p = 0.0191$. The percent of households with *No alarms* in this table is different from other tables because of non-response to the question about alarm interconnection.

Table 5-6 shows that 19.2 percent of non-fire households had interconnected alarms in contrast to 12.9 percent of fire households. The statistical test of interconnect against stand alone, one alarm and no alarms by fire and non-fire household status was statistically significant.

Another feature that can improve the notification to occupants about a fire is when smoke alarms are connected to a home security system. Some systems have a smoke alarm that is loud enough to alert all residents, while other systems dial a central alarm company when activated. This is addressed in Table 5-7 below.

Table 5-7
Home Security Service Connection by Fire and Non-fire Households (Percent)

Home Security Service Connection	All Households	Fire Households	Non-fire Households
No alarms	3.3	7.6	3.3
One alarm	15.9	20.3	15.9
Not connected	67.0	64.0	67.0
Connected	13.8	8.0	13.8

Notes: Based on n = 2971 responses. The sample for this table excludes households that did not know if they had smoke alarms or did not know if the alarms were connected to a home security service. The survey did not ask if households with one alarm were connected to a home security service. Test of independence of household status and home security service connection in collapsed table included only *Not connected* and *Connected*, n = 2,219, $F = 8.8503$, $p = 0.0030$. The percent of households with *No alarms* in this table is different from other tables because of non-response to the question about home security service connections.

Like interconnected alarms, connections to home security services did not characterize the majority of homes. Among fire households, 8.0 percent were connected to a home security system, while for non-fire households, 13.8 percent had alarms connected to such systems. The difference in proportions for the collapsed table comparing connected and not connected by fire or non-fire household was statistically significant.

Alarms can be battery powered, powered by the house electrical system, or powered by a combination of battery and electrical, where usually the battery provides a backup in case of household power failure. The preferred type of alarm uses house current (also known as hard-wired alarms) with battery backup to provide power in the event that the house electricity fails.

Table 5-8 below displays the distribution of types of power used for smoke alarms. The unit of analysis in this table is the alarm, so that a household may contribute more than one observation.

Table 5-8
Power Sources for Smoke Alarms in Use by Fire and Non-fire Households (Percent)

Power Source	All Households	Fire Households	Non-fire Households
Battery	69.9	71.9	69.9
House current	13.0	9.6	13.0
House current with battery backup	17.1	18.4	17.1

Notes: Data from n = 9,313 alarms where the respondent provided information about the source of power for the smoke alarm. F = 1.3569, p = 0.2575.

As shown in Table 5-8, 71.9 percent of fire households had battery powered alarms, 9.6 percent had house current powered alarms, and 18.4 percent had battery backup alarms. Non-fire households had slightly more house current powered alarms and slightly fewer battery powered alarms, but the difference by type of household was small and not statistically significant.

House current powered alarms with battery backup are the preferred types of alarms, followed by house current only, and then by battery only.[114] Using data from the National Fire Incident Reporting System (NFIRS) for fire department-attended fires between 2000 and 2004, it was shown that, when present, battery powered smoke alarms operated in 61 percent of the incidents, house current powered alarms operated in 70 percent of the incidents, and house current with battery backup alarms operated in 76 percent of the incidents.[115] Building codes have changed over time to require alarms powered by house current and, as a result, newer homes are more likely to have these types of smoke alarms.[116]

In the 1984 survey, 72 percent of the alarms in use by non-fire survey households were battery powered and 79.3 percent in fire households were battery powered. In that survey, only 2.3 percent of the alarms in fire households and 8.5 percent of the alarms in non-fire households used house current with battery backup as the power source.[117] Table 5-8 shows that the proportion of alarms using house current with battery backup has increased since 1984 and the proportion of battery powered alarms has decreased.

[114] NFPA 72 requires smoke alarms to be installed outside each sleeping area and on every level of the home. In new construction, smoke alarms are also required in all sleeping rooms. Alarms must be hard-wired with battery backup in new construction but may be battery powered in existing homes. For details see http://www.nfpa.org/faq.asp?categoryID=925#23013.
[115] Ahrens, M (2007b) *op cit*., page 13. The data are for non-confined fires. This information is not collected in NFIRS for confined fires.
[116] Smith, CL (1994), "Smoke Alarm Operability Survey—Report on Findings." U.S. Consumer Product Safety Commission, Washington, DC.
[117] Audits and Surveys, *op cit*., page 54.

Fire Extinguishers. In addition to smoke alarms, extinguishers have the potential to reduce fire losses. Table 5-9 shows the distribution of the number of fire extinguishers by fire and non-fire households

Table 5-9
Number of Household Fire Extinguishers
by Fire and Non-fire Households (Percent)

Number of Extinguishers	All Households	Fire Households	Non-fire Households
No extinguishers	23.6	28.1	23.5
One extinguisher	38.7	39.3	38.7
Two extinguishers	24.6	23.8	24.7
Three extinguishers	8.3	6.3	8.3
Four or more extinguishers	4.8	2.5	4.8

Notes: Based on n = 3003 respondents, $F = 2.5966$, $p < 0.0344$.

Table 5-9 shows that fire households were less likely to have fire extinguishers than non-fire households. The average number of extinguishers in fire households was 1.16 (95 percent confidence interval 1.08 – 1.25), while the average in non-fire households was 1.36 (95 percent confidence interval 1.28 – 1.43). The difference in the averages was statistically significant ($t = 3.27$, $p = 0.0011$).

High Risk Households

This section examines if there is a difference in household smoke alarm configurations in high risk populations. Two issues are considered as follows: (1) if there were smoke alarms on all floors and (2) if there were alarms in all bedrooms. This elaborates on the results shown in Table 5-4 and Table 5-5. As mentioned previously, having smoke alarms in every sleeping room and on each level of the house is recommended by fire safety experts.[118]

In this section, high risk households are defined as the households with characteristics that were shown to differ significantly between fire and non-fire households in Chapter 4. These characteristics included residential property ownership

[118] In addition to NFPA 72 above, see U. S. Consumer Product Safety Commission (2008), "Smoke Alarms – Why, Where and Which." CPSC Document #559. Available at http://www.cpsc.gov/CPSCPUB/PUBS/559.pdf.

(Table 4-3), household size (Table 4-5), occupant age distribution (Tables 4-6a, 4-6b, and 4-6c), and head of household educational levels (Table 4-9). In addition, while not identified as statistically significantly different between fire and non-fire households in Chapter 4, there is much evidence that smoking is a risk factor, so that is also considered in this section. Also, the urban and non-urban contrast is shown in the tables, although this did not appear to differ significantly between fire and non-fire households. This category is shown because other research has cited urban and non-urban location as a risk factor.

Tables 5-10 and 5-11 present the estimates from the survey.

Table 5-10
Risk Factors and Households with Smoke Alarms on All Floors

Risk Factor	Percent with Smoke Alarms on All Floors	Sample Size	*F*	*P*
Renters	80.8			
Owners	85.1	3003	2.3616	0.1245
1-4 household members	84.3			
5 or more	84.4	2998	0.0015	0.9691
At least one person under 18	86.8			
Nobody under 18	82.4	2967	4.1603	0.0415
At least one person over 65	81.1			
Nobody over 65	84.8	2967	1.5454	0.2139
Not college graduate	82.3			
College graduate or higher	85.4	2960	1.6728	0.1960
At least one smoker	83.9			
No smokers	84.0	3023	0.0033	0.9544
Urban	85.4			
Non-urban	78.0	3030	6.4363	0.0112

Notes: This table is presented differently from other tables in that it only shows the percent possessing the attribute. The percent without the attribute is omitted to save space in the table. For example, for *Renters*, 80.8 percent have smoke alarms on all floors (shown), while 19.2 percent do not have smoke alarms on all floors (not shown). The two statistics, *F* and *p,* in the last two columns are from tests of the independence of the household characteristic against whether there were smoke alarms on all floors. The statistical testing procedure is the same as that used for other tables in this chapter. The percent of households in the sample with smoke alarms on all floors was 84.0.

Table 5-10 compares the proportion of households with smoke alarms on all floors by various risk factors. Renters, for example, are compared with owners; and household size compares households with 5 members or more against those with fewer than 5 members.

Table 5-10 shows each of the seven risk factors with similar percentages of smoke alarms on all floors, that is, between 78.0 and 86.8 percent. Two groups have statistically significant differences in the percent with smoke alarms on all floors. These are At Least One Person Under 18 and the Urban/Non-urban factor.

Table 5-11 shows results for the seven risk factors and the percentage of Smoke Alarms in All Bedrooms.

Table 5-11
Risk Factors and Households with Smoke Alarms in All Bedrooms

Risk Factor	Percent with Smoke Alarms in All Bedrooms	Sample Size	*F*	*p*
Renters	35.6			
Owners	28.9	2986	3.7097	0.0542
1-4 household members	29.9			
5 or more	33.6	2982	0.7629	0.3825
At least one person under 18	35.2			
Nobody under 18	27.4	2952	6.7874	0.0092
At least one person over 65	20.9			
Nobody over 65	32.7	2952	13.0564	0.0003
Not college graduate	27.2			
College graduate or higher	32.1	2945	2.8704	0.0903
At least one smoker	25.9			
No smokers	32.6	3003	5.1635	0.0231
Urban	32.3			
Non-urban	23.9	3008	7.9421	0.0049

Notes: See notes for Table 5-10. The percentage of households in the sample with smoke alarms in all bedrooms was 30.7.

For all households, 30.7 percent have smoke alarms in all bedrooms. In Table 5-11 four groups have significantly different percentages. In three of the groups, urban/non-urban, presence of a smoker, and household members over 65, the higher risk subsets (non-urban, smoker, and at least one person over 65) are less likely to have smoke alarms in all bedrooms than the lower risk group. In the other risk groups, people under 18, households in the higher risk category of *At least one person under 18* are more likely to have smoke alarms in all bedrooms. [119]

Conclusion

The largest single distinction between this survey and the 1984 survey was that almost all households (96.7 percent) in this survey have smoke alarms as compared with 62 percent in 1984. Two of the characteristics found to be significant discriminators of the presence or absence of smoke alarms in the 1984 survey, i.e., owners vs. renters and multiple family vs. single family dwellings, were not significant in the present survey. Region was significant in the current survey, with relatively more households with alarms in the Northeast and Midwest and fewer in the South and West. Also, households in urban communities were significantly more likely to have smoke alarms than households in non-urban areas.

In comparing between fire and non-fire households, fire households averaged 2.92 alarms while non-fire households averaged 3.54 alarms per household, a statistically significant difference. This may be somewhat explained by non-fire households having homes with more floors than fire households; and non-fire households had, on average, significantly more alarms per floor than fire households. The proportion of households with smoke alarms powered by the preferred choice of house current or house current with battery backup did not differ between fire and non-fire households.

In the 1984 survey, the difference in the average number of smoke alarms in fire and non-fire households was not statistically significant.

In the present survey, 8.0 percent of fire households and 13.8 percent of non-fire households had smoke alarms connected to a home security service, a statistically significant difference. The 1984 survey did not ask about connections to a service. The U. S. Consumer Product Safety Commission recommends smoke alarms on all floors and in all bedrooms. For fire households, 82.4 percent had alarms on all floors, while 84.0 percent of non-fire households had alarms on all floors. There was also a larger proportion of non-fire households than fire households with smoke alarms in all bedrooms (30.8 percent of non-fire households as compared with 21.7 percent of fire households).

For characteristics identified as high fire risk in Chapter 4, households with such characteristics had differences from other households with respect to the presence or absence of alarms on all floors or in all bedrooms. If there was a family member under 18 in the household, it was more likely that there were smoke alarms on all floors and in

[119] The cutpoint of 1-4 household members in Tables 5-10 and 5-11 was arbitrary. Other cutpoints were explored without changing the results. For example, using 1-3 household members and 4 or more in Table 5-10 showed 84.1 percent and 84.8 percent with smoke alarms on all floors ($F = 0.1007$, $p = 0.7510$). For Table 5-11, the results were 28.9 and 33.7 percent, respectively ($F = 2.3646$, $p = 0.1242$).

all bedrooms. On the other hand, a smaller proportion of households with smokers or at least one person over 65 had smoke alarms in all bedrooms.

In summary, while most households now have at least one smoke alarm, there is the potential to provide more protection with currently available smoke alarm technology. There could be more households with interconnected smoke alarms, more households with alarms powered by house current with battery backup instead of battery power alone, and more households could have alarms on all floors and in all bedrooms.

There are also steps that consumers can take to improve fire safety without changing the alarm technology. The survey did not ask if respondents routinely tested their smoke alarms, changed the batteries annually, or if the alarms were audible at every location in the home.[120] The literature on fire department-attended fires describes that smoke alarms were reported not to have operated in more than 75 percent of residential fires.[121] Presence of the alarms in the home is a first step, but residents need to do more to make sure they will be operational when needed. Moreover, residents need to know what to do when the alarm sounds and to practice a fire escape plan.

More than three-fourths of non-fire households and more than two-thirds of fire households had at least one portable fire extinguisher in the residence. While having a fire extinguisher may help in some fires, there have been questions raised about the usefulness of extinguishers. For example, extinguishers may cause splattering which can spread cooking fires.[122] The survey did not ask what type of extinguisher was in the household or if the respondent knew that different types of extinguishers were designed for different types of fires.[123] The survey also did not ask if the extinguisher had been tested or maintained or if the respondent knew how to operate the extinguisher.

Chapter 8 addresses how smoke alarms alerted fire households to fires and how extinguishers were used.

[120] The survey asked if alarms had been tested only of fire households in the situation when the alarm did not sound during the fire. There is more information on this in Chapter 8.
[121] U.S. Fire Administration (2006), "Investigation of Fatal Residential Structure Fires with Operational Smoke Alarms." Topical Fire Research Series, U.S. Fire Administration, Emmitsburg, MD, page 4.
[122] Hall JR Jr. (2005), "Home Cooking Fire Patterns and Trends." National Fire Protection Association, Quincy, MA, page 6.
[123] For example, see Fire Protection Association Australia (2005), "Fire Safety Data Sheet: Fire Extinguishers." Victoria, Australia.

Chapter 6
Characteristics of Residential Fires

This chapter and the next two chapters return to the analysis of fires that was begun in Chapter 3. In that chapter, it was estimated that there were 7.43 million fires annually, of which 254,000 were attended by fire departments and 7.18 million were unattended. That was a ratio of 28.2 unattended fires for each fire department-attended fire, or, to put it another way, about 3.5 percent of all residential fires were attended by fire departments.

This chapter has two objectives, first, to begin to describe the characteristics of residential fires and, second, to contrast fire incidents that were attended by fire departments with those that were not. Chapter 7, which follows, analyzes only unattended fires, presenting a more detailed breakdown of the characteristics of those fires and the households that experienced them. Chapter 7 also compares fire incidence in the present survey with the 1984 survey, in part to provide a more detailed analysis of the factors associated with the decline in fires between 1984 and the present survey.[124] Chapter 8 focuses on the role played by smoke alarms and fire extinguishers in fires.

Following the description of the methods immediately below, the results are separated into four sections as follows:

- Comparison of demographic and other characteristics of households with attended and unattended fire incidents
- Comparison of fire characteristics of attended and unattended fire incidents
- Fire losses in attended and unattended incidents
- Presence or absence of smoke alarms and extinguishers in attended and unattended incidents

The last part of the chapter discusses and summarizes the characteristics that discriminate between attended and unattended fires. An appendix to the chapter presents estimates of the amount of the sampling error as related to the estimated number of fires.

Methods

The analyses in Chapters 6, 7, and 8 are based on the 14-day recall period for low severity incidents and the 21-day recall period for high severity incidents, as introduced in Chapter 3. Non-fire households or households where the fire occurred outside the 14/21-day recall period are not considered in these chapters.[125] This makes the data different from Chapters 4 and 5, which defined fire and non-fire households on the basis of whether a fire occurred in the full 91-day period. Also, the unit of analysis in Chapters

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[124] The 1984 survey is found in Audits and Surveys, Inc. (1985), *op cit.*

[125] In Chapter 7, comparisons between the present survey and the 1984 survey use all fires in the three-month period. See that chapter for details.

6, 7 and 8 is the fire, not the household, thus households with two fires in the period provide two separate records, and those with three fires provide three records.

The data in this chapter and the next two chapters were prepared in a similar way to the data used to estimate fire incident rates in Chapter 3. First, non-fire household records were removed, leaving a dataset with the 916 fire household records, describing 961 fire incidents. Each record contained up to three fire incidents and a description of the household characteristics. The dataset was then merged with the imputation dataset that contained 15 fire dates for each fire. Variables in the imputation dataset were the date of each fire incident reported by the household, the severity of each fire, the sampling weight (expansion weight from Chapter 2), the date of the telephone interview with the household, and the household stratum.[126] If the fire household had specified month and day of the fire, then the fire date on each of the 15 imputation records would have been identical. Otherwise, when day or month was missing, the dates were imputed 15 times using the probabilistic imputation process as described in Chapter 3. The reason for multiple imputations was to incorporate some additional variability in the dates of the fire, ultimately leading to additional variability in the household fire incidence rates.

The merged dataset contained (15 x 916=) 13,740 records, i.e., one record for each fire household. This was then expanded to the number of fires (15 x 961=14,415 fire records), with each record containing both household, and fire characteristics. Because each fire incident was replicated 15 times, the weights were then divided by 15 to bring them back to the correct sampling weights. This then allowed the sample to represent the 7.43 million annual fires in the U.S. that were estimated in Chapter 3.

The tables in this chapter were developed by partitioning the fire incidents into various categories associated with the fire, the household, or both. Examples include region of the country, age of residence, household income, fire department-attended or unattended. SAS® data step programs were written to extract the cases and assign the categories. Tabulation of the estimated number of fires in each category was done using Proc Freq or Proc SQL in the SAS system.

While all fire incidents (i.e., attended and unattended collectively) and unattended fire incidents (separately) are estimated reasonably precisely with coefficients of variation (CVs) of 8.5 and 8.8 percent, respectively, fire department-attended fires are estimated with much less precision, with a CV of 37.9 percent, because there are far fewer attended incidents in the survey.[127] Of the 961 fire incidents in the survey, between 260 and 271 incidents were in the 14/21-day recall period and were used to estimate the total number of fires. These are the only incidents used in this chapter and the next two chapters. Of these incidents, between 14 and 16 incidents were fire department-attended.

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[126] There were 11 strata, as discussed in Chapter 2.

[127] The CV is the standard deviation divided by the mean and is expressed as a percent. The standard deviation includes the variability attributable to sampling and to imputation. For more details see Chapter 3.

The small number of fire department-attended incidents not only contributes to the amount of sampling variability in the estimated incident rate (measured by the size of the CV) but also restricts further analysis of attended fires. With between 14 and 16 fire department-attended fires, there can be at most 16 different areas where the fire started, 16 different heat sources, 16 different items first ignited, etc. As a result, some low probability categories in the tables are likely to have no estimated attended fires -- not because there were no attended fire incidents in the U.S. during the year, but because the survey did not have any of these incidents. These cases are indicated with a dash in the tables rather than a zero. The reader needs to be aware of this limitation of the data when looking at the attended fires and the ratio of unattended to attended fires in the tables in this chapter. This issue also extends to any breakdown of fire incidents, such as area of fire origin, heat source, etc. where the number of estimated fires is relatively low and therefore likely to have been based on a small number of actual responses.

Like the estimates for attended and unattended fires in Chapter 3, every estimated number of fires in this chapter and every ratio of unattended fires to attended fires have an associated standard error and confidence interval. To avoid cluttering the tables, these statistics are not presented in the tables. Instead, the reader can get a sense of the precision of the estimate from the coefficient of variation. As the estimated number of fires increases, the CV decreases. Tables relating the CV to the estimated number of fires and text describing how the tables were constructed are found in the appendix to this chapter. These tables can be used as a generalized variance (CV) function. For more information on the generalized variance function, see Wolter.[128]

The tables in this chapter show estimated fires (in thousands), broken down by unattended and attended, and the ratio of unattended to attended fires.

Results

Household and Demographic Characteristics

Table 6-1 shows the breakdown of attended and unattended fires by area of the country.

[128] Wolter KM (1985), *Introduction to Variance Estimation*. Springer-Verlag, NY, Chapter 5.

Table 6-1
Estimated Unattended and Attended Fires by Region
(Thousands of Fires)

Region	All Fires	Unattended Fires	Attended Fires	Unattended Fires per Attended Fires
All	7,430	7,176	254	28.2
South	2,822	2,717	105	25.9
West	2,271	2,175	97	22.5
Northeast	1,271	1,238	33	37.8
Midwest	1,066	1,046	20	52.4

Notes: Totals may not add due to rounding. The last column is Unattended Fires divided by Attended Fires. Ratios are computed in SAS® based on the unrounded estimated number of fires and may not agree exactly with the ratio of rounded fires. The first row, *All*, does not change in any of the tables and will not appear in any other tables in this chapter. The percentage of U.S. households by region is as follows: Northeast 18.7 percent, South 36.4 percent, Midwest 22.9 percent and West 22.0 percent. See Chapter 4, Table 4-1 for a listing of states in each region. Approximate CVs for estimated fires in thousands: 1,000, 27.2 percent; 2,000, 22.1 percent; 3,000, 17.9 percent. For details about how the CV is calculated, see the appendix to this chapter.

In Table 6-1, it appears that the largest estimated number of fires, both unattended and attended, was in the South, followed by the West, Northeast, and Midwest.[129] This is not surprising considering that the South (as defined in the survey) has the largest number of households; the West and Midwest have about the same number of households; and the Northeast has the fewest households. Correcting for the number of households, then, the number of fires (both unattended and attended) per 100 households was as follows: South 6.85, West 9.09, Northeast 6.00, and Midwest 4.11.[130] In addition to having the smallest per household fire rate, the Midwest also had proportionately fewer fire department-attended fires with 52.4 unattended fires per attended fire. This was followed by the Northeast at 37.8 unattended to attended fires, the South and the West at 25.9 and 22.5, respectively.

Of the 7.43 million fires, 5.98 million occurred in urban regions and 1.45 million in non-urban regions. In urban regions, 5.83 million were unattended and 154,000 were attended, while in non-urban regions, 1.35 million were unattended and 101,000 were

[129] Usually the term "estimated" will not appear with fires. The reader should understand that all statistics in this survey are estimated, not actual counts of events.
[130] Households by region from the U.S. Bureau of the Census obtained from http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH2-all.csv.

attended. The ratio of unattended to attended fires was 37.9 in urban regions and 13.4 in non-urban regions.

By dwelling type, 4.63 million fires occurred in single family residences and 2.64 million occurred in other types of residences.[131] Other types included apartments, mobile or manufactured homes, multifamily dwellings, townhouses, row houses and condos. Within single family residences, 115,000 fires were fire department-attended, for a ratio of 39.2 unattended fires per attended fire. Other home types had 124,000 fire department-attended fires, for a ratio of 20.3 unattended fires per attended fire.

In owner occupied housing, there were 4.86 million fires, of which 194,000 were fire department-attended. Among renters, there were 2.53 million fires, of which 45,000 were fire department-attended. Note that in the U.S. there are more than twice as many households that own rather than rent their residences.[132] Thus, the number of fires per 100 households was 6.19 for owner occupied housing and 7.58 for rental housing. Owners had 24.1 unattended fires for each attended fire, while renters had 55.1 unattended fires for each attended fire.[133]

Table 6-2 shows the relationship between the age of residence and fire department attendance.

[131] Respondents did not know the type of residence or refused to respond in cases covering 157,000 fires.
[132] Households by type of occupancy from the U.S. Bureau of the Census at http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-all.csv.
[133] Respondents accounting for 46,000 fires did not know or refused to answer if they rented or owned the residence.

Table 6-2
Attended and Unattended Fires by Age of Residence
(Thousands of Fires)

Age of Residence (years)	All Fires	Unattended Fires	Attended Fires	Ratio
0-15	2,669	2,667	2	1,182.0
16-25	1,280	1,224	56	21.8
26-35	948	885	63	14.1
36-45	699	628	71	8.8
46 or older	1,474	1,427	47	30.5

Notes: See notes for Table 6-1. Ratio is Unattended Fires divided by Attended Fires. Respondents reporting 360,000 fires did not know or refused to provide the age of the dwelling. All quantities are estimates. Approximate CVs for fires in thousands: 700, 37.2 percent; 1,000, 27.2 percent; 2,500, 19.9 percent.

In the survey data, as shown in Table 6-2, there were almost no fire department-attended fires in properties 15 years or newer. The ratio of unattended to attended fires appears to decline as properties age. This suggests that fires in older properties are more likely to involve fire departments than newer properties. For properties 46 years old or older, however, the ratio is higher with relatively fewer attended fires.

Table 6-3 shows the distribution of attended and unattended fires by household income.

Table 6-3
Attended and Unattended Fires by Household Income
(Thousands of Fires)

Household Income	All Fires	Unattended Fires	Attended Fires	Ratio
$0-$14,999	628	628	-	-
$15,000-$34,999	1,894	1,781	113	15.8
$35,000-$74,999	1,630	1,564	66	23.8
$75,000 or more	2,040	2,010	30	67.9

Notes: See notes for Tables 6-1 and 6-2. Also, the table does not include responses representing 1.24 million fires where the respondent either refused to provide or did not know the household income. No fire department-attended fires were reported for survey respondents with household incomes less than $15,000 per year. This is shown with a dash (-) in the table to symbolize that infrequent outcomes are unlikely to be reported in samples. It does not mean that there were no fire department-attended fires in the U.S. occurring in households with incomes less than $15,000 per year. Approximate CVs for fires in thousands: 600, 42.2 percent; 1,500, 24.5 percent; 2,000, 22.1 percent.

Table 6-3 shows that there were no fire department-attended fires in residences where households reported incomes of $15,000 or less. The relationship between household income and unattended fires shows that as incomes increase the ratio of unattended to attended fires increases, suggesting that relatively more attended fires occurred in lower income residences.

With respect to the household size, no clear pattern emerged relating the number of people in the household to the distribution of attended and unattended fires, as shown in Table 6-4 below.

Table 6-4
Attended and Unattended Fires by Household Size
(Thousands of Fires)

Number of People in the Household	All Fires	Unattended Fires	Attended Fires	Ratio
1	951	941	11	89.2
2	1,788	1,737	51	34.1
3	1,522	1,442	80	18.0
4	1,637	1,614	23	69.0
5 or more	1,427	1,353	74	18.3

Notes: See notes for Tables 6-1 and 6-2. The table omits responses representing 104,000 fires where the respondent refused to provide the household size. Approximate CVs for fires in thousands: 1,000, 27.2 percent; 1,500, 24.5 percent.

Taking the distribution of household size in the population into account, it appears that per household fire incidence increases with household size.[134] Households with a single member had 3.2 fires per 100 households, two member households had 4.8 fires, three member households had 8.3 fires, four member households had 10.0 fires, and larger households had 12.9 fires per 100 households. This pattern of increasing fire incidence was also consistent for unattended fires and attended fires separately. The ratio of unattended to attended fires was not consistently increasing or decreasing with household size, as shown above.

Households with at least one member under 18 years of age reported 3.78 million fire incidents, of which 3.65 million were unattended and 124,000 were attended. Households with no members under 18 had 3.56 million fires, of which 3.43 million were unattended and 131,000 were attended. The unattended to attended ratios were 29.5 for households with a member under 18 and 26.3 for households without any members under 18; both ratios are close to the overall ratio of 28.2 unattended fires per attended fire. Taking the number of households in the population into account showed 9.4 fires per 100 households in households with at least one member under 18 and 4.9 fires per 100 households when no household members were under 18.[135]

[134] In 2005, there were 30.1 million households with a single member, 37.4 million with two members, 18.3 million with three members, 16.4 million with four members, and 11.1 million with five or more members. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-all.csv.

[135] There were 40.1 million households with at least one member under 18 and 73.3 million households with no members under 18. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-all.csv.

Households with at least one member at least 65 years of age reported 344,000 fires, of which 312,000 were unattended and 32,000 were attended. Households with no members 65 years of age and older reported 6.99 million fires, 6.78 million unattended and 222,000 attended. Taking the household population into account, this was 8.1 fires per 100 households for those with all members 64 and younger and 1.3 fires per 100 households for all households with at least one member over 64.[136] The ratios were 30.5 unattended fires for each attended fire for households with members 64 and younger and 9.7 unattended fires to attended fires for households with at least one household member over 64.[137]

With respect to ethnicity, households identifying themselves as having a household head of Hispanic or Latino descent reported 777,000 fires, of which 684,000 were unattended and 93,000 were attended, for a ratio of 7.4 unattended fires to attended fires. On a population basis, there were 6.4 fires per 100 such households.[138]

By race, families with a White head of household reported 5.32 million fires, 5.15 million unattended and 173,000 attended fires for a ratio of 29.8 unattended fires to attended fires. This was 5.7 fires per 100 households.[139] Families with a Black household head reported 640,000 fires, of which 600,000 were unattended and 40,000 were attended, for a ratio of 15 unattended fires per attended fire. Correcting for population, there were an estimated 4.6 fires per 100 households.[140]

Fire Characteristics

This section focuses on the characteristics of residential fires.

Table 6-5 shows the distribution of unattended and attended fires by the location in the residence where the fire started.

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[136] There were 86.8 million households with all members under 65 and 26.5 million with at least one member 65 or over. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-all.csv.

[137] Responses are not shown for both age group analyses representing 93,000 fires where the respondent did not know or refused to provide information about the household composition.

[138] Respondents refused to disclose the ethnicity of the head of household in cases representing an estimated 345,000 fires. There were 12.2 million households with a Hispanic head. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-hisp.csv. Note that Hispanic persons may be of any race and, as a result, may also be counted as Black or White household heads.

[139] Based on 92.9 million households. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-whitealone.csv.

[140] Based on 13.8 million households. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-blackalone.csv.

Table 6-5
Attended and Unattended Fires by Area of Fire Origin
(Thousands of Fires)

Area of Fire Origin	All Fires	Unattended Fires	Attended Fires	Ratio
Kitchen	5,080	4,987	93	53.4
Living room	569	530	39	13.7
Bedroom	505	505	-	-
Bathroom	438	438	-	-
Other areas	373	355	18	20.1
Basement	210	199	11	17.3
Dining room	160	140	20	7.0
Attached garage	95	22	73	0.3

Notes: See notes for Tables 6-1 and 6-2. *Other areas* include exterior of the house, siding, hall or entryway, porch or deck, inside enclosed wall space, laundry room, storage area, attic, or unspecified areas. The last category had more than half the incidents. Numbers may not add to totals due to rounding. Approximate CVs for fires in thousands: 150, 74.5 percent; 400, 54.3 percent; 5,000, 11.8 percent.

Table 6-5 shows that the largest number of fires at 5,080,000 began in the kitchen. Most were not attended by the fire service and the ratio is about twice the overall average at 53.4 unattended fires to attended fires. Also, fires beginning in bedrooms and bathrooms with 505,000 and 438,000 incidents, respectively, were also unlikely to be fire department-attended. On the other hand, fires starting in living rooms (569,000 incidents), dining rooms or dining areas (160,000 incidents), or basements (210,000 incidents) and garages (95,000 incidents) were more likely to be fire department-attended.

Table 6-6 shows the distribution of types of fire by heat source.

Table 6-6

Attended and Unattended Fires by Heat Source
(Thousands of Fires)

Heat Source	All Fires	Unattended Fires	Attended Fires	Ratio
Cooking appliances	4,757	4,664	93	49.9
Open flame	783	744	39	19.1
Other household appliances	671	651	20	32.6
Electrical lighting and wiring	616	616	-	-
Heating and cooling equipment	326	281	46	6.2
Cigarettes	167	155	11	13.5
A fire that spread to the house	92	47	45	1.0
Other (unspecified)	17	17	-	-

Notes: See notes for Tables 6-1 and 6-2. *Open flame* includes candle, match, lighter, torch, spark from a fireplace, and fireworks. Approximate CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 600, 42.2 percent; 800, 32.8 percent; 4,500, 13.1 percent.

As expected from Table 6-5 where the majority of estimated fires began in the kitchen, cooking appliances dominate the heat sources shown in Table 6-6. A larger proportion of cooking appliance fires is likely to be unattended by the fire service, with a ratio of 49.9 unattended to attended fires. Other household appliances (non-cooking by definition), the third most frequent source of heat with 671,000 fires, were also less likely to be attended by fire departments, with a ratio of 32.6 unattended to attended fires. There were no attended fires recorded for electrical lighting and wiring fires, or other unspecified fires. On the other hand, fires originating in heating and cooling equipment (326,000 incidents) or a lit cigarette (167,000 incidents) were more likely to involve fire department attendance, with ratios of 6.2 and 13.5 unattended to attended fires, respectively. Fires involving open flame were also more likely to be fire department-attended, with 19.1 unattended fires per attended fire.

Table 6-7 displays the item first ignited in residential fires.

Table 6-7
Attended and Unattended Fires by Item First Ignited
(Thousands of Fires)

Item First Ignited	All Fires	Unattended Fires	Attended Fires	Ratio
Cooking materials	4,009	3,915	93	41.9
Appliance	690	690	-	-
Unspecified	660	660	-	-
Paper	417	407	10	40.8
Linen	361	361	-	-
Bedding	253	253	-	-
Electrical wire	244	244	1	422.0
Clothing	130	130	-	.
Cabinetry	110	72	39	1.8
Household utensils	96	96	-	-
Light vegetation	95	95	-	-
Decoration	73	73	-	-
Floor covering	64	64	-	-
Structural members	55	10	45	0.2
Other materials	172	107	65	1.6

Notes: See notes for Tables 6-1 and 6-2. *Other materials* include rubbish, heavy vegetation, a person burned by a fire or flame, upholstered furniture, animal, pipe, mattress, or wood. Note that none of these categories was associated with more than 45,000 fire incidents. Approximate CVs for fires in thousands: 150, 74.5 percent; 200, 70.0 percent; 400, 54.3 percent; 700, 37.2 percent; 4,000, 14.6 percent.

As shown in Table 6-7, the most frequent item first ignited was cooking materials, accounting for 4.0 million incidents, with 41.9 unattended fire incidents for each attended incident.[141] The second most frequent item first ignited in fires was an appliance,

[141]Item First Ignited refers to the fuel load that was ignited by the heat source and at least for a short time had the capability to sustain the fire. This produced some confusion among many survey respondents who specified the container or the heat source instead. For example, frequently in cooking fires, respondents mentioned the pan or pot on the stove as the item first ignited. This is impossible because metal cookware cannot ignite except at very high temperatures. We changed this to “cooking materials,” assuming that the respondent meant that the contents of the cookware had ignited. Other respondents specified the source of heat as the item first ignited, for example when they specified “appliance” as the item first ignited. Respondents may have believed that objects engulfed in flames were ignited. There is a more detailed discussion about the process for coding Item First Ignited in Chapter 7.

probably the cooking appliances in many cases. There were no fire department-attended fires for many categories including appliances, unspecified, linen, bedding, clothing, household utensils, and others. Of the Items First Ignited categories, only cabinetry, structural members (walls, floors, beams) and other materials were associated with a substantial proportion of attended fires relative to unattended fires.

Table 6-8
Attended and Unattended Fires by Time of Day
(Thousands of Fires)

Time Of Day	All Fires	Unattended Fires	Attended Fires	Ratio	Fires per Hour
6 am – noon	1,287	1,226	61	20.0	214.5
Noon – 5 pm	1,923	1,864	60	31.2	384.6
5 – 9 pm	2,827	2,766	61	45.0	706.8
9 pm – midnight	898	887	11	77.4	299.3
Midnight – 6 am	494	433	61	7.2	82.3

Notes: See notes for Tables 6-1 and 6-2. Time of Day includes the left endpoint but does not include the right endpoint. Time of Day was determined from two variables. Respondents were first asked what time the fire occurred. If they reported that they did not know, they were then asked if the fire occurred in one of the following periods, the morning, afternoon, evening, at night, or overnight. If they asked for further clarification, the Time of Day categories shown in Table 6-8 were read to them. Approximate CVs for fires in thousands: 400, 54.3 percent; 900, 28.9 percent; 1,000, 27.2 percent; 2,000, 22.1 percent; 3,000, 17.9 percent.

Table 6-8 shows most fires occurred between 5 pm and 9 pm, which is consistent with most fires in the survey being cooking related. To compare the distribution of fires, it is best to compare fires per hour rather than total fires in Table 6-8 because some time categories have more hours than other time categories. On an hourly basis, 5 pm to 9 pm had the highest hourly fire incidence followed by noon to 5 pm and 9 pm to midnight. Fires occurring between midnight and noon were less frequent on an hourly basis.

In terms of the ratio of unattended to attended fires, fires between noon and midnight were more likely to be unattended than fires between midnight and noon. Many of the fires later in the day were cooking fires, which previous tables have shown to involve fire department attendance less frequently than fires involving other heat sources and different areas of origin.

Fire Losses

The next set of tables contrasts fire department-unattended and attended fires by the extent of fire losses. In general, the tables show that fire departments were likely to have attended fires with greater fire losses.

Table 6-9
Attended and Unattended Fires by Extent of Flame Damage
(Thousands of Fires)

Flame Damage	All Fires	Unattended Fires	Attended Fires	Ratio
None	4,429	4,397	32	136.0
Item first ignited only	2,507	2,458	49	50.2
Several items	302	229	73	3.1
Whole room	81	36	45	0.8
Beyond room	39	-	39	-
Whole house	15	-	15	-
Outside house only	55	55	0	190.0

Notes: See notes for Tables 6-1 and 6-2. The table omits responses involving 1,000 fires where respondents did not know the extent of flame damage. Attended fires for *Outside house only* is greater than zero but rounded to zero. There were no reported unattended fires for *Beyond room* and *Whole house* categories. Approximate CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 2,500, 19.9 percent; 4,500, 13.1 percent.

Aside from the last row, Outside house only, Table 6-9 is arranged in order of increasing flame damage. Table 6-9 shows that as the extent of flame damage became larger, it was more likely that the incident was fire department-attended.

As shown in the table, most fires did not involve any flame damage or involved damage only to the item first ignited, and most were not attended by fire departments. When there was no flame damage, as was the case with 4.4 million fires, there were 136 unattended fires for each attended fire. When the damage was to the item first ignited only, which occurred in 2.5 million fires, there were 50.2 unattended fires to each attended fire. Damage to several items resulted in 3.1 unattended fires to every attended fire. When the damage involved the whole room, there were more attended fires than unattended fires; and when the damage spread outside the room or to the whole house, all fires were attended by fire departments.

Table 6-10
Attended and Unattended Fires by Extent of Smoke Damage
(Thousands of Fires)

Smoke Damage	All Fires	Unattended Fires	Attended Fires	Ratio
None	5,472	5,442	31	178.0
A little smoke damage	1,164	1,104	60	18.5
Damage in most of the room	338	314	23	13.5
Damage to another room	91	80	11	7.0
Damage in whole house	315	186	129	1.4
Outside of house only	48	47	0	164.0

Notes: See notes for Tables 6-1 and 6-2. Omits responses associated with 2,000 fires where respondents did not know or refused to provide information on the extent of smoke damage. *Outside of house only* attended fires was greater than zero but rounded to zero. Approximate CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 5,000, 11.8 percent.

Like Table 6-9, the extent of smoke damage is in ascending order in Table 6-10, with the exception of the last row. Table 6-10 shows that, like flame damage, most fires also involved no smoke damage or a small amount of smoke damage. Of the 7.4 million fires, almost 5.5 million had no smoke damage, and 1.2 million had what respondents reported to be "a little smoke damage." On the other hand, relatively few fires, under one-half million incidents, had smoke damage that spread to another room or the whole house.

Table 6-10 also shows that as smoke damage increased, the ratio of unattended fires to attended fires decreased, indicating more fire department presence was associated with fires with greater amounts of smoke damage. For example, when there was no smoke damage, there were 178 unattended fires for every attended fire. This decreased to 18.5 unattended fires for every attended fire (below the survey average of 28.2) for fires involving a little smoke damage, 13.5 when most of the room was damaged by smoke, and to 7.0 when another room was involved.

Table 6-11
Attended and Unattended Fires by Cost of Property Damage
(Thousands of Fires)

Property Loss	All Fires	Unattended Fires	Attended Fires	Ratio
None	3,819	3,810	9	407.0
$1-$99	2,212	2,182	30	72.4
$100-$999	844	834	10	83.6
Over $1000	303	109	194	0.6

Note: See notes for Tables 6-1 and 6-2. Also, respondents were asked to specify an estimate for property damage that would include the cost of repair or replacement of the home and contents. They were asked to include costs even if the costs were covered by insurance. The table omits responses associated with 251,000 fire incidents where the respondents did not know or refused to provide an estimate of the property damage. Approximate CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 800, 32.8 percent; 2,000, 22.1 percent; 4,000, 14.6 percent.

Table 6-11 shows that most residential fires had no reported property damage, and for these fires, almost all were not attended by the fire service. This pattern of almost no fire department attendance generally held true until the fire damage exceeded $1000, where there were more attended fires than unattended fires.

In 65,000 fire incidents, the conditions after the fire required families to stay out of the residence for one night or more. Of these, 9,600 fires were unattended and 55,000 were attended for a ratio of 0.2 unattended fires to attended fires; i.e., almost all such fires were attended by fire departments. In the remaining 7.4 million fires (7.2 million unattended and 199,000 attended), where the respondents could return immediately after the fire, the ratio was 35.9.

The last measure of fire losses is whether people were hurt or injured in the incident. There were an estimated 130,000 people who got sick or were injured in fires.[142] All the incidents where these fire losses occurred were reported to have been unattended by fire departments.

[142] Survey respondents reported in question 72 that somebody was hurt, got sick, or died in the fire in an estimated 180,000 fire incidents. When question 72 was answered positively, then the respondents were asked questions 74 and 76 about the number of deaths and injuries, respectively. There were no reported deaths in the answer to question 74, and there were an estimated 130,000 people reported to have been injured or sickened in the fire. It is likely that respondents may have changed their minds about several injuries or illnesses. Survey interviewers did not probe about the discrepancy. In any case, the relative standard error (or CV) is so large for an estimated 130,000 or 180,000 illnesses or injuries that the difference between 130,000 or 180,000 incidents is not statistically meaningful.

Smoke Alarms and Extinguishers

As noted in Chapter 4, most fire and non-fire households had smoke alarms. There were 6.5 million fires (6.3 million unattended and 239,000 attended) where there were smoke alarms present and 749,000 fires (734,000 unattended and 15,000 attended) in residences where there were no smoke alarms. The ratios were 26.4 unattended fires for each attended fire in residences with smoke alarms and 47.4 unattended fires for each attended fire where there were no smoke alarms present. In residences where smoke alarm were present, it was more likely that fires were attended rather than unattended, but such an effect may be due to other housing, demographic, or fire characteristics.

With respect to fire extinguishers, there were 4.7 million fires in residences with extinguishers, of which 4.6 million were unattended fires and 150,000 were attended fires. Households without extinguishers had 2.7 million incidents of which 2.6 million were unattended and 105,000 were attended. Households with extinguishers had 30.7 unattended fires per attended fire, while those households without extinguishers had 24.6 unattended fires per attended fire. This indicates the presence of extinguishers had at best a small effect in reducing the number of fire department-attended fires.

Conclusion

This chapter presented descriptions of the characteristics of the estimated 7.4 million fire department-attended and unattended fires from the Residential Fire Survey. Like Chapter 3, the analysis was based on the 14- and 21-day recall periods, scaled to estimate annual and per household fire incidence. Estimates in this chapter have more sampling variability than total fire estimates from Chapter 3, because they are based on partitions of the data, which result in smaller samples. As shown in the appendix to the chapter, the sampling variability, expressed as a percent of the estimate, decreases with increasing estimates. Estimates of less than one million fires have a coefficient of variation of at least 27 percent; estimates less than one-half million, 50 percent; and estimates of less than 250,000, about 66 percent.

In the chapter, it was shown that the largest number of fires was in the South, followed by the West, Northeast, and Midwest. Given how the regions were defined, the South had the largest population of households, and the Northeast and West had the lowest. On a per household basis, the West had the largest fire incidence at 9.09 fires per 100 households, followed by the South and Northeast, with the Midwest as the lowest. About twice as many fires occurred in owner occupied housing as renter occupied housing. This was expected because there was about twice as much owner occupied housing as renter occupied housing in the U.S. Correcting for the type of occupancy showed that there were 6.19 fires per 100 households for owner occupied housing and 7.58 fires per 100 households for renter occupied housing.

In terms of the ratio of unattended to attended fires, the pattern was the same as the per household basis by region. The West had the lowest ratio of unattended to attended fires (i.e., a larger proportion of fires were fire department-attended than in other regions), followed by the South and Northeast, with the Midwest as the highest. Although owner occupied housing had a smaller per capita fire incidence, there was a higher ratio of unattended to attended fires among renters than owners.

In urban regions, fires were three times more likely to be unattended than in non-urban regions. About twice as many fires occurred in single family residences than other types of residences. This was to be expected because more people live in single family homes than other types of residences. In single family home fires, there were 39.9 unattended fires per attended fire, while in non-single family housing there were 20.7 unattended fires per attended fire. As housing of all types aged, the ratio of unattended to attended fires decreased, indicating that there were relatively more attended fires in older housing. This ratio increased with income, indicating that lower income households had relatively more attended fires.

The per household fire incidence rate also was shown to increase with increasing household size. Households with one member had 3.2 fires per 100 households, two members 4.8 fires, and five and larger households 12.9 fires per 100 households. Households with a family member under 18 had 9.4 fires per 100 households in contrast to those without anyone under 18 at 4.9 fires per 100 households. Households with a family member 65 or older had 1.3 fires per 100 households in contrast to those without anybody 65 or older at 8.1 fires per 100 households.

There was no consistent pattern between the ratio of unattended to attended fires and household size, or whether the household had a family member under 18. However, households with at least one member 65 or older had 9.5 attended fires for every unattended fire in contrast to other households with 30.5 when all the household members were under the age of 65. Thus, there were fewer fires in households with older members, but when fires occurred, they were more likely to be fire department-attended.

By race and ethnicity characteristics, the fire rate was 4.6 fires per 100 households for households with a Black household head, 5.7 fires per 100 households for households with a White household head and 6.4 fires per 100 households for households with a Hispanic or Latino head of household. Also, households headed by Hispanic and Black persons had fewer unattended fires per attended fire than households headed by White persons.

Most fires (5.1 million -- both attended and unattended) began in the kitchen, and most fires (4.8 million) were cooking-related. These fires were less likely to be fire department-attended than other fires as there were 49.9 unattended cooking appliance fires per fire department-attended fire. Almost all cooking fires began in the kitchen. Fires starting in the living room and dining room, although much less frequent, were more likely to involve the fire department, as were fires involving cigarettes and other open flame heat sources. Heating and cooling equipment fires also were more likely to involve the fire department, as were fires starting in the basement, as well as fires involving cabinetry or structural materials.

By time of day, the most likely time for fires was between 5 pm and 9 pm, followed by noon to 5 pm. The period 5 pm to 9 pm also had the second highest ratio of unattended to attended fires, consistent with this time being the time that the evening meal is cooked. On the other hand, fires occurring between midnight and noon, while occurring less frequently on a per hour basis than other times of the day, had the lowest ratio of unattended to attended fires. Thus fires occurring between midnight and noon were relatively more likely to involve fire departments.

Most fires involved no loss or very small losses (although with so many fires, the total losses were not insignificant). According to respondents, most fires had no flame damage and no smoke damage. In these cases, with no reported damage or property loss, the ratio of fire department-unattended to attended incidents was quite high. For example, the ratio was 136.0 unattended to attended fires when there was no flame damage, 178.0 when there was no smoke damage, and 407.0 when there was no property loss. In contrast, when there was flame damage to several items or the whole room; smoke damage to most of the room, another room or the whole house; and property damage over $1000, the proportion of unattended to attended fires was much lower.

Most residences, as described in Chapter 4, had smoke alarms. Households with smoke alarms were more likely to have fire department-attended incidents than households without smoke alarms. For households with smoke alarms, there were 26.4 unattended fires per attended fire, while those without smoke alarms had 47.4 unattended fires per attended fire. This difference in the ratio of unattended to attended fires may be related to other household characteristics that differ in smoke alarm and non-smoke alarm households.

Households with fire extinguishers had 30.7 unattended fires to attended fires while, non-extinguisher households had 24.6 unattended fires to attended fires. Everything else being constant, extinguishers may be associated with a small reduction in the proportion of fire department-attended fires.

The findings of this chapter should be considered as associations between fires and other factors rather than causal relationships, because examining one factor at a time only can provide an overall characterization of incidents. The next chapter continues this examination in a more detailed way. In that chapter, fire incidents are analyzed by source of heat, i.e., appliance and non-appliance fires. Within the categories of appliance fires, cooking fires, electrical lighting and electrical wiring fires, heating and cooling appliance fires, and other household appliance fires are analyzed separately. Non-appliance fires include cigarette fires and small open flame fires. The next chapter also compares the number of various types of non-fire department-attended fires with the estimates from the 1984 survey.

Appendix to Chapter 6

Generalized Coefficient of Variation[143]

As mentioned in the text for this chapter, it is undesirable to put confidence intervals or coefficients of variations (CV) with each estimate in the text. However, reporting statistics without a measure of sampling error does not provide the reader with any sense of precision of the estimate. An approach to this is to provide a generalized coefficient of variation that can guide the reader about the approximate precision of any given estimate.

The CV is the standard error (standard deviation of the estimate) divided by the parameter estimate. When normal distribution theory holds, the 95 percent confidence interval for parameters such as means or proportions can be expressed as the

$$\text{Parameter Estimate} * (1 \pm 1.96 * \text{CV}/100) \qquad (1)$$

where the CV is a percent. Equation (1) shows that the variability around the parameter estimate is about twice the CV.

All other things being equal, the CV should decrease with increasing parameter estimates.

To estimate the relationship between the estimated number of fires and the CV, we randomly generated samples from the dataset of different sizes, ranging from 1.5 percent of the fire incidents to 85 percent of the incidents.[144] Only incidents in the 14/21-day recall period were used. Graphical analysis showed that the relationship was exponential, which could be linearized by using the log of the CV instead of the CV.

After transforming to the log of CV, the graphical analysis shows that from an estimated 1,000,000 fires to 6,500,000 fires, the graph was linear and very smooth (R^2 *adjusted*=0.9443). The equation for the CV estimated by the regression relationship was

$$\text{CV} = 33.4567 * exp(-0.0002081119 * \text{Fires}/1000) \qquad (2)$$

Selected values of the CV computed with equation (2) are shown in Table A3-1 below.

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[143] For more information on the generalized variance function see Wolter (1985), *op cit.,* Chapter 5.

[144] Sampling of cases and computation of estimated standard errors used the SAS® System (Proc Surveymeans and Proc MIAnalyze); similar to the approach as that used in Chapter 3. Graphical analysis and regression computations were made in the *R* language.

Table A3-1
Generalized Coefficients of Variation
(1,000,000-6,000,000 Fires)

Estimated Number of Fires (thousands)	Coefficient of Variation (percent)
1,000	27.2
1,500	24.5
2,000	22.1
2,500	19.9
3,000	17.9
3,500	16.1
4,000	14.6
4,500	13.1
5,000	11.8
5,500	10.7
6,000	9.6

For example, if the estimated number of fires was 3,000,000 (shown as 3,000 in Table A3-1), then the CV is 17.9 percent and the 95 percent confidence interval would be 1,946,000 - 4,054,000. To put it another way, the confidence interval would be plus or minus approximately 35.8 percent of the parameter estimate.

The equation fits best in the middle of the range. The values in Table A3-1 are most accurate in the middle of the table and less accurate at the lower or upper end.

A separate regression model was fitted to values from 200,000 to 1,000,000 fires. The fitted equation was

$$CV = 90.0531 * exp(-0.001262848 * Fires/1000) \qquad (3)$$

The fit was also good, with an R^2 *adjusted* value of 0.8896. Tabled values of equation (3) are below in Table A3-2.

Table A3-2
Generalized Coefficients of Variation
(150,000-950,000 Fires)

Estimated Number of Fires (thousands)	Coefficient of Variation (percent)
150	74.5
200	70.0
250	65.7
300	61.7
350	57.9
400	54.3
450	51.0
500	47.9
550	45.0
600	42.2
650	39.6
700	37.2
750	34.9
800	32.8
850	30.8
900	28.9
950	27.1

The variance and CV of parameter estimates from survey data depends on the number of cases, the weights associated with the cases, and the distribution of the values of the estimates within and between the strata. Two estimates that resulted in the same estimated number of fires could have different CVs because the number of fires between or within strata was different. However, the generalized CVs should provide the reader with an approximate value of the sampling variability of estimates of various sizes.

Chapter 7
Consumer Products Involved in Unattended Residential Fires

In Chapter 3, it was estimated that there were 7.43 million residential fires in the U.S., of which 7.18 million were not attended by the fire service. The estimated number of unattended fires was about one-third of the 22.9 million unattended residential structure fires estimated to have occurred in 1984 by the last residential fire survey. One question raised by the current survey estimates in Chapter 3 is why there has been such a steep decline in the number of residential fires, and in particular, unattended fires. To understand this decline, it is necessary to examine the nature of residential fires more closely. This examination was begun in Chapter 6, and continues in this chapter where the focus is on where in the residence the fire began and the consumer products that were involved in the fire.

A major objective of this chapter is to compare fires by type between the 1984 survey and the current survey. Some methodological issues with this comparison are discussed in the next section.

The analysis in this chapter, like in Chapters 3, 6, and 8, is based on fires rather than households. The source data for the fire estimates in this chapter are the low severity fire incidents that occurred during the 14-day recall period and the high severity incidents that occurred during the 21-day recall period. To facilitate comparison with the 1984 survey, only fire incidents reported not to have been attended by fire departments are used in this chapter. If all fire incidents had been used instead of only unattended incidents, the results would differ very slightly because of the small number of attended fires. Separate analyses for only attended fires are not recommended because the estimates from attended fires have large relative variances because of the small number of such incidents.

Following the methods section, the chapter begins with an overview of the origin and causes of residential fires as reported in the survey, including the room of origin, time of origin, types of equipment or appliances, item first ignited in the fire, and other characteristics. Then the chapter focuses on the major categories of equipment (or appliances) involved in residential fires, namely fires associated with cooking equipment, electrical wiring, and heating and cooling equipment. Fires not involving appliances, such as those associated with candle, match, lighter, and cigarette heat sources are then analyzed. The last section is a discussion and summary of the results. An appendix to this chapter provides more detail on the methods used in making comparisons between estimates from the current survey and the 1984 survey.

Methods

One objective of this chapter is to compare the fire estimates from the current survey with the estimates from the 1984 survey. By breaking down the estimates by fire origin, heat source, cause, and other factors, it is possible to develop some insight as to how the composition of unreported residential fires has changed in the 20 years between the surveys. However, this raises a problem because there is a major difference between the two surveys in the way that the data are analyzed. In the 1984 survey, even though a one-month recall period was used for estimating total attended and unattended fire incidence, data from the full three months were used for more detailed analyses. These included analyses of where fires started in the residence, the item first ignited, and other such breakdowns. The three-month estimates were then scaled to the totals from the one-month period, so that the total number of fires agreed with the one-month estimates.[145]

This then presents two options for the analysis of the current survey as follows:

- Option 1. Estimate consumer product-related fire incidence in the current survey using the 14/21-day recall period.
- Option 2. Estimate consumer product-related fire incidence in the current survey using the three-month period.

The estimates will be different in a predictable way. As shown in Chapter 3, incidents of greater severity are likely to be remembered for a longer time; consequently, estimates based on a three-month period are likely to contain more severe incidents than estimates based on a one-month period. The question then is how to make estimates with the current survey that most accurately represent 2004-2005 fire incidence and, at the same time, are comparable to the 1984 survey.

It turns out that no single estimate can be made that accomplishes both objectives. While using a 14/21-day recall period produces the best estimate of fires for the 2004 survey in Option 1, the distribution of types of incidents in the 14/21-day period is likely to be less severe than incidents in the full three-month period. The comparison then is likely to show a decline in severity from 1984 to 2004, which would only be an artifact of the analysis, not necessarily a real change over the 20 years. On the other hand, Option 2 avoids the problem with comparisons between surveys, but the fire estimates based on the three-month period are not accurate because they are too heavily weighted toward the higher severity incidents.

This chapter takes a middle position by presenting the estimates based on the 14/21-day recall period, but making between-survey comparisons with estimates based

[145] Audits and Surveys (1985), *op cit*., page 35. Although the incidents were reweighted in that survey to the annual totals estimated from the one-month recall period, the distribution of the types of fires is not affected by the reweighting. The authors do not explain the reason for their shift to the full three-month period, but it is likely that they were considering the larger sample size available from the three-month period that would reduce the variance of the estimates.

on the full three-month period scaled to the calendar year.[146] To avoid having two fire estimates for every category, when comparing with the 1984 survey, the difference is shown only in percentage terms, usually as a percentage decrease from the comparable 1984 fire estimate. There is more detail about this in the appendix in this chapter.

The tables in this chapter were developed by partitioning the non-fire department-attended fire incidents into various categories associated with the fire incident. Examples are area of fire origin, item first ignited, source of heat, etc. Tables include the estimated number of fires, the percentage distribution, and, when data were available from the 1984 survey, the percentage change in 2004 from 1984. SAS® data step programs were written to extract the cases and assign the categories. Tabulation of the estimated number of fires in each category was done using Proc Freq or Proc SQL in the SAS system.

Like the estimates for attended and unattended fires in Chapter 3, every estimated number of fires in this chapter and every ratio of unattended fires to attended fires have an associated standard error and confidence interval. To avoid cluttering the tables, these statistics are not presented in the tables. Instead the reader can get a sense of the precision of the estimate from the coefficient of variation (CV). As the estimated number of fires increases, the CV decreases. Tables relating the CV to the estimated number of fires and a description of how the tables were constructed are found in the appendix to Chapter 6.

Results

Overview

Table 7-1 shows the household locations where the unattended residential fires occurred.

[146] The annual estimate that was based on the full three-month recall period was 5.379 million fires. The weights were scaled by multiplying by 7.430/5.379 to reweight to the total number of fires estimated in Chapter 3, using the 14/21-day recall periods.

Table 7-1
Area of Fire Origin of Unattended Residential Fires
(Thousands of Fires)

Area of Fire Origin	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All locations	7,176	100.0	69.3
Kitchen	4,987	69.5	72.1
Living room	530	7.4	75.6
Bedroom	505	7.0	51.6
Bathroom	438	6.1	66.8
Other locations	716	10.0	33.8

Notes: Estimated number of fires and percents based on 14/21-day recall period projected to one year and to national estimates. Percentage decrease from 1984 survey is based on three-month recall period in both 2004 and 1984 surveys. See the Methods section and the appendix to this chapter for details. Totals may not add due to rounding. Other locations include basement (199,000 fires), dining room/dining area (140,000 fires), and the following categories with less than 100,000 estimated fire incidents: exterior of the house, siding, hall, garage or carport, porch or deck, inside the wall, laundry room, storage area, and roof. Estimated coefficients of variation (CV) for fires in thousands: 500, 47.9 percent; 700, 37.2 percent. See the appendix to Chapter 6 for details about the computations of the estimated CV.

Table 7-1 shows that almost 70 percent of the unattended fires began in the kitchen. The living room, bedroom, and bathroom areas accounted for 7.4, 7.0, and 6.1 percent respectively. Finally, the other locations accounted for 10.0 percent of the incidents.

Most, but not all, fires that started in the kitchen (4.5 million or 91 percent of the 4.987 million fires in Table 7-1) were cooking related.[147] Electrical lighting or wiring accounted for 31 percent of living room fires and 44 percent of bedroom fires. A lit cigarette was associated with 11 percent of living room fires and 6 percent of bedroom fires.

The table shows an overall 69.3 percent decrease in residential fires not attended by the fire service from the 1984 survey. The largest category of fires, kitchen fires, showed a decrease of 72.1 percent. By itself, this decrease accounts for a large proportion of the decrease in the total number of fires between the two surveys. Fires originating in the living room decreased the most by 75.6 percent. Smaller decreases were observed in fires originating in the bathroom, bedroom, and other locations.

[147] Most cooking-related fires began in the kitchen, and most kitchen fires involved cooking. A small number of cooking fires began outside the kitchen, and a small number of non-cooking fires began in the kitchen.

The 1984 survey did not report on the number of fires that were associated with smoking materials, but there were occasional references to smoking materials in that survey; for example, 25.6 percent of the bedroom fires (estimated 308,500 fires) were smoking related.[148] The comparable estimate from the present survey shows a 70.2 percent decrease in smoking-related bedroom fires.

Table 7-2 presents an overall description of the fires by source of heat. The percentage decrease from the 1984 survey for fires involving heat sources other than appliances, such as cigarettes and open flame incidents, is not shown in this table because the numbers of those types of fires were not presented in the 1984 report.

[148] In the 1984 survey, smoking-material related fires were estimated from the response to the question "What provided the heat that started the fire?" The response indicating smoking materials was "Smoking Materials—Cigarettes, Cigars, Pipe Tobacco." See Audits and Surveys (1985), *op cit.,* pages 35-36.

Table 7-2
Source of Heat for Unattended Residential Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All heat sources	7,176	100.0	69.3
Cooking appliances	4,664	65.0	63.3
Open flame	744	10.4	
Other household appliances	651	9.1	84.4
Electrical lighting and wiring	616	8.6	51.7
Heating and cooling equipment	281	3.9	69.5
Cigarettes	155	2.2	
Other heat sources	64	0.9	

Notes: See notes for Table 7-1. Cooking appliances include stoves, toasters, coffee makers, and parts such as wiring and plugs. Open flame includes matches, lighters, torches and candles. Other household appliances include TVs, washer-dryers, irons, hair dryers, power tools, and refrigerators. Electrical lighting and wiring includes lamp cords, extension cords, fuses, light bulbs, and fixtures. Heating and cooling equipment includes furnaces, fireplaces, central and room air conditioners, space heaters, and water heaters. Something else includes fires started by lightning. Other heat sources include fires starting elsewhere and spreading to the house and fires started by lightning. Estimates from the 1984 survey were used for the percentage decrease from 1984. Comparable fire estimates from the 1984 survey were available only for Cooking appliances, Other household appliances, Electrical lighting and wiring, and Heating and cooling equipment. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 600, 42.2 percent; 5,000, 11.8 percent. See the appendix to Chapter 6 for details.

Table 7-2 shows that 4.66 million fires involved cooking appliances. This was almost two-thirds of all estimated unattended fire incidents. The second largest category was open flame (candles, matches, lighters, torches) at 744,000 incidents, followed by other household appliances at 651,000, and electrical lighting and wiring at 616,000 incidents.

In comparing the number of appliance fires with the 1984 survey, there was a smaller decline in cooking appliance-related fires than all fires. Electrical lighting and wiring-related fires also decreased less than the overall fire percentage, and other household appliances-related fires decreased by a greater amount.

Table 7-3 shows the item first ignited. Item first ignited was derived from two questions in the survey that were answered as free text. Question 17a was, “Now please think of the items that caught on fire. Which item caught fire first?” Question 17 was

"What other items caught fire?" An attempt was made to reconstruct the NFIRS definition of item first ignited which is defined as "… the first object ignited by the heat source that had sufficient volume or heat intensity to extend to uncontrolled or self-perpetuating fire."[149] Responses in the two free text fields were analyzed and edited, when necessary, to come as close as possible to this definition.

One problem involved separating item first ignited from the appliance or the heat source. For example, when "stove" was reported as both the heat source and item first ignited, the more likely item first ignited was "cooking materials." Also "cooking materials" was substituted for "pot," when pot was reported as the item first ignited. Again, although many people would think that the pot or the stove caught fire, it was more likely to be the contents of the pot.

Another problem involved appliances. When an appliance was named by respondents both as the source of heat and item first ignited, but a component part could have caught fire, "appliance casing or housing" was coded. Examples include the hood over a stove, wiring inside or connecting an appliance to electrical power, the burner on a stove, the inside liner of the microwave oven, the electrical elements in a coffee maker, the inside of a water heater, wiring in a vacuum cleaner, etc.

In some cases, the coding was more straightforward. Paper was coded when the data indicated bags, match boxes, napkins, newspaper, etc. Linen included towels and potholders. Bedding was sheets, pillow cases, and blankets. Electrical wire included circuit boards, sockets, plugs, and wires (not attached to an appliance). Clothing was selected to identify wearing apparel either on or not on a person. Light vegetation included grass, plants, and leaves. Household utensils were bowls, containers, plates, and pots in the rare cases when pots were the item first ignited, but the pots were not used for cooking at the time. Cabinetry included furniture such as tables, desks, drawers, bookcases, but excluded chairs and appliances. Floor coverings included carpets. Heavy vegetation included trees. Decorations were ornaments or accessories such as pictures. Human and animal indicated where the heat source made contact with a person or an animal before other items. Structural members included framing, walls, roofs, siding, and trim.

Finally, none or unspecified was coded when not enough information was provided to determine if the fire had spread from the original heat source to some other object. Responses so coded included "ceiling fan caused smoke," "the wire in the lamp," and "washer just smoking."

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[149] United States Fire Administration (2003), "NFIRS 5.0 Complete Reference Guide." Emmitsburg, MD, pages 4-18.

Table 7-3
Item First Ignited in Unattended Residential Fires
(Thousands of Fires)

Item First Ignited	Number of Fires	Percent
All fires	7,176	100.0
Cooking materials	3,915	54.6
Appliance casing or housing	690	9.6
None or unspecified	660	9.2
Paper	407	5.7
Linen	361	5.0
Bedding	253	3.5
Electrical wire	244	3.4
Clothing	130	1.8
Household utensils	96	1.3
Light vegetation	95	1.3
Other items	325	4.5

Notes: See notes for Table 7-1. *Other items* include the following in descending order of frequency: cabinetry, floor covering, heavy vegetation, person or animal, rubbish, and structural members. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 400, 54.3 percent; 700, 37.2 percent; 4,000, 14.6 percent. Items with estimated numbers of fires under 90,000 are included in *Other items* and are not presented on separate lines. Because of the difficulties in interpreting the survey responses to the questions associated with Items First Ignited, as discussed in the text, some responses may not be reliable.

In Table 7-3, the largest category was cooking materials at 3.9 million fires or 54.6 percent of the total. This result is consistent with cooking fires as the most frequent type of fire incident. Some other items listed in the table such as appliance casing or housing, linen, and clothing can be ignited by cooking equipment. Appliance casing or housing, none or unspecified (no item mentioned), paper, linen, bedding, electrical wire, and clothing were the remaining categories with appreciable estimated numbers of incidents.

An estimated 130,000 people were injured or got sick in these incidents; approximately one injury or illness for every 56 fires. Of these, 102,000 illnesses or injuries were associated with cooking fires and 27,000 were associated with open flame fires.[150] About half the illnesses or injuries in cooking fires involved cooking materials (food, cooking oil, or grease). When asked what type of medical attention was required, the largest response category was no medical attention (97,000 illnesses/injuries), and the

[150] The respondent(s) did not specify the type of open flame. It was not a candle, match, lighter, torch or spark from fireplace.

second largest was first aid received at the scene (32,000 illnesses/injuries). The most frequent type of injury was burns (101,000 illnesses/injuries), followed by other, unspecified (28,000).[151]

Respondents were asked if they had to stay somewhere other than their residence for a night or more because of the fire. There were an estimated 9,600 fires where this occurred. In these incidents, the residents returned within a week. All of these were cooking-related fires.

Table 7-4 below shows the average and total dollar value of property loss by heat source. These fires involved an estimated total damage to buildings and contents of $612 million.

[151] The injury and illness estimates above are based on very small sample sizes and, as a result, have CVs that are at least 75 percent. Also, in the introduction to Chapter 6, it was pointed out that low probability events are unlikely to be captured when there are small sample sizes. This does not mean that low probability events such as serious injuries and hospitalization do not occur in fires, just that they were not captured in the data.

Table 7-4
Average and Total Dollar Value of Property Loss
by Heat Source for Unattended Residential Fires
(Thousands of Fires)

Heat Source	Number of Fires	Average Loss Per Fire ($)	Total Loss (Million $)
All heat sources	7,176	85.32	612.2
Cooking appliances	4,664	70.30	327.9
Open flame	744	25.79	19.2
Other household appliances	651	242.58	157.9
Electrical lighting and wiring	616	70.30	43.3
Heating and cooling equipment	281	180.94	50.8
Cigarettes	155	16.95	2.6
Other heat sources	64	48.83	3.1

Notes: See notes for Table 7-1. Definitions of heat sources are found in the notes for Table 7-2. Dollar loss is direct loss per fire, as reported in the survey, including expenses for repairing the residence and replacement of the contents of damaged areas. Property loss was not reported for an estimated 240,000 fires. Average damage is based on records reporting property loss; total loss is computed from the number of fires and the average loss per fire. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 600, 42.2 percent; 4,500, 13.1 percent.

The largest category of total dollar loss involved cooking appliances, at $327.9 million, with an average loss of $70.30 per incident. The loss attributed to cooking fires represented more than half the total estimated loss from all unattended fires.

By individual incident, the costliest types of incidents involved other household appliances with an average cost per fire of $242.58 (total loss $157.9 million), heating and cooling equipment at $180.94 per fire (total of $50.8 million), and something else at $179.99 per fire ($3.1 million).[152] Fires involving appliances tended to be more costly on average than other types of fires because the cost may have included repair or replacement of the appliance. Note that cigarette and open flame incidents had the lowest reported property damage per incident at $16.95 and $25.79 per incident, collectively accounting for almost $22 million or 4 percent of estimated total fire losses.

Household Appliance/Equipment Fires -- An Overview

[152] There is more detail on other household appliances in Table 7-16 and Table 7-17.

As shown in Table 7-2, the source of heat for most fires was cooking appliances. In the analysis of fire data, fire incidents are often separated into those involving appliances or equipment and those where the heat source was not an appliance.[153] In Table 7-5, appliances included the following categories: cooking appliances, electrical lighting or wiring, another household appliance, and heating or cooling equipment. Non-appliances included various open flame sources (as described in Table 7-2) and lit cigarettes, lightning, and unspecified.

Collectively, appliances were involved in 6.2 million fire incidents, accounting for 86.6 percent of all unattended residential fires. By type of area, 84.7 percent of fires in urban areas (4.9 million fires) involved appliances, while in non-urban areas 94.7 percent (1.3 million fires) involved appliances. In detached single family homes, 81.8 percent of the fires (3.8 million fires) involved appliances, while in other types of residences, 95.0 percent of the fires (2.4 million fires) involved appliances.

Between 1984 and 2004, the estimated number of appliance fires not attended by the fire service decreased by 65.3 percent, and non-appliance fires decreased by 84.0 percent.[154] As the largest component of non-appliance fires were those started by cigarettes and small open flames, this decline in non-appliance fires probably reflects the decrease in smoking-related incidents.

Table 7-5 records the estimated number of unattended residential appliance fires and non-appliance fires by time of day when they occurred.

[153] Appliance and Equipment are used in this text as synonyms. The National Fire Incident Reporting System (NFIRS) uses the term equipment and does not use the term appliance, but in keeping with the 1984 survey and more widespread usage, the term appliance is usually used in this report.
[154] Appliance and non-appliance fires are from the 1984 report in Audits and Surveys (1985), Table 6-2. Tabulations of non-appliance fires were not further broken down into smoking materials, open flame, etc. in the 1984 survey, so those comparisons cannot be made with the present survey.

Table 7-5
Time of Fire Occurrence of Unattended Residential Fires
By Appliance and Non-appliance Fires
(Thousands of Fires)

Time of Day[155]	All	Number of Fires Appliance	Non-appliance
All times	7,176	6,212	964
6 am – noon	1,226	1,147	79
Noon – 5 pm	1,864	1,544	320
5 – 9 pm	2,766	2,408	358
9 pm – midnight	887	696	190
Midnight – 6 am	433	417	17

Note: Notes: See notes for Table 7-1. Also, Time of Day includes the left but not the right endpoint, e.g., fires occurring at noon are in the *Noon – 5 pm* time period. The table excludes equipment classified as other (0.2 percent of incidents). Appliance fires include cooking appliances, heating and air-conditioning equipment, electrical lighting or wiring, and other household appliances. Non-appliance fires include all other categories. Estimated CVs for fires in thousands: 200, 70.0 percent; 400, 54.3 percent; 700, 37.2 percent; 1,000, 27.2 percent; 1,500, 24.5 percent; 2,500, 19.9 percent; 3,000, 17.9 percent.

Table 7-5 shows that most appliance fires (38.1 percent) and most non-appliance fires (37.1 percent) occurred between 5 and 9 pm. The highest hourly fire incidence rate was also in that period, at 1,648 appliance fires per hour and 24 non-appliance fires per hour.[156] The next highest hourly rate was 845 appliance fires per hour between noon and 5 pm.

Table 7-6 shows item first ignited by appliance and non-appliance fires.

[155] The time categories shown in the table were selected because the survey offered respondents a choice of specifying the actual time of the incident, or if they were unable to recall the time, the time periods in the table.

[156] Note that each part of the day in the table may contain a different number of hours. For example, the periods *6 am – Noon* and *Midnight – 6 am* each include 6 hours, *Noon – 5 pm* has 5 hours, etc. To compare rates with different numbers of hours, hourly rates were calculated by dividing the number of fires by the product of the number of hours in the period and the number of days in the year (365.25). The time categories were taken from the survey instrument. For more details, see Table 6-8, in Chapter 6 and the text following that table.

Table 7-6
Item First Ignited in Unattended Residential Fires
by Appliance and Non-appliance Fires
(Thousands of Fires)

Item	Appliance Fires Number	Appliance Fires Percent	Non-appliance Fires Number	Non-appliance Fires Percent
All	6,212	100.0	964	100.0
Cooking materials	3,879	62.5	-	-
Appliance case	649	10.4	-	-
None	483	7.8	177	18.4
Linen	318	5.1	-	-
Electrical wire	244	3.9	-	-
Paper	219	3.5	188	19.5
Bedding	179	2.9	-	-
Household utensils	92	1.5	-	-
Light vegetation	-	0.0	92	9.6
Other	149	2.4	503	52.2

Notes: See notes for Table 7-1. Items first ignited with estimated numbers of fires fewer than 90,000 are shown collectively in the *Other* category.[157] Dashes in the table indicate estimated number of fires under 90,000. Items first ignited for Appliance-*Other* fires include clothing and floor coverings. Items first ignited for Non-appliance-*Other* Fires include bedding, decorations, cabinetry, heavy vegetation, clothing, and other items. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 600, 42.2 percent; 4,000, 14.6 percent.

The distribution of items first ignited by appliance and non-appliance fires are very different. As cooking fires were the largest category of appliance fires, it is not surprising that cooking materials represented the largest category of item first ignited with 3.9 million fires (62.5 percent) where an appliance was the heat source. These are followed by appliance case (housing and casing) at 649,000 fires (10.4 percent) which were also probably largely cooking related. No item first ignited reported (483,000 fires or 7.8 percent), linen (mostly kitchen towels, pot holders, etc. at 318,000 or 5.1 percent), paper (219,000 fires or 3.5 percent), electrical wiring (244,000 fires or 3.9 percent), and bedding (179,000 fires or 2.9 percent) constitute almost all the remaining items. For fires that had non-appliance heat sources, paper was the largest category of item first ignited at 188,000 fires or 19.5 percent, followed by no item reported (177,000 fires or 18.4 percent), and light vegetation (92,000 fires or 9.6 percent).

[157] Excluding detailed estimates with fewer than 90,000 fires will not be consistently used in this chapter, but is being used with item first ignited, because it appears that the question may not have been answered reliably by many respondents. See the discussion following Table 7-3.

The next sections contain analyses on the four main categories of fires with appliances as heat sources as follows: cooking fires, electrical wiring fires, heating and cooling equipment fires, and other household appliance fires.

Cooking Fires

Table 7-7 shows the types of cooking appliances involved in residential fires.

Table 7-7
Cooking Appliances Involved in Unattended Residential Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All cooking appliances	4,664	100.0	63.3
Stove/Range (all power types)	3,789	81.2	61.4
Electric	2,596	55.7	
Gas	1,131	24.2	
Other	62	1.3	
Microwave oven	332	7.1	
Toaster oven, toaster	208	4.5	69.0
Outdoor grill	124	2.7	
Coffeemaker, teapot	68	1.5	85.3
Countertop oven	48	1.0	
Other cooking appliance	42	0.9	
Unspecified	52	1.1	

Note: See notes for Table 7-1. Also, *Unspecified* includes fires where the respondent identified the heat source as "other appliance" and "don't know" and those who indicated that the fire involved a cooking appliance but did not answer the question to specify the appliance. The category *Stove/Range* includes electric, gas and other powered stoves. *Gas* includes the responses "gas, type unknown," "natural gas," and "propane." *Other* power sources for *Stove/Range* include wood, charcoal, and fuel oil, and the response "other." Percentage decreases are only presented for the categories reported in the 1984 survey. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 1,000, 27.2 percent; 2,500, 19.9 percent; 4,000, 14.6 percent.

Table 7-7 shows that stoves (including both the top burners and the oven unit), accounted for the largest amount of fire department-unattended cooking appliance-related fires at 3.8 million fires (81.2 percent). Electric stoves were involved in 55.7 percent of the incidents and gas stoves were involved in 24.2 percent of the cooking appliance fires.

According to the American Housing Survey in 2005, 61 percent of households used electricity as their cooking fuel and 39 percent used gas.[158] This would indicate about 3.8 stove fires per 100 households with electric stoves per year and 2.6 stove fires per 100 households with gas stoves per year. This is about a 47 percent higher unattended fire risk factor for electric stoves. The risk factor for attended fires computed from official statistics also shows a 47 percent increased risk factor for electric stoves as compared with gas. Interestingly, the official statistics show that the risk of civilian injury due to electric stoves was 118 percent higher and property damage was 133 percent higher. However, the risk of fire deaths for gas stoves was 15 percent higher.[159]

Cooking appliance-related unattended fires decreased 63.3 percent between 1984 and 2004, a slightly smaller decrease than all fires.[160] There was a similar decrease in stove-related fires and toaster oven-related fires. Coffee and teapot fires decreased the most by 85.3 percent. The 1984 survey reported the number of fires associated with some other cooking appliances, such as deep fryers and frying pans. For 2004 there were too few fires involving these cooking appliances to show in Table 7-7; however, the estimated number of fires decreased by 92.0 and 95.5 percent, respectively.

In the 2004 survey, 71.5 percent of cooking appliance fires involved electric appliances and 23.1 percent involved gas (natural gas, propane, butane, or type of gas unspecified). In comparison with the 1984 survey, there was a 57.6 percent decrease in electrically powered cooking appliance fires since 1984 and a 68.6 percent decrease in gas appliance-related fires.[161]

Table 7-8 shows that most of the cooking-related fires involved food, cooking oil, or grease catching on fire. This type of incident accounted for 83.2 percent of the cooking-related fires or 3.9 million fires. Also, 289,000 fires involved linens (6.2 percent), mostly dish towels, pot holders, and tablecloths. The remaining items first ignited that accounted for more than 90,000 fires were no item first reported (126,000 fires and 2.7 percent), and paper (95,000 fires and 2 percent). Items with small estimated numbers of fires are shown in the Other line. These included household utensils such as plastic spoons and containers, clothing, appliance housings or casings, bedding, and light vegetation. Collectively they accounted for 275,000 fires and about 5.9 percent of the total.

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[158] U.S. Census Bureau (2006b), Current Housing Reports, Series H150/05, *American Housing Survey for the United States: 2005.* U.S. Government Printing Office, Washington, DC, 20401, Table 1A-5, page 6.
[159] Hall JR Jr. (2005), *op cit.*,, page 8, and Table 8, page 27. Also, Smith L, Monticone R, and Gillum B (1999), "Range Fires: Characteristics Reported in National Fire Data and a CPSC Special Study." U.S. Consumer Product Safety Commission, Washington, DC.
[160] Cooking fires in 1984 from Audits and Surveys (1985), *op cit*. All cooking fires from Table 6-4, page 38. Appliance detail from Table 6-5, page 39.
[161] In 1984, 66.6 percent of cooking appliance fires used electric power and 28.9 percent used gas. See Audits and Surveys (1985), *op cit*., page 41.

Table 7-8
Item First Ignited in Unattended Residential Cooking Fires
(Thousands of Fires)

Item First Ignited	Number of Fires	Percent
All	4,664	100.0
Cooking materials	3,879	83.2
Linen	289	6.2
No item reported	126	2.7
Paper	95	2.0
Other	275	5.9

Notes: See notes for Table 7-1. *Other* includes clothing, household utensils, appliance housing or casing, bedding, and light vegetation. Estimated CVs for fires in thousands: 150, 74.5; 300, 61.7; 4,000, 4.6.

When asked if the cooking appliance was working properly before the fire, in 98.7 percent of the incidents, respondents said that the appliance was working properly. The only appliances with substantially lower percentages of incidents where the appliance was said to be working properly before the fire were coffeemakers and teapots, which were said to have worked properly in 65.3 percent of the incidents where they were the heat source. No comparable statistics were reported for the 1984 survey, either for all cooking fires or coffeemaker/teapot fires. [162] In the 1984 survey, equipment failure was associated with the fire in 59.2 percent of the toaster fire incidents and 47.2 percent of the toaster oven fires. In contrast, in the 2004 survey, there were no reported toaster or toaster oven incidents where the appliances were reported as not working properly before the fire.

The next three tables display the consequences of fire department-unattended cooking fires. Tables 7-9 and 7-10 show the number of fires by flame and smoke damage categories. Table 7-11 presents an estimate of the amount of property damage by type of cooking fire. All of these tables depart from the usual format of comparing with the 1984 survey because damage and injury estimates were not presented in that survey.

[162] Audits and Surveys (1985), *op cit.,* page 41. As the structure of the questions in the two surveys was not identical, comparisons may be difficult. Question 19 in the 1984 survey asked, "In your opinion what caused the fire? Was it … 1. Equipment or product failure, 2. Human carelessness, 3. Children playing with fire, 4. Something else (specify):" The 2004 survey asked, "Did the source of heat that started the fire seem to be working properly just before the fire?" There were no questions in the 2004 survey asking if human carelessness caused the fire.

Table 7-9
Extent of Flame Damage Associated with
Unattended Residential Cooking Appliance Fires
(Thousands of Fires)

Source of Heat	All Incidents	No Flame Damage	Confined to One Item	Several Items
All cooking appliances	4,664	2,867	1,630	166
Stove/Range	3,788	2,398	1,275	115
Electric	2,596	1,734	825	37
Gas	1,131	602	451	78
Other	62	62	0	0
Microwave oven	332	190	136	6
Toaster oven, toaster	208	137	71	0
Coffeemaker, teapot	68	0	24	45
Countertop oven	48	33	15	0
Outdoor grill	124	37	87	0
Other appliance	42	42	0	0
Unspecified	52	30	22	0

Notes: See notes for Table 7-1. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 450, 51.0 percent; 600, 42.2 percent; 1,000, 27.2 percent; 2,500, 19.9 percent; 4,000 14.6 percent.

Table 7-9 shows that for fire department-unattended cooking fires, in general, the amount of flame damage was small. For example, an estimated 166,000 fire incidents (3.6 percent) resulted in flame damage beyond the original item where the fire started; the other items had either no flame damage or damage to a single item, typically the appliance itself. For all stoves and ranges, 97.0 percent of the incidents had no flame damage or damage was confined to a single item, while 115,000 incidents had damage that spread beyond a single item. Only coffeemakers and teapots showed a sizeable proportion of incidents involving flame damage beyond the original item (45,000 of 68,000 incidents or 65.3 percent).

Table 7-10 shows the extent of smoke damage associated with fire department-unattended cooking fires.

Table 7-10
Extent of Smoke Damage Associated with
Unattended Residential Cooking Appliance Fires
(Thousands of Fires)

Source of Heat	All Incidents	No Smoke Damage	Little Damage or Only Room of Origin	Smoke Damage to Other Rooms or Whole House
All cooking appliances	4,664	3,564	907	191
Stove/Range	3,788	2,880	721	188
Electric	2,596	1,920	487	188
Gas	1,131	897	233	0
Other	62	62	0	0
Microwave oven	332	303	24	3
Toaster oven, toaster	208	176	32	0
Coffeemaker, teapot	68	23	45	0
Countertop oven	48	48	0	0
Outdoor grill	124	124	0	0
Other appliances	42	9	34	0
Unspecified	52	1	52	0

Notes: See notes for Table 7-1. Also, for *Microwave oven*, the column All Incidents includes an estimated 2,400 fires where the smoke damage was not specified. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 500, 47.9 percent; 700, 37.2 percent; 1,000, 27.2 percent; 2,000, 22.1 percent; 3,000, 17.9 percent; 4,000, 14.6 percent.

Like flame damage, the amount of smoke damage per fire tended to be low. An estimated 191,000 cooking fires (4.1 percent) involved smoke damage beyond the room where the fire started. There was almost no smoke damage beyond the room of origin for fires involving appliances other than stoves.

Table 7-11
Estimated Property Damage Associated with
Unattended Residential Cooking Appliance Fires
(Thousands of Fires)

Source of Heat	All	None	$1-$9	$10-$99	Over $100
All cooking appliances	4,664	2,810	408	954	352
Stove/Range	3,788	2,414	359	679	202
Electric	2,596	1,723	259	386	119
Gas	1,131	633	95	293	84
Other	62	57	5	0	0
Microwave oven	332	100	49	59	125
Toaster oven, toaster	208	138	0	69	0
Coffeemaker, teapot	68	0	0	68	0
Countertop oven	48	48	0	0	0
Outdoor grill	124	68	0	57	0
Other appliance	42	13	0	0	24
Unspecified	52	30	0	22	1

Note: See notes for Table 7-1. Also, the All category and subtotals include some estimated fires where the respondent did not know or refused to state the amount of property damage. These estimates do not appear in other columns These were as follows: *Electric stoves*, 119,000 fires; *Gas stoves*, 25,000 fires; *Other appliances* 6,000 fires; and *Toaster oven, toaster* < 1000 fires. Estimated CVs for fires in thousands: 150, 74.5; 300, 61.7; 600, 42.2; 1,000, 27.2; 1,500 24.5; 2,500 19.9; 4,000, 14.6.

Table 7-11 shows that an estimated 2.8 million cooking fires (60.2 percent) had no reported financial loss from property damage and most cooking fires had little loss. For ranges and stoves, for example, there were an estimated 881,000 fires (23.3 percent) with property damage of $10 or more, while 63.7 percent had no reported property damage. An estimated 202,000 range or stove fires had estimated property damage of $100 or more. Also, of note in this table is the high proportion of microwave oven fires with property damage over $100. Respondents were not asked to detail the types of property damage leading to the estimate, but for microwave ovens, some of the cost probably involved replacement or repair of the appliance.

The 1984 survey also presented property loss estimates for selected kitchen appliances. For fires associated with ranges and ovens, 70.7 percent had no property damage.[163] However, it is difficult to compare non-zero dollar losses between the two periods without correcting for inflation.

Few cooking-related fires were serious enough to require people to leave the residence. There were an estimated 9,600 fires, comprised of 5,700 range or oven fires and 3,300 microwave oven fires and 600 toaster oven fires, in which respondents reported leaving the residence. All respondents who were forced to leave reported that they were able to return home in less than a week.

Also, relatively few cooking-related fires involved injuries. There were an estimated 102,000 people injured in these incidents. Seventy-two percent of the injured victims had burns and the remaining 28 percent reported their injuries as "other" (i.e., not a burn, smoke inhalation, a laceration, bruise, or fracture.) Twenty-eight percent of victims required medical treatment, and that treatment was described as having received first aid at the scene. No victims were hospitalized.

Electrical Lighting and Wiring Fires

At 616,000 estimated fires, electrical lighting and wiring fires ranked fourth in the number of unattended fire incidents. Table 7-12 shows the distribution of the estimated unattended fires by type of lighting and wiring appliance.

[163] Audits and Surveys (1985), *op cit.,* page 42.

Table 7-12
Electrical Lighting and Wiring Equipment Involved
in Unattended Residential Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All lighting and wiring	616	100.0	51.7
Light fixture	140	22.7	45.4
Lamp and light bulb	68	11.1	
Fuse, circuit breaker panel	62	10.0	83.2
Cord (unspecified)	57	9.3	
Other installed wiring	48	7.8	36.3
Other lighting and wiring	43	7.0	
Lamp cord	36	5.8	
Extension cord	5	0.8	90.6
Unspecified	157	25.5	

Notes: See notes for Table 7-1. Estimated CVs for fires in thousands: 150, 74.5 percent; 600, 42.2 percent.

Aside from the Unspecified category, Table 7-12 shows that the largest number of electrical lighting and wiring fires was associated with light fixtures, at 140,000 fires or 22.7 percent of the total. Lamp and light bulb related incidents accounted for 68,000 fires and 11.1 percent of the total. Wiring accounted for about 146,000 fires. Wiring fires included 57,000 fires associated with cords (unspecified), 48,000 fires from other installed wiring, 36,000 incidents that were lamp cord fires, and 5,000 fires involving extension cords. Some of the fires reported in the category of other lighting and wiring may have also involved wiring.

Also, Table 7-12 shows that electrical lighting and wiring fires decreased by 51.7 percent from the 1984 survey, where there were an estimated 864,000 incidents.[164] The largest percentage drop occurred in fuse and circuit breaker panel fires at 83.2 percent and extension cord fires at 90.6 percent. Light fixture-related fires with a decrease of 45.4 percent and other installed wiring-related fires at 36.3 percent did not decrease as much as all fires.

[164] Audits and Surveys (1985), *op cit.*, page 45. The percentage decreases are based on the comparable estimate of 438,000 fires. See the appendix to this chapter for the description of the methodology used in comparing between the surveys.

Table 7-13 presents the distribution of items first ignited in fire department-unattended electrical fires.

Table 7-13
Item First Ignited in Unattended Residential Electrical Fires
(Thousands of Fires)

Item	Number of Fires	Percent
All lighting and wiring fires	616	100.0
Bedding	149	24.1
No item reported	137	22.3
Electrical wiring	130	21.1
Other	200	32.5

Notes: See notes for Table 7-1. The *Other* category includes appliance housings and casings, paper, and linens. Estimated CVs for fires in thousands: 150, 74.5 percent; 600, 42.2 percent.

An estimated 24.1 percent of the items first ignited were bedding (sheets, pillows, bedclothes), accounting for about 149,000 fires. Respondents did not specify the item first ignited in 22.3 percent of incidents, or 137,000 fires, possibly indicating that nothing was ignited except the heat source itself. Electrical wiring and the Other category (appliance casings, paper, and linens), accounted for the rest of the items first ignited in electrical fires.

Respondents said that the electrical lighting and wiring equipment was working properly before the fire in an estimated 553,000 fires or 89.7 percent of the incidents. The equipment most frequently mentioned as not working properly before the fire was Cord (unspecified), accounting for an estimated 57,000 fire incidents.

Of the 616,000 electrical lighting and wiring fires, respondents reported no flame damage occurred in 488,000 fires (79.2 percent). Of the remaining 127,000 fires, flame damage was confined to the first item ignited. In an estimated 458,000 fires (74.5 percent), respondents reported no smoke damage at all. In the remaining 158,000 incidents, respondents were unable to describe how much smoke damage had occurred, if any.

In 270,000 incidents (43.8 percent), respondents indicated that property damage resulting from the fire was $10 or less. In 97,000 fires (16 percent), damage was between $10 and $99, and in 237,000 fires (38.5 percent), the damage exceeded $100. The last category, for damage over $100, included an estimated 85,000 light fixtures fires; 72,000 fires where the respondent did not know the specific wiring or lighting source of the incident; 43,000 incidents involving other wiring or lighting; and 37,000 incidents involving fuses, circuit breakers, and panel boards.

There were no injuries reported to have resulted from electrical lighting and wiring fire incidents.

Heating and Cooling Appliance Fires

Heating and cooling appliances were involved in an estimated 281,000 fires, about 4 percent of all fire department-unattended incidents, ranking immediately after electrical lighting and wiring fires in the total number of appliance fire incidents. Table 7-14 shows the distribution of the number of fires by the type of equipment.

Table 7-14
Heating and Cooling Appliances Involved in Unattended Residential Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All heating and cooling	281	100.0	69.5
Central and fixed heating	85	30.1	73.0
Fixed local heating equipment	84	30.1	
Central heating furnace	-	-	
Portable heater	97	34.5	71.7
Heating stove	10	3.6	
Unspecified	89	31.8	
Water heater	-	-	69.4
Fireplace	-	-	99.4

Notes: See notes for Table 7-1. The *Unspecified* category includes the responses “don’t know,” “refused,” and “other heating and cooling appliances.” The 1984 survey estimates for totals were from Audits and Surveys, Inc., *op cit.,* (1985, Table 6-3, page 37) except for air conditioning which was in Table 6-13, page 49. Some of the detailed estimates from the 1984 survey were in Table 6-12, page 48. The 1984 survey separates heating from cooling equipment, which is no longer possible because of equipment such as heat pumps that provide both residential heating and cooling. There were an estimated 200 fires involving central heating furnaces (shown as “-”, otherwise it would need to be shown as 0.2). There were no fires involving water heaters or fireplaces during the 14/21-day recall period, but there were fires during the three-month period, which were used to compute the percentage decrease. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent.

Of the estimated 281,000 unattended heating and cooling fires, the largest category was associated with portable heaters at 97,000 fires, accounting for 34.5 percent of the total incidents. Central and fixed heating equipment-related incidents collectively represented 85,000 incidents (30.1 percent), of which less than 1,000 incidents were associated with central heating. There were no incidents involving air conditioners, fireplaces, or installed water heaters. Respondents did not specify the type of heating equipment in an estimated 89,000 incidents.

In comparing with the 1984 survey, overall heating and cooling equipment-related incidents decreased 69.5 percent from the estimated 675,000 incidents in 1984.[165] This was about the same decrease observed for all equipment types. In both the present survey and the 1984 survey, portable heaters accounted for the largest number of heating and cooling equipment-related fires.[166]

In the incidents involving equipment attached to a chimney or vent, all the incidents involved the equipment itself, not the chimney or vent. All the portable heaters were powered by electricity. Respondents indicated that most of the fixed local heater incidents involved either "other" fuel or "gas (type unknown)."[167] Respondents said that the equipment was the main source of heat in their homes for less than 1,000 of the 281,000 fire incidents. All equipment was said to be working properly before the fire.

Item first ignited in unattended heating and cooling equipment-related fires is shown in table 7-15.

[165] See notes for Table 7-14.
[166] Audits and Surveys (1985), *op cit.*, page 47, Table 6-12.
[167] The survey question was, "What kind of fuel/source of power did it use?" The individual's response was then recorded verbatim, without presenting the individual with a list of likely fuel/power types.

Table 7-15
Item First Ignited in Unattended Residential
Heating and Cooling Equipment Fires
(Thousands of Fires)

Item	Number of Fires	Percent
All heating and cooling	281	100.0
Electrical wire	114	40.5
Appliance	80	28.6
Other	87	30.9

Notes: See notes for Table 7-1. *Other* includes paper, no item first ignited reported, household utensils, and linens. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent.

Heating and cooling equipment fires ignited electrical wire, possibly attached to the appliance itself, in 114,000 fires (40.5 percent) and other parts of the appliance itself in 80,000 fires (28.6 percent). The remaining items first ignited were paper, household utensils, and linens. All fires where the items first ignited were appliances and household utensils involved fixed heating and cooling equipment such as central and fixed heating, water heaters, fireplaces, and stoves. When the item first ignited was specified, portable heater fires involved only electrical wire as the item first ignited.

Flame damage was reported as “none” in an estimated 194,000 incidents (69 percent). Only fires associated with portable heaters were reported to have had flame damage spreading to several items (30,000 estimated incidents). An estimated 57,000 incidents involved flame damage confined to the first item ignited. In 219,000 incidents (78 percent), there was no smoke damage reported. Of the remaining 61,000 incidents, there was little smoke damage or the smoke damage was confined to the room of origin. No property damage was reported in 193,000 incidents (69 percent). Damage was reported as between $10 and $100 in 30,000 incidents (11 percent) and over $100 in 57,000 incidents (20 percent).

There were less than 200 injuries estimated to have occurred in heating and cooling equipment-related fire incidents.

Other Household Appliances

Table 7-16 shows the estimated number of fires associated with other household appliances. This category ranked third as the heat source in unattended fires, behind cooking appliances and open flames, with an estimated 651,000 fires or 9 percent of the total unattended fires. This was an 84.4 percent decrease from the 1984 survey where an estimated 2.03 million fires involved other household appliances.[168]

Table 7-16
Sources of Heat for Other Household Appliances Involved
in Unattended Residential Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All other household appliances	651	100.0	84.4
Personal grooming equipment	234	35.9	
Home office equipment	90	13.8	33.4
Clothes washer	75	11.5	89.6
Humidifier	70	10.8	
Iron	60	9.2	89.4
Refrigerator or freezer	37	5.7	77.9
Home entertainment	23	3.6	95.2
Unspecified	62	9.5	

Notes: See notes for Table 7-1. Also, *Unspecified* includes the responses “don’t know” and “other household appliances.” Estimated CVs for fires in thousands: 150, 74.5 percent; 250, 65.7 percent; 650, 42.2 percent.

The largest number of fires involved personal grooming appliances such as hair dryers, curling irons, etc. These appliances were associated with an estimated 234,000 fires, more than one-third of the other household appliance-related incidents. There were 90,000 fires involving home office equipment (personal computers, printers, faxes, etc.), accounting for 13.8 percent of incidents; clothes washers involved 75,000 fires (11.5 percent), and humidifiers involved 70,000 fires (10.8 percent).

[168] Audits and Surveys (1985), *op cit*., page 37, Table 6-3. In the 1984 survey, other appliances (TVs, radios, dryers, washers, and tools) accounted for 1,891,000 fires and air conditioning and refrigeration accounted for 143,000 fires.

Fire incidents involving other household appliances declined 84.4 percent between the two surveys, a larger decline than the 69.3 percent decline for unattended fires in general. The decrease in the number of fires in home entertainment equipment, clothes washers, irons, refrigerator/freezers, clothes dryers, vacuum cleaners, and power tools contributed to the decline. The single category not following this trend was home office equipment where the reduction was about one-third. The lower decline might have been a result of the proliferation of personal computers and other office equipment in residences.

Table 7-17 shows the distribution of items first ignited in the other appliance fires.

Table 7-17
Item First Ignited in Unattended
Residential Fires Involving Other Appliances
(Thousands of Fires)

Item	Number of Fires	Percent
All	651	100.0
Appliance casing	406	62.4
No item reported	185	28.4
Floor covering	60	9.2

Notes: See notes for Table 7-1. Estimated CVs for fires in thousands: 150, 74.5 percent; 400, 54.3 percent; 650, 42.2 percent.

Table 7-17 shows that in most of the incidents, the item first ignited was the appliance itself. Floor coverings, primarily rugs, were the items first ignited in 9.2 percent of the incidents, representing 60,000 fires.

All appliances described in Table 7-17 were powered by electricity. In all the incidents, the survey respondents reported that the appliances had been working properly before the fire.

In 484,000 incidents (74 percent), there was no flame damage, while in the remaining 167,000 incidents; the flame damage was confined to the item that was ignited first or the appliance itself. The incidents with flame damage were approximately equally divided among fires involving personal grooming equipment, irons, and the “don’t know” category.

Smoke damage estimates were similar. In 506,000 incidents (78 percent), there was no smoke damage; in 70,000 incidents (11 percent), the smoke damage was confined to the room of origin; and in 74,000 incidents (11 percent), the smoke damage spread to another room or area. Only fires involving clothes washers and humidifiers produced smoke damage to the room of origin or to another room.

In 561,000 incidents (86 percent), there was some property damage. No property damage was reported for 90,000 incidents (14 percent). Property damage was between $1 and $100 in 365,000 incidents (56 percent). Property damage over $100 was reported for 196,000 incidents (30 percent). Fires involving home entertainment systems, refrigerators or freezers, and clothes washers had property damage of $100.

There were no injuries reported in any of these incidents.

Cigarette and Small Open Flame Fires[169]

Table 7-18 shows the distribution of heat sources for cigarette and small open flame fires. The table does not show the percentage decrease from the 1984 survey because that survey did not report on the number of fires associated with cigarette and small open flame heat sources.

[169] This is the first and only detailed section on non-appliance fires in this chapter. In addition to the cigarette and small open flame heat sources, there were an estimated 47,000 fires that began outside the house and spread to the house and 17,000 fires where the heat source was not specified. Neither of these categories had a sufficient estimated number of fires to warrant more detailed breakdowns in the chapter.

Table 7-18
Unattended Residential Cigarette
and Small Open Flame Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent
All small open flame and cigarettes	900	100.0
Candle	465	51.6
Cigarette	155	17.2
Lighter	140	15.6
Match	84	9.4
Other open flame	55	6.1

Notes: See notes for Table 7-1. Also, *Other open flame* includes torch, spark from fireplace, and other unspecified open flame sources. Estimated CVs for fires in thousands: 150, 74.5 percent; 450, 51.0 percent; 900, 28.9 percent.

Table 7-18 shows that the largest proportion of incidents, slightly more than half at 465,000, involved candles. Lighters and cigarettes accounted collectively for almost 300,000 fires, while matches were the source of heat in 84,000 incidents.

Children under 10 started an estimated 35,000 small open flame and cigarette fires (3.8 percent). No incidents were started by children under 5. An estimated 30,000 fires involved lighters and the remainder involved other open flames including torches, matches, and unspecified heat sources.

Table 7-19 shows the distribution of item first ignited in unattended cigarette and small open flame-related fires.

Table 7-19
Item First Ignited in Unattended Residential
Cigarette and Small Open Flame Fires
(Thousands of Fires)

Item	Number of Fires	Percent
All cigarettes	155	100.0
Bedding	74	47.7
Other	81	52.3
All open flame	744	100.0
Paper	169	22.7
No item reported	161	21.7
Decoration	73	9.8
Cabinetry	72	9.6
Other	270	36.3

Notes: See notes for Table 7-1. The category *Other*, under *All cigarettes*, includes heavy vegetation, paper, rubbish, and floor coverings. The category *Other*, under *All open flame*, includes light vegetation, clothing, linens, appliance casings, cooking materials, and other items. Estimated CVs for fires in thousands: 150, 74.5 percent; 400, 54.3 percent; 700, 37.2 percent.

Table 7-19 shows cigarette fires and small open flame fires separately because the patterns of items first ignited are different for the different types of heat sources.

For fires involving cigarettes as the heat source, the largest single category of item first ignited was bedding at 74,000 incidents (47.7 percent). In incidents where the heat sources involved open flame, the largest single category of item first ignited was paper, at 169,000 incidents, accounting for 22.7 percent of the open flame incidents, followed by no item reported at an estimated 161,000 incidents.

In the 465,000 estimated candle fires, there was no reported flame damage in 156,000 fires, the flame damage was confined to the first item ignited in 240,000 fires, the flame damage involved several items in 33,000 fires, and the whole room in 36,000 fires. There was no smoke damage in 356,000 candle fires, a little smoke damage in 72,000 candle fires, and smoke damage in the room of origin in 36,000 candle fires. In 246,000 candle fires, there was no reported dollar amount of property damage. In 67,000 incidents, damage was $100 or more, damage was between $10 and $99 in 52,000 incidents, and between $1 and $9 in 69,000 incidents.

With respect to fires associated with lighters, for an estimated 127,000 fires, survey respondents reported that there was no flame damage. In the remaining incidents, 13,000 fires, the flame damage involved only the item first ignited. None of the lighter fires produced any smoke damage. Also, most fire incidents, 127,000, did not result in any property damage, although 3,000 fires had estimated losses between $1 and $9 and 10,000 fires had losses between $10 and $99.

Cigarette-related fires had no flame damage in one-third of the incidents (52,000 fires), flame damage to only the item first ignited in 100,000 fires, and flame damage to several items in 3,000 fires. Smoke damage was split almost 50-50 between none (80,000 incidents) and to the room of origin (75,000 incidents). More than two-thirds of the incidents, 106,000 fires, had no reported dollar loss from the fire, while for 17,000 incidents, reported dollar losses were greater than $100, 17,000 reported losses between $10 and $99, and 15,000 incidents involved losses under $10.

Incidents involving matches resulted in flame damage to the first item ignited and no smoke damage in all 84,000 incidents. No property damage was reported in 29,000 incidents (34 percent), and respondents did not know the amount of damage in the remaining incidents. For incidents involving other open flame heat sources, no flame damage was reported in 29,000 of the 55,000 incidents, damage to the first item in 23,000 incidents, and to the outside of the house in 3,000 incidents (fires starting outside the house). There was no smoke damage in 31,000 incidents, a little smoke damage in 23,000 incidents, and damage to the outside of the house in 1,000 incidents. Property damage was reported as none for an estimated 9,000 fires, $1-9 for 3,000 fires, and $10-99 for 42,000 fires.

Three percent of the incidents (27,000) involved injuries. In 24,000 of these incidents, no medical attention was required, while in 3,000 incidents, first aid at the scene was required. All the injuries were burns. In these injury incidents, 24,000 fires were started with matches, while in the remaining 3,000 incidents, a lighter was the heat source.

Conclusion

The analysis in this chapter used the same methodology as that used in Chapters 3 and 6, by using low severity incidents in the 14-day recall period and high severity incidents in the 21-day recall period and then scaling to a calendar year.

The only departure from this methodology was when comparing the estimated number of fires with the estimates in the 1984 survey. Similar to the 1984 survey, the comparison statistics used the entire three-month recall period, scaled to the total number of fires from the 14/21-day recall period. As pointed out earlier in this chapter and as fully developed in Chapter 3, there is evidence that survey respondents tend to remember incidents of greater severity longer than incidents with less severity. As a result, the data from the three-month recall period in either survey is weighted toward more serious incidents than would be found in a general sample of fires.

Because the three-month recall period is weighted toward more serious incidents, neither survey used the three-month recall period for making estimates of annual fire incidence. However, the 1984 survey used the three-month period for analysis of the types of fires. The reasoning for that choice of period was not stated in their report, but it was probably motivated by the need to obtain an adequate sample size for the more detailed analyses. In order to compare the results from the two surveys, it is necessary to use data from the current survey covering the same period. Otherwise, everything else being equal, comparing a 14/21-day survey to a three-month survey, the 14/21-day survey would show, on average, less severe fires and lower fire losses. In order to avoid that apparent artifactual decline in severity, it was necessary to develop a second set of estimates in the current survey based on the three-month period but scaled to the calendar year. This was essentially the same procedure used for the 1984 survey, and the estimates should then be comparable. These three-month estimates are used only for computing the percentage change in fire incidents. The estimated number of fires based on the three-month recall period using the current survey does not appear anywhere in the chapter.

Using these comparable three-month estimates in this chapter, it was estimated that there was a 69.3 percent decrease in the number of fire department-unattended fires between 1984 and 2004. The decrease in the number of cooking appliance-related fires was slightly less, at 63.3 percent. However, as cooking fires represent about two-thirds of the incidents, the decline in cooking fires explains a large part of the decrease in total incidents.

Other household appliance fires declined 84.4 percent, and heating and cooling equipment fires declined 69.0 percent. Electrical lighting and wiring fires did not decline as much, at 51.7 percent of the 1984 incidents. Because the 1984 survey did not present estimates of fires associated with smoking materials and open flames, it is not possible to calculate the decrease in the number of fires; but it seems likely that the decrease was at least as large as the overall decrease of 69.3 percent, and perhaps considerably more. One clue is that the 1984 survey presented estimates for the number of non-appliance fires, a category that included smoking and small open flame fires. Using that estimate, it was possible to show that there was an 84.0 percent decrease in non-appliance fires. Some of that decrease was undoubtedly due to decreases in smoking and small open flame fires, which in turn were likely to be related to decreases in smoking in the population.

Similar to the 1984 survey, most of the 7.2 million fires that were not attended by fire departments occurred in kitchens and most involved cooking appliances. Unattended fires resulted in an estimated 130,000 injuries, most frequently burns. Most injuries did not require medical attention; for those that did, first aid at the scene was the most frequently reported treatment. In 9,600 incidents, residents had to leave the home for a night or more because of the fire but in all cases were able to return within a week. The

7.2 million incidents resulted in an estimated $612 million in property damage and loss from the fire.

About 81 percent of the 4.7 million cooking appliance-related fires involved ranges or stoves, with about twice as many electric range fires as gas range fires. As there are more electric stoves in use in the population, such a result was not unexpected. Correcting for the number of stoves by fuel type, the fire risk factors were estimated at 3.8 electric stove fires per 100 households and 2.6 gas stove fires per 100 households. It is worth noting that the increased fire risk associated with electric stoves is consistent with official statistics on fire department-attended fires. Official statistics also show that electric stove fires have a higher risk of injury and property loss but a lower risk of death.

After range fires, microwave ovens accounted for 7.1 percent of the cooking appliance fires; and toaster oven fires accounted for 4.5 percent of these incidents. The most frequently mentioned item first ignited was cooking materials (foodstuffs, grease, etc.) at 83.2 percent of the incidents, with linens (dish towels, pot holders, table cloths) second at 6.2 percent. The estimated total dollar loss from cooking fires was $328 million.

After cooking appliances, open flame and cigarette fires were the next largest category, accounting for an estimated 900,000 incidents. With open flame fires, paper was the most frequently mentioned item first ignited, while cigarette fires most frequently ignited bedding. Cigarette fires involved $2.6 million in property loss, while open flame incidents involved $19 million. The average loss in these incidents was the lowest of all the heat source categories.

There were 651,000 household appliance fires, involving $158 million in property damage. Appliances such as dishwashers, clothes washers and dryers, TVs, home entertainment equipment, computers, and home office equipment averaged $243 per incident in losses, the largest average loss per fire. Household appliance fires decreased 84.4 percent from the 1984 survey, the largest percentage decrease among the different types of equipment involved in fires. This finding is noteworthy because there are many more of household appliances in the home now than there were in 1984.

Electrical lighting and wiring fires accounted for 616,000 incidents and $43 million in fire losses. There was a 51.7 percent decrease in the number of incidents between the two surveys, the smallest percentage decrease observed among different categories of equipment. Heating and cooling equipment fires involved 281,000 incidents and $51 million in losses. There was a 69.5 percent decrease in the number of incidents from the 1984 survey, just about the same percentage as all incidents.

To conclude, numerically, the largest drop in fire department-unattended fires between the two surveys was in fires associated with cooking equipment. There were over 12,000,000 fire department-unattended cooking equipment related-fires in 1984, which was more than the total number of fire department-unattended fires in the 2004 survey. In percentage terms, non-appliance fires decreased almost 84 percent from 2004, almost 20 percentage points more than appliance fires. The 1984 survey did not present estimates for the number of cigarette fires, but there is a strong possibility that much of that decline in these types of fires was associated with decreases in the number of cigarette fires, which in turn was probably associated with decreases in the number of smokers over the last 20 years.

Appendix to Chapter 7

Calculation of the Percentage Change Between the 2004 Survey and the 1984 Survey

Several tables in this chapter show the percentage changes in the estimated number of unattended fires between the current survey and the 1984 survey. As mentioned in the text, estimates of the number of equipment specific fires in the 1984 survey used a different procedure than the estimate for total fires. The purpose of this appendix is to describe the methodology and the similar methodology used in the 2004 survey that was used to compare estimates.

The key difference from the 1984 survey was that the estimate of total fires in that survey was based on a one-month recall period, but the estimate of equipment specific fires was based on a three-month recall period. To take into account that respondents may have forgotten incidents occurring earlier in the recall period, the authors of the 1984 survey scaled the incidents to the total estimated from the one-month period. This corrects for some forgotten incidents but it does not take into account the problem that incidents of lesser severity are less likely to be recalled. As a result, the mixture of types of fires over a three-month period is likely to have fires of greater severity than those in the one-month period.

As a result, comparing equipment specific fires in the 1984 survey with those in the 2004 survey based on the 14/21-day recall period would be likely to show a decrease in incident severity. That decrease would be an artifact of two different recall periods, not necessarily a true decrease in severity.

The solution used in this chapter was to compare estimates calculated in the same way. The comparable estimates from the 2004 survey were calculated by using the full three-month period, but scaling to the total based on the 14/21 day recall period. However, this creates two estimates for every category, one estimate based on the 14/21-day recall period, believed to be the most accurate, and the other based on the three-month period, the most comparable. To avoid confusing the reader with two different sets of fire estimates, the comparable estimate is used only to compute the percentage change between the 1984 and 2004 survey. The comparable estimates are not shown in this chapter.

The percentage change between the two surveys is computed as follows:

Pct Change = 100 * (1 – 2004 survey estimate/1984 survey estimate)

where the 2004 survey estimate is computed on the basis of the full three-month period, scaled to the 2004 annual estimates from the 14/21-day recall period analysis.

The example below shows how some of the percentage changes were computed in Table 7-2 in the chapter.

Table 7A-1
Changes in Selected Appliance Categories

Equipment	2004 Best Estimate	2004 Comparable Estimate	1984 Survey Estimate	Percent Change from 1984 Survey
All fires	7,176	6,854	22,322	69.3
Cooking appliances	4,664	4,533	12,344	63.3
Other household appliances	651	316	2,034	84.4
Electrical lighting and wiring	616	430	890	51.7
Heating and cooling	281	233	763	69.5

Column 2 in Table 7A-1 (2004 Best Estimate) shows the estimated number of fires appearing in Table 7-2 in the text. These were computed using the 14/21-day recall period scaled to the calendar year. The next column (2004 Comparable Estimate) shows the 2004 estimates that were comparable to the 1984 survey. The 2004 Comparable Estimate does not appear anywhere in the chapter, to avoid confusing the reader with estimates that are believed to be less accurate. It is used only to calculate the Percent Change that appears in chapter tables.

Chapter 8
Operation and Effectiveness of Smoke Alarms and Fire Extinguishers

Having characterized fire households and residential fires in previous chapters, this chapter investigates how residents became aware of fires and how these fires were extinguished. This involves examining the role of smoke alarms and fire extinguishers in residential fires.

As shown in Chapter 5, smoke alarms have become almost universal in homes, with an estimated 96.7 percent of U.S. households having at least one smoke alarm.[170] This is a substantial increase from the mid-1970s where alarm prevalence was about 20 percent, 62 percent of households in 1984, and 84 percent in the mid-1990s.[171] As many have noted, smoke alarms are an inexpensive method of providing early warning in residential fires. This can translate into saving lives and preventing injuries. According to the NFPA, the death rate in fire department-attended home structure fires was twice as high in homes fires where no smoke alarm was present as compared with home fires where an alarm was present.[172]

This chapter explores two issues about smoke alarms. After looking at how residents became aware of a fire, including because of an alarm sounding, the chapter then characterizes how alarms operated in various fire scenarios. The benefits from smoke alarm operation follow in increasing order:

- The smoke alarm sounds
- The smoke alarm alerts household members to the fire
- When the alarm sounds, it provides the only alert of the fire

If the alarm alerted people at the same time as some other event, such as a household member smelling smoke, the alarm may have provided a benefit by confirming the existence of the fire. If the alarm provided the only alert of the fire, then the alarm is of even greater benefit by providing an earlier warning of the fire. This can allow household members to put their escape plans into action earlier or apply some other strategy.

The second issue about alarms concerns the reasons why alarms did not operate during residential fires. This first requires determining if enough smoke reached the alarm so that it should have operated. After establishing that the alarm should have operated, according to the survey respondent, the remaining focus is on the condition of

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[170] This was 96.8 percent of non-fire households and 92.7 percent of fire households.

[171] Ahrens M (2007b), *op cit.* Ballesteros M, Kresnow MJ, (2007), "Prevalence of Residential Smoke Alarms and Fire Escape Plans in the U.S: Results from the Second Injury Control and Risk Survey (ICARIS-2)," *Public Health Reports*, Vol. 122, pp. 224-231. Audits and Surveys (1985), *op cit.,* page 53. Market Facts (1993), "Smoke Detector Operability Study Final Report," Washington, DC, page 7. Smith CL (1994), "Smoke Detector Operability Survey, Report on Findings," U.S. Consumer Product Safety Commission, Bethesda, MD.

[172] Ahrens (2007b), *op cit.,* page 18.

the alarm, including the respondent's perception of whether the alarm was in working order and when it was last tested.

The chapter then addresses how the fire was put out and the usage of fire extinguishers, especially focusing on whether the extinguishers operated when residents tried to use them. Different from smoke alarms, the use of fire extinguishers to fight fires is controversial because such actions might cause occupants to delay leaving the residence.[173]

Following a brief description of the methods, the chapter then begins with an overview of how residents were alerted to the fire (smoke alarms), and how the fire was put out (fire extinguishers). Specific types of fires are then considered in subsequent sections. The chapter concludes with a discussion section.

Methods

Like the previous two chapters and Chapter 3, the unit of analysis in this chapter is fires using the annual fire incidence rates based on the 14- and 21-day recall periods. From the analysis in Chapter 3, this involves an estimated 7.43 million fires, of which 254,000 were attended by fire services and 7.18 million were unattended.

For the most part, the analyses in the chapter use the percentage of total incidents, rather than percentages conditional on some other factor. For example, when considering if a smoke alarm alerted people to a fire, the percent of such cases is computed as the estimated number of incidents where the alarm alerted people divided by the estimated total fire incidents. In order for an alarm to have alerted people, a number of events must have occurred as follows: someone was home, there was an installed smoke alarm, the alarm was in working order, enough smoke must have reached the alarm, the alarm sounded, and someone heard it. Thus, the percent of such cases is an estimate for the joint probability that all these events occurred. Another type of computation is the conditional probability of an alarm alerting someone given that someone was home and the alarm sounded. This would be computed from the estimated number of fire incidents where the alarm alerted people divided by the estimated number of fire incidents where people were home, an alarm was present, and the alarm sounded.

This report presents the first computation, because that represents the overall benefit of the alarm. Readers who prefer the second computation will find enough information in the tables to estimate those probabilities.

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[173] According to the NFPA, "… A portable fire extinguisher can save lives and property by putting out a small fire or containing it until the fire department arrives; but portable extinguishers have limitations. Because fire grows and spreads so rapidly, the number one priority for residents is to get out safely…" From the fact sheet on fire extinguishers: http://www.nfpa.org/itemDetail.asp?categoryID=277&itemID=18264&URL=Research%20&%20Reports/Fact%20sheets/Fire%20protection%20equipment/Fire%20extinguishers

The tables in this chapter look different from the other tables in this report because, for the most part, they contain only percentages. This is to facilitate comparisons of smoke alarm and extinguisher operation for different types of fires, (e.g., attended or unattended fires, kitchen or living room fires, etc.). Every table presents the estimated total number of fires, allowing the reader to reconstruct the estimated number of fires in any particular table cell, if desired.

Different from the last two chapters, the tables in this chapter do not contain coefficients of variation (CV). As shown in the appendix to Chapter 6, the CV is inversely proportional to the estimated number of fires. Estimates of appropriate CVs are available from the tables in the appendix to Chapter 6 after the percentages are converted to the estimated number of fires.

The survey questionnaire requested information on the respondents' fire losses, some of which were presented in earlier chapters. These include information on injuries, time away from home, lost time from work, flame damage, smoke damage, and dollar value of property damage. It is tempting to try to relate the fire losses to how the smoke alarm or fire extinguisher operated during the incident. Everything else being constant, one would think that incidents in which the alarm operated would have fewer fire losses than in those fires where the alarm did not operate. However, everything cannot be held constant. In particular, smoke alarm operation and use of an extinguisher may indicate a more serious fire than when the alarm did not operate and when the extinguisher was not needed. Because of this, Chapter 8 does not relate alarm operation or extinguisher operation to fire losses, and such an analysis is discouraged.[174]

Each section in this chapter presents estimates in a series of five tables. The first three tables contain information on smoke alarms. These are as follows:

Method of Discovery of the Fire
Smoke Alarm Operation
Reasons for Non-operating Smoke Alarms

The remaining two tables address extinguishers. These are as follows:

How the Fire Was Extinguished
Location and Use of the Fire Extinguisher

These sets of tables are presented for a number of different scenarios. The first set of tables includes all fire incidents, contrasting between fire department-attended and unattended incidents. All the remaining tables in the chapter are for unattended fires only. The next set of tables is by the area of fire origin (where the fire began), followed

[174] It is also problematical to relate the presence of smoke alarms to fire losses. First, most of the residences in the survey had smoke alarms, resulting in a small sample size and imprecise estimates for fires in residences without smoke alarms. Second, residences that do not have smoke alarms may be different from those that do in ways that are related to the type of fire and fire damage. Thus, the presence of smoke alarms and fire extinguishers may be a proxy for some other variable associated with fires.

by heat source (appliance fires first and non-appliance fires second), then finally by the different smoke alarm configurations in residences.

As in previous chapters, all computations were made using the SAS® software system. Unless otherwise noted, the data are based on the 14- and 21-day recall periods developed in Chapter 3. Missing dates are imputed using the multiple imputation procedure from Chapter 3. All the cases are weighted by the appropriate sampling weights to provide national level annual estimates. When it is desirable in this chapter to compare results with the 1984 survey, estimates are made based on the full three-month recall period scaled to the annual estimates based on the 14/21-day totals in the same way as was done in Chapter 6. The text notes when estimates are based on the three-month period.

Results

Overview: All Incidents

This section considers all fire incidents, examining smoke alarm and extinguisher performance in fire department-attended and unattended incidents. As shown in Chapter 6, more than two-thirds of fire incidents began in the kitchen. As a result, the estimates in summary tables are dominated by cooking fires. Later tables in the chapter contrast smoke alarm and extinguisher use in cooking and non-cooking fire incidents.

Table 8-1 presents the method of discovery for all fires, unattended fires, and attended fires.

Table 8-1
Method of Discovery by Attended and Unattended Fires
(Percent of Fires)

Method of Discovery	All Fires	Unattended Fires	Attended Fires
Nobody home	4.0	2.8	38.9
Person present at fire origin	22.7	23.2	8.9
Other evidence of fire			
Smelled smoke	18.2	18.9	-
Saw flames	16.0	16.6	-
Saw smoke	14.3	14.0	23.7
Heard fire	3.1	3.2	-
Felt heat	1.7	1.8	-
Smoke alarm alerted people	11.8	11.8	12.5
Someone else provided an alert	3.6	3.8	-
Something else provided an alert	1.3	0.8	15.7
Estimated number of fires (thousands)	*7,430*	*7,176*	*254*

Notes: Multiple responses were permitted to the survey questions about how residents discovered a fire. The table omits responses associated with a small number of incidents where the respondent said they did not know or refused to answer how the fire was discovered; in general, the "refused" and "don't know" responses are not included in tables. When respondents reported nobody was at home, no further questions were posed to them about the fire incident. Detail lines may not sum to 100 percent due to rounding, multiple responses, or omission of "refused" and "don't know" responses. Estimated percentages are based on the total number of fires shown in the last row of the table, i.e., 7.43 million, 7.176 million unattended fires and 254,000 attended fires. Dashes (-) indicate estimates of 0 (zero) percent from the data, but the dashes indicate that the population percent may be greater than zero.

Table 8-1 describes how people discovered that there was a fire. In that table, for the estimated 7.4 million residential fires, nobody was home in 4.0 percent of incidents; thus, someone was at home in the other 96.0 percent of incidents. When nobody was home, it would have been impossible for respondents to answer the remaining questions about whether the alarm sounded, what alerted them to the fire, etc. Consequently, when the survey respondent indicated that nobody was home when the fire started, questions about the alarm sounding and notifying residents were skipped. Thus, it is possible that fires where nobody was home had sounding alarms, or even alarms that alerted neighbors or bystanders.

In Table 8-1, the responses about method of discovery of the fire were very different for fire department-attended and unattended fires. Nobody was home in 38.9 percent of fire department-attended fires in contrast to nobody home in 2.8 percent of unattended fires. Fires that started when nobody was home were qualitatively different from fires started with a resident at home. For example, when someone was home at the time of the fire, 66.5 percent of the fire incidents involved a cooking appliance, 8.6 percent involved electrical lighting or electrical wiring, 8.6 percent involved another household appliance, 5.6 percent involved a candle and 3.2 percent involved heating or cooling equipment. In contrast, when nobody was home when the fire started, 32.7 percent involved heating or cooling equipment, 22.7 percent involved a candle, 20.3 percent involved another household appliance, and 5.7 percent involved cooking appliances. Similar differences might also be expected in the room of fire origin and the item first ignited.

As shown Table 8-1, in 22.7 percent of incidents, someone was present at the fire when it started. Respondents indicated that they smelled smoke in 18.2 percent of fires, saw flames in 16.0 percent, saw smoke in 14.3 percent, and heard or felt the fire in 4.8 percent of incidents. Respondents indicated that in 11.8 percent of fires, the smoke alarm alerted them to the fire. Other means of alerting people to the fire included another household member telling the respondent about the fire, or something else (unspecified) provided the alert of the fire.

For those incidents when people were home at the time of the fire, people were alerted to the fire by the smoke alarm (possibly in combination with other evidence of fire) in 11.8 percent of the fires. Conditional on someone being home, people were alerted by the alarm in 12.1 percent of unattended fires and in 20.5 percent of attended fires.[175]

Table 8-2 describes further how the smoke alarm operated during the fire.

[175] Calculated from the estimated number of fires. Similar calculations can be made from Table 8-1. First note that for unattended fires, someone was home in (100 - 2.8 =) 97.2 percent of incidents and for attended fires someone was at home in (100 - 38.9 =) 61.1 percent. Then the smoke alarm alerted people conditional on someone home in (11.8 / 97.2 =) 12.1 percent for unattended fires and (12.5 / 61.1 =) 20.5 percent for attended fires.

Table 8-2
Smoke Alarm Operation by Attended and Unattended Fires
(Percent of Fires)

Smoke Alarm Operation	All Fires	Unattended Fires	Attended Fires
When the fire started			
Someone was at home	96.0	97.2	61.1
Nobody was home	4.0	2.8	38.9
If someone was home			
There was a smoke alarm	85.6	86.4	61.1
There was no smoke alarm	9.7	10.1	0.0
If there was a smoke alarm and someone home			
The alarm sounded	30.3	30.0	40.0
The alarm did not sound	55.2	56.5	20.7
If people were home and the alarm sounded			
It alerted people to the fire	11.8	11.8	12.5
Something else alerted people	18.5	18.2	27.5
If the smoke alarm alerted people			
It provided the only alert	9.8	9.7	12.5
Something else also alerted people	2.0	2.1	0.0
All Fires	*7,430*	*7,176*	*254*

Notes: See Table 8-1.

Table 8-2 shows that in 85.6 percent of fires (86.4 percent for unattended and 61.1 percent for attended), someone was home and there was at least one smoke alarm in the residence. When considering the presence of alarms alone, regardless of whether someone was home, the survey responses indicated that 88.6 percent of fires occurred in households that had alarms (88.4 percent for unattended fires and 93.9 percent for attended fires).[176] Thus the main distinction between attended and unattended fires is not so much the presence of alarms, but whether someone was at home during the fire.

[176] In Chapter 5, it was shown that 92.7 percent of fire households had at least one smoke alarm. There are two reasons for the difference between this number and the estimate that 88.6 percent of fires occurred in households that had alarms. First, the data in this chapter are based on fires, not households, so that households with more than one fire are counted more than once. Second, the analysis in Chapter 5 was based on all fire households, i.e. those with fires in the full 91-day period, while the statistics in this chapter are from households with fires in the 14- and 21-day recall periods. From this comparison it seems likely that households with higher fire household incidence rates are slightly less likely to have smoke alarms.

Table 8-2 also shows that someone was home and the smoke alarm sounded in 30.3 percent of incidents (30.0 percent unattended and 40.0 percent attended). Using calculations that are comparable to the 1984 survey, the alarms in the present survey sounded in 24 percent more unattended incidents and in 21 percent more attended incidents than as reported in the 1984 survey.[177]

As shown in both Table 8-1 and Table 8-2, the alarm alerted people to the fire in 11.8 percent of incidents. In 18.5 percent of incidents, something else also alerted people to the fire. In 9.8 percent of incidents, the sounding alarm was the only alert of the fire.

One measure of the benefit of smoke alarms may be seen in those 9.8 percent of incidents where the alarm provided the only alert. If the household did not have an alarm, it is not necessarily true that they would have been unaware of the fire, because the other alerting events shown in Table 8-1 might have occurred. However, the sounding alarm in those 9.8 percent of incidents may have provided the respondents with additional time to extinguish or contain the fire or to put escape plans into action.

Table 8-3 addresses the estimated 55.2 percent of fires (56.5 percent unattended and 20.7 percent attended) where the smoke alarm did not sound.

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[177] The 1984 Residential Fire Survey (Audits and Surveys, 1985, *op cit.*, page 57) reported that the smoke alarm sounded in 30.2 percent of unreported residential fires when people were at home, and in 43.2 percent of reported fires when people were at home. These statistics cannot be compared with Table 8-2, because the 1984 survey statistics used the full three-month recall period, while Table 8-2 (like other tables in this chapter) uses the 14/21-day recall period. Comparable statistics from the present survey, using the full 91-day recall period, and conditioning on someone home, would be 38.4 percent of fires where the alarm sounded for all incidents, 37.5 percent of unattended fires, and 52.2 percent of fire department-attended fires. The percentage change for unattended incidents was computed as 100 * (0.375 / 0.302 – 1) = 24.1 percent. The comparable statistics from the current survey are presented to demonstrate the calculation. The best estimate of the proportion of alarms that sounded is based on the 14/21-day recall period and is shown above in the text. The methodology for computing the comparable statistics is explained in more depth in the Appendix to Chapter 7.

Table 8-3
Reasons for Non-operating Smoke Alarm by Attended and Unattended Fires
(Percent of Fires)

Reasons for Non-operating	All Fires	Unattended Fires	Attended Fires
Someone was home, there was a smoke alarm, and the alarm did not sound	55.2	56.5	20.7
If alarm did not sound			
Enough smoke reached the alarm	6.0	5.9	9.5
Not enough smoke	49.0	50.3	11.2
If enough smoke reached the alarm			
Alarm was in working order	5.4	5.2	9.5
Alarm was not in working order	0.6	0.7	-
Alarm tested last			
Less than a month before the fire	11.5	11.6	11.2
1-6 months before	28.3	28.9	8.9
7-12 months before	6.5	6.8	0.6
One year or more before	5.7	5.9	-
Alarm has not been tested	2.0	2.1	-
Estimated number of fires (thousands)	*7,430*	*7,176*	*254*

Notes: See Table 8-1. Note that all questions in this table were skipped if respondents reported that the smoke alarm alerted people to the fire. Missing responses are omitted from the table.

In more than half the unattended fires, as shown in Table 8-3, the alarm did not sound, probably in keeping with the small nature of the fire, when discovered. For most unattended fires where the alarm did not sound, the survey respondents believed that not enough smoke reached the alarm. This is in keeping with most such fires being small. For attended fires, in slightly less than half the fires, respondents believed that enough smoke reached the alarm, which is in keeping with the more serious nature of attended fire incidents. If enough smoke reached the alarm, respondents usually indicated that they believed that, before the fire, the alarm was in working order. Only a small fraction of respondents believed the alarm was not in working order.

Respondents who reported that the alarms did not operate were also asked when the alarms were tested last. Most indicated that they had tested the alarms during the last year.

Table 8-4 describes how fires were extinguished.

Table 8-4
How the Fire Was Extinguished by Attended and Unattended Fires
(Percent of Fires)

Extinguishment Method	All Fires	Unattended Fires	Attended Fires
Nobody home	4.0	2.8	38.9
What was done to put out fire			
Put water on the fire	18.7	19.2	4.1
Turned off power to appliance	18.0	18.3	9.8
Smothered	15.8	16.1	9.2
Separated fuel from heat source, moved outside	11.5	11.9	-
Used baking soda, salt, flour, etc.	6.6	6.8	-
Blew out the fire	6.2	6.4	-
Used an extinguisher	5.0	4.5	17.7
Other	2.2	2.2	2.5
How was fire ultimately extinguished			
Fire department	2.2	-	64.4
Someone in the household	77.7	79.7	23.5
Went out by itself	17.6	17.8	12.0
Somebody else put it out	1.9	2.0	-
Estimated number of fires (thousands)	*7,430*	*7,176*	*254*

Notes: Multiple responses were permitted for the questions, "What was done to put out the fire?" and "How was the fire ultimately extinguished?" Totals may not add to 100 percent because of multiple responses and omission of missing responses. Also see the notes following Table 8-1.

Table 8-4 shows that fire extinguishers were used in 5.0 percent of fire incidents (4.5 percent of unattended fires and 17.7 percent of attended fires). Fire extinguishers were much more likely to be used in attended fires than in unattended fires and, in particular, were the most frequent method used by residents to extinguish the fire in attended fires.[178]

In keeping with the observation that most fires started in the kitchen, putting water on a fire was the most frequent way that unattended fires were extinguished.

[178] In such cases the fire department may have arrived after the fire was extinguished. Fire departments typically will respond to such alarms even when the fire is reported as having been put out, to remove hazardous or hot materials, or to provide first aid and emergency transportation.

Removing power, separating from the heat source (including removing the pan from the stove), and smothering were also frequent methods.

Ultimately someone in the household extinguished the fire in 77.7 percent of fire incidents, it went out by itself in 17.6 percent of incidents, the fire department extinguished the fire in 2.2 percent of incidents, and someone else put it out in 1.9 percent of incidents.

Table 8-5
Location and Use of Fire Extinguisher by Attended and Unattended Fires
(Percent of Fires)

Extinguisher Location and Use	All Fires	Unattended Fires	Attended Fires
Nobody home	4.0	2.8	38.9
Someone home and fire extinguisher available			
In same room where fire started	32.1	32.8	12.5
In a different room	28.4	28.5	26.5
No extinguisher present	35.5	35.9	22.1
Someone tried to use an extinguisher			
Extinguisher was in room where fire started	3.2	3.4	-
Extinguisher was in a different room	1.7	1.2	17.7
Results from using the extinguisher			
Put out the fire completely	2.5	2.5	2.5
Minimized but did not put out fire	1.1	1.1	-
Had little or no effect	1.0	0.6	11.2
Estimated number of fires (thousands)	*7,430*	*7,176*	*254*

Note: Detail lines may not add to 100 percent because of omission of "missing" and "don't know" responses.

As shown in Table 8-5, in more than 60 percent of unattended fire incidents, residents were home and had fire extinguishers available. In slightly less than one-third of these incidents, the extinguishers were located in the same room as the fire. For attended fires where someone was home, in 12.5 percent of incidents the extinguisher was in the same room as the fire and 26.5 percent it was in a different room. The smaller percent of attended fires where there were extinguishers present (in either the same or different rooms) also results from a smaller percentage of people at home at the time of the fire for attended fires.

Table 8-5 also suggests that when the extinguisher was located in the same room where the fire started, it was more likely to be used than when it was located in a different room. When used in unattended fire incidents, the extinguisher was likely to put out the fire or minimize the fire in more than half the incidents. For the most part, fire extinguishers had little or no effect for fires that were ultimately attended by fire departments.

In the 1984 Residential Fire Survey, a home fire extinguisher was used in 4.7 percent of incidents. Fire extinguisher usage in the present survey represents a 51 percent increase over the previous survey. [179]

The remainder of this chapter considers only fires that were not attended by fire departments.

Area of Fire Origin

This section examines the issues of fire discovery and fire extinguishment for fires not attended by fire departments by the area where the fire began. Six areas were chosen for the tables in this section as follows: kitchen, living room, bedroom, bathroom, basement, and other areas. The other areas include the attic, dining room, laundry room, porch or deck, roof, siding, storage room, utility room, hallway, and every other place in the residence not otherwise classified. The reason for combining these areas was because no single area accounted for many incidents.

To some extent, the area where a fire began often suggested what the heat source and item first ignited were, although not always. For example, 91 percent of fires that started in the kitchen were cooking fires, i.e., involved the stove or some other cooking appliance as the heat source.[180] The area of fire origin also had some relationship to the proximity of the smoke alarm. For example, as shown in Chapter 5, smoke alarms are often in bedrooms. Smoke alarms are not often found in kitchens because steam and smoke can set off nuisance alarms.[181]

Table 8-6 shows how fires were discovered by the area of fire origin.

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[179] Audits and Surveys (1985), *op cit.,* page 32. The comparable statistic based on the three-month recall period in the present survey is 7.1 percent for all fires (6.1 percent for fire department unattended and 18.6 percent for attended).
[180] Also 97 percent of cooking fires started in the kitchen.
[181] Smith CL (1994), *op cit*.

Table 8-6
Method of Discovery by Area Where Fire Began
(Percent of Unattended Fires)

Method of Discovery	Kitchen	Living Room	Bed-room	Bath-room	Other Areas	Base-ment
Nobody home	0.3	-	11.9	0.1	14.9	23.5
Person present at fire origin	24.2	45.4	3.8	42.2	3.0	-
Other evidence of fire						
Smelled smoke	17.4	28.2	48.0	16.2	4.8	-
Saw flames	19.0	7.8	0.1	-	38.7	-
Saw smoke	15.6	24.1	3.0	10.7	7.0	-
Heard fire	1.9	-	-	30.8	0.1	-
Felt heat	1.7	-	8.7	-	0.2	-
Smoke alarm alerted people	14.9	0.3	11.6	0.8	2.1	12.4
Someone else provided an alert	4.0	10.3	3.7	-	0.2	-
Something else provided an alert	0.4	-	3.8	-	-	7.8
Estimated number of unattended fires (thousands)	*4,987*	*530*	*505*	*438*	*517*	*199*

Notes: See Table 8-1.

This table shows several different patterns in the methods of discovery of the fire. Almost half the living room and bathroom fires were discovered by a person present when the fire began. The person may have discovered the fire by smelling or seeing smoke or, with bathroom fires, hearing the fire. The smoke alarm rarely alerted residents to the fire incident, probably because neither room was likely to have an alarm installed.

In nearly one-quarter of the kitchen fires, someone was present at the fire origin. Like the living room and bathroom fires, in many cases residents were probably near enough to the kitchen to be aware of smoke, heat, or flames; but in other cases, they were not present at the origin of the fire. According to the literature, the leading factor resulting in fire department-attended cooking fires is unattended cooking.[182] In 14.9 percent of the kitchen fire incidents, residents reported that the smoke alarm alerted them to the fire.

[182] Ahrens M, Hall JR Jr., Comoletti J, Gamache S and LeBeau A (2007), "Behavioral Mitigation of Cooking Fires through Strategies Based on Statistical Analysis," FEMA, Washington, DC, page 2.

In fires originating in bedrooms, other areas, and the basement, residents were less likely to be home when the fire began. When residents were home, bedroom and other area fires provided other evidence such as the smell of smoke or seeing smoke or seeing flames. In contrast, residents were unlikely to become aware of basement fires from the presence of smoke, flames, or heat. Residents were more likely to be aware of basement fires from hearing the smoke alarm. Smoke alarms alerted people in 11.6 percent of bedroom fires and 12.4 percent of basement fires. This finding is likely to reflect where smoke alarms were located in residences.

Table 8-7 provides more detail on the operation of the smoke alarm during these fire incidents.

Table 8-7
Smoke Alarm Operation by Area Where Fire Began
(Percent of Unattended Fires)

Smoke Alarm Operation	Kitchen	Living Room	Bed-room	Bath-room	Other Areas	Base-ment
When the fire started						
Someone was at home	99.7	100.0	88.1	99.9	85.1	76.5
Nobody was home	0.3	-	11.9	0.1	14.7	23.5
If somebody was home						
There was a smoke alarm	89.5	99.1	76.8	99.9	67.8	20.3
There was no smoke alarm	9.6	0.9	11.3	-	13.5	56.2
If there was a smoke alarm and someone home						
The alarm sounded	36.9	25.0	16.7	0.8	12.1	12.4
The alarm did not sound	52.5	74.1	60.1	99.1	55.7	7.8
If people were home and the alarm sounded						
It alerted people to the fire	14.9	0.3	11.6	0.8	2.1	12.4
It did not alert people to the fire	22.0	24.7	5.1	0.0	10.0	-
If the smoke alarm alerted people						
It provided the only alert	12.0	0.3	11.6	0.1	2.1	12.4
Something else also alerted people	2.9	-	-	0.8	-	-
Estimated number of unattended fires (thousands)	*4,987*	*530*	*505*	*438*	*517*	*199*

Notes: See Table 8-2.

In kitchen fires, as shown in Table 8-6, an alarm alerted people to a fire in 14.9 percent of incidents (also repeated in Table 8-7 above). Table 8-7 shows that people were at home and that there was a smoke alarm in 89.5 percent of residences where there was a kitchen fire, and the alarm sounded in 36.9 percent of these incidents. The alarm provided the only alert in 12 percent of the incidents. Thus, in slightly less than one-third of the kitchen fires where the alarm sounded, the alarm provided the only alert.

With respect to living room and bathroom fires, in neither case did the alarm typically alert people to the fire, but for different reasons. In living room fires, people were at home and the alarm sounded in 25 percent of the incidents; but aside from 0.3 percent of incidents, something else usually alerted residents. In bathroom fires, the alarm sounded in less than 1 percent of incidents.

In bedroom fires, the alarm sounded in 16.7 percent of incidents, alerting residents in 11.6 percent of incidents, more than two-thirds of the incidents where the alarm sounded. When residents were alerted by smoke alarms, it was the only alert of the fire.

In basement fires, someone was home and there was a smoke alarm in the residence in 20.3 percent of incidents. The alarm sounded in 12.4 percent of incidents, providing the only alert of the incident in every case where it sounded. In fires beginning in other areas, the alarm sounded in 12.1 percent of incidents, alerting people and providing the only alert in 2.1 percent of incidents.

Tables 8-6 and 8-7 provide some evidence of the importance of having alarms on all floors and in all bedrooms. In fires starting in the basement, smoke alarms were shown to have provided the only information of the existence of the fire. In fires starting in bedrooms, in 11.6 percent of incidents, smoke alarms alerted residents and in such cases, those were the only alerts. Further discussion about alarm location is included in the section on alarm configurations later in this chapter.

Tables 8-6 and 8-7 also provide some information about the relationship between where people were at the time of the fire, the location of the alarm, and whether the alarm alerted household members. Alarms were typically located in hallways, in basements, and in bedrooms. Alarms were rarely located in kitchens or bathrooms. When fires began in the basement, residents were rarely in that area; thus, other evidence of fire such as the smell of smoke or seeing or hearing the fire did not alert them to the fire. When the alarm sounded, it was the only alert. In contrast, in living room and bathroom fires, residents were present when the fire began in about half the incidents.

Table 8-8 describes the incidents where someone was home, there was an alarm present in the residence, but the alarm did not sound during the fire. As shown in Table 8-7, this occurred in about half of the kitchen fire incidents, half of the incidents in other areas, and half of the bedroom incidents. For living room fires, in almost three-quarters of the incidents the alarm did not sound, and it did not sound in almost all the fires starting in the bathroom.

Table 8-8
Reasons for Non-operating Smoke Alarm by Area Where Fire Began
(Percent of Unattended Fires)

Reasons for Non-operating	Kitchen	Living Room	Bed-room	Bath-room	Other Areas	Base-ment
Someone was home and there was a smoke alarm in the residence	52.5	74.1	60.1	99.1	55.7	7.8
If alarm did not sound						
Enough smoke reached the alarm	8.3	1.1	-	-	0.2	-
Not enough smoke	43.8	73.0	60.1	99.1	55.5	7.8
Don't know/refused	0.4	-	-	-	-	-
If enough smoke reached the alarm						
Alarm was in working order	7.4	1.1	-	-	0.2	-
Alarm was not in working order	0.9	-	-	-	-	-
Alarm tested last						
Less than a month before the fire	8.7	14.0	15.8	28.6	22.3	-
1-6 months before	27.9	24.7	26.5	70.5	18.2	7.8
7-12 months before	5.4	10.2	16.9	-	15.0	-
One year or more before	6.6	17.1	0.9	-	-	-
Alarm has not been tested	2.1	8.0	-	-	-	-
Don't know/refused	1.7	-	-	-	0.1	-
Estimated number of unattended fires (thousands)	*4,987*	*530*	*505*	*438*	*517*	*199*

Notes: See Table 8-3.

Table 8-8 indicates that the most frequent reason why alarms did not sound was because insufficient smoke reached the alarms. The only situation where residents believed that sufficient smoke reached non-sounding alarms was in kitchen fires. As shown in previous tables, most residents believed that their alarms were in working order and most reported having tested their alarms during the previous year.

Tables 8-9 and 8-10 describe how fires were extinguished.

Table 8-9
How the Fire Was Extinguished by Area Where Fire Began
(Percent of Unattended Fires)

Extinguishment Method	Kitchen	Living Room	Bed-room	Bath-room	Other Areas	Base-ment
Nobody home	0.3	-	11.9	0.1	14.9	23.5
What was done to put out fire						
Put water on the fire	20.8	31.7	3.8	0.6	29.2	-
Turned off power to appliance	17.0	30.1	-	52.2	7.9	20.3
Smothered	19.3	7.6	13.3	1.4	15.2	-
Separated from heat source, moved outside	12.6	0.8	28.2	16.0	1.0	-
Used baking soda, salt, flour, etc.	9.8	-	-	-	0.3	-
Blew out the fire	7.0	-	5.9	-	16.5	-
Used an extinguisher	5.2	0.5	8.6	0.1	4.0	-
Other	3.1	-	-	0.1	-	0.1
How was fire ultimately extinguished						
Someone in the household	83.3	69.5	49.5	99.9	80.7	44.0
Went out by itself	14.4	28.4	50.5	-	16.0	37.3
Somebody else put it out	2.3	2.1	-	0.1	3.2	-
Estimated number of unattended fires (thousands)	*4,987*	*530*	*505*	*438*	*517*	*199*

Notes: See Table 8-4.

Table 8-9 shows that putting water on the fire, removing power, and smothering were the most frequent methods for extinguishing kitchen fires, followed by separating from a heat source, moving the object outside, using baking soda, etc. In fires starting outside the kitchen, the strategy was most likely to depend on the nature of the item ignited and the availability of water. Living room fires and fires in other areas often were extinguished with water. In basement and bathroom fires, the most frequent approach was to turn off the power to the equipment that was the source of heat for the fire. In bedroom fires, almost one-third were extinguished by separating from the heat source or moving the hot object outside.

Extinguishers were used in 5.2 percent of kitchen fire incidents, 8.6 percent of fires originating in bedrooms, and 4 percent of fires in other areas. Extinguishers were used in less than 1 percent of living room, bathroom, and basement fires.

Table 8-10
Location and Use of Fire Extinguisher by Area Where Fire Began
(Percent of Unattended Fires)

Extinguisher Location and Use	Kitchen	Living Room	Bed-room	Bath-room	Other Areas	Base-ment
Nobody home	0.3	-	11.9	0.1	14.9	23.5
Someone home and extinguisher available						
In same room where fire started	45.0	10.1	7.5	-	-	7.8
In different room	16.0	60.2	68.5	85.0	36.1	12.6
No extinguisher present	38.7	29.8	12.1	14.9	49.0	56.0
Someone tried to use an extinguisher						
Extinguisher was in room of fire origin	4.8	-	-	-	-	-
Extinguisher was in a different room	0.4	0.5	8.6	0.1	4.0	-
Results from using the extinguisher						
Put out the fire completely	3.1	0.5	-	0.1	4.0	-
Minimized but did not put out fire	1.6	-	-	-	-	-
Had little or no effect	-	-	8.6	-	-	-
Estimated number of unattended fires (thousands)	*4,987*	*530*	*505*	*438*	*517*	*199*

Notes: See Table 8-5.

Table 8-10 shows that accessibility of a fire extinguisher is of some importance in extinguisher usage. For example, when the extinguisher was kept in the kitchen, there was a 10.7 percent chance that the extinguisher was used in a kitchen fire (= 4.8 percent / 45.0 percent), in contrast to a 2.5 percent chance that the extinguisher was used in a kitchen fire if it was in a different room. The table also suggests that the kitchen and basement are places where extinguishers are likely to be kept.

When used, the extinguisher put out the fire completely in kitchen fires about two-thirds of the time. In bedroom fires, the extinguisher appeared to have little or no effect; while in fires originating in other areas, the extinguisher put out the fire completely.

Appliance Fires

Table 8-11 presents data on how appliance fires were discovered by type of appliance involved.

Table 8-11
Method of Discovery for Appliance Fires
(Percent of Unattended Fires)

Method of Discovery	Stove Range	Other Cooking Appliance	Other Appliance	Lighting Wiring	Heating Cooling
Nobody home	-	-	9.4	-	20.9
Person present at fire origin	21.3	19.1	41.8	28.1	35.7
Other evidence of fire					
Smelled smoke	15.6	14.5	16.7	48.8	27.4
Saw flames	20.7	29.5	-	0.8	13.8
Saw smoke	14.5	24.1	10.8	8.2	-
Heard fire	2.2	0.2	10.0	-	3.6
Felt heat	2.2	0.2	-	0.1	-
Smoke alarm alerted people	15.7	16.0	-	5.2	4.1
Someone else provided an alert	5.1	-	-	8.8	0.1
Something else provided an alert	0.5	0.4	-	-	-
Estimated number of unattended fires (thousands)	*3,789*	*876*	*651*	*616*	*281*

Notes: See Table 8-1. Other Cooking Appliance includes microwave ovens, toaster ovens and toasters, coffeemakers, teapots, counter top ovens, outdoor grills, and other devices. Other Appliance includes personal grooming equipment (hair dryers, curlers, etc.), home office equipment, washing machines, humidifiers, irons, etc.

As most stove and range fires occurred in the kitchen and most kitchen fires involved stoves or ranges, the stove and range and the other cooking columns in Table 8-11 are similar to the kitchen fire results in the previous set of tables in this chapter. The only notable difference between stove and range fires and other cooking appliance fires was that residents were more likely to see flames or smoke as evidence of fire for those involving cooking appliances than for fires involving stoves or ranges. The smoke alarm alerted people in 15.7 percent of stove or range fires and 16 percent of cooking fires, a slightly higher percentage than in all fires. Note that cooking appliance fires (both stove or range and other) had about one person in five present at the fire origin, implying that four of five fires involved some degree of unattended cooking.

In other appliance fires, almost half the incidents involved someone present at the time when the incident began. Smelling smoke, seeing smoke, or hearing the fire provided the most frequent evidence of fire. No incidents involved people reporting that they were alerted to the fire by the smoke alarm. In lighting and wiring incidents and heating and cooling incidents, the smoke alarm alerted people in 5.2 and 4.1 percent of incidents, respectively.[183] Smelling or seeing smoke or seeing flames provided the most frequent alert of these types of fires.

183 Heating and cooling equipment fires were presented in Table 7-14. About one-third of the incidents involved central heating and cooling equipment, one-third portable heaters, and one-third were unspecified. Lighting and wiring incidents were presented in Table 7-12. Almost one-quarter of incidents involved light fixtures; the remainder involved light bulbs and lamps, fuses or circuit breaker panels, electrical cords, and other such equipment.

Table 8-12
Smoke Alarm Operation for Appliance Fires
(Percent of Unattended Fires)

Smoke Alarm Operation	Stove Range	Other Cooking Appliance	Other Appliance	Lighting Wiring	Heating Cooling
When the fire started					
Someone was at home	100.0	100.0	90.6	100.0	79.1
Nobody was home	-	--	9.2	-	20.9
If somebody was home					
There was a smoke alarm	87.1	97.2	79.2	83.8	77.4
There was no smoke alarm	12.1	2.3	11.4	15.3	1.6
If there was a smoke alarm and someone home					
The alarm sounded	40.9	30.4	3.7	6.4	17.9
The alarm did not sound	46.1	66.8	75.5	77.4	59.5
If people were home and the alarm sounded					
It alerted people to the fire	15.7	16.0	-	5.2	4.1
Something else alerted people	25.2	14.4	3.7	1.2	13.8
If the smoke alarm alerted people					
It provided the only alert	13.4	10.7	-	5.2	0.6
Something else also alerted	2.3	5.3	-	-	3.6
Estimated number of unattended fires (thousands)	*3,789*	*876*	*651*	*616*	*281*

Notes: See Table 8-2.

Table 8-12 shows that smoke alarms sounded in 40.9 percent of stove and range fires, alerted people to the fire in 15.7 percent of the incidents, and provided the only alert in 13.4 percent of incidents. Thus, when alarms alerted people to stove and range fires, they usually provided the only alert. Other cooking fires had similar statistics, sounding in 30.4 percent of incidents, alerting people in 16 percent of incidents, and providing the only alert in 10.7 percent of incidents. For heating and cooling fire incidents, the alarm sounded less frequently at 17.9 percent, alerting residents in 4.1 percent of incidents (about one-quarter of the incidents where the alarm sounded), and providing the only alert in 0.6 percent of incidents.

Also, as shown in Table 8-12, in lighting and wiring incidents, alarms sounded in 6.4 percent of incidents, alerted people in 5.2 percent of incidents, and when the alarms alerted people, they were the only alert. Alarms sounded in 3.7 percent of other appliance incidents and did not alert people to any of those fire incidents.

Table 8-13
Reasons for Non-operating Smoke Alarms for Appliance Fires
(Percent of Unattended Fires)

Reasons for Non-operating	Stove Range	Other Cooking Appliance	Other Appliance	Lighting Wiring	Heating Cooling
If alarm did not sound					
Enough smoke reached the alarm	8.6	4.5	-	0.8	-
Not enough smoke	37.6	60.2	75.5	76.7	59.5
Don't know/refused	-	2.0	-	-	-
If enough smoke reached the alarm					
Alarm was in working order	7.3	4.5	-	0.8	-
Alarm was not in working order	1.3	-	-	-	-
Alarm tested last					
Less than a month before the fire	9.2	12.6	30.0	11.4	-
1-6 months before	24.2	29.8	26.0	42.6	59.5
7-12 months before	3.5	12.0	5.7	22.7	-
One year or more before	8.4	0.8	13.8	0.8	-
Alarm has not been tested	0.1	11.5	-	-	-
Don't know/refused	0.8	-	-	-	-
Estimated number of unattended fires (thousands)	*3,789*	*876*	*651*	*616*	*281*

Notes: See Table 8-3.

As shown in Table 8-13, the most frequent explanation for alarms not sounding was that insufficient smoke reached the alarms. This was the case in more than one-third of stove and range fires, slightly less than two-thirds of other cooking and heating/cooling equipment fires, and three-quarters of other appliance and lighting and wiring fires. Respondents indicated that, when enough smoke reached the alarm, it was usually in working order. Most respondents also reported that the alarm was tested during the previous year.

Table 8-14
How the Fire Was Extinguished for Appliance Fires
(Percent of Unattended Fires)

Extinguishment Method	Stove Range	Other Cooking Appliance	Other Appliance	Lighting Wiring	Heating Cooling
Nobody home	-	-	9.4	-	20.9
What was done to put out fire					
Put water on the fire	22.6	13.6	-	13.8	3.6
Turned off power to appliance	13.5	39.1	49.0	16.1	10.7
Smothered	23.1	1.1	-	-	42.6
Separated from heat source, moved outside	12.8	16.7	-	23.1	1.4
Used baking soda, salt, flour, etc.	11.4	6.8	-	-	-
Blew out the fire	7.4	3.9	-	-	-
Used an extinguisher	4.1	9.9	-	-	-
Other	3.6	2.5	-	-	-
How was fire ultimately extinguished					
Someone in the household	87.3	67.4	48.8	73.4	98.6
Went out by itself	12.4	24.1	50.9	20.6	1.4
Somebody else put it out	0.3	8.5	0.2	-	-
Estimated number of unattended fires (thousands)	*3,789*	*876*	*651*	*616*	*281*

Notes: See Table 8-4.

In Table 8-14 it was reported that stove and range fires were extinguished most frequently by smothering, next most frequently by putting water on the fire, then by removing power, and then by separation of the burning items from the heat source. Turning off the power was the most frequent method of extinguishment for other cooking fires, and was the only type of extinguishment for other appliance fires. In lighting and wiring fires, separation from the heat source, removing power, and using water were the most frequent methods.[184] Heating and cooling fires were extinguished by smothering in almost half the cases, and by removal of power, separation from the heat source, and applying water to the fire in the remaining fire incidents.

Fire extinguishers were used in almost 10 percent of other cooking incidents, 4.1 percent of stove and range incidents, but not for any of the other appliance, lighting and wiring, and heating and cooling fire incidents.

[184] If the electricity is turned off, then putting water on the burning materials is safe. Otherwise, there is a risk of electric shock and of spreading the fire when applying water to an electrical fire.

Table 8-15
Location and Use of Fire Extinguisher for Appliance Fires
(Percent of Unattended Fires)

Extinguisher Location and Use	Stove Range	Other Cooking Appliance	Other Appliance	Lighting Wiring	Heating Cooling
Nobody home	-	-	9.4	-	20.9
Someone home and extinguisher available					
In same room where fire started	45.8	28.2	9.3	13.8	35.7
In different room	15.6	22.9	46.0	65.4	39.6
No extinguisher present	38.7	48.9	35.3	20.7	3.8
Someone tried to use an extinguisher					
Extinguisher was in room of fire origin	3.5	9.9	-	-	-
Extinguisher was in a different room	0.5	-	-	-	-
Results from using the extinguisher					
Put out the fire completely	2.5	7.1	-	-	-
Minimized but did not put out fire	1.6	-	-	-	-
Had little or no effect	-	-	-	-	-
Estimated number of unattended fires (thousands)	*3,789*	*876*	*651*	*616*	*281*

Notes: See Table 8-5.

Table 8-15 shows that for cooking fires, extinguishers were more likely to be used if they were kept in the room where the fire started. This is especially noticeable with other cooking fires where, in 9.9 percent of incidents, the extinguisher was in the same room as the fire and was used to put out the fire; if the extinguisher was in a different room, there were no incidents when it was used. For stove and range fires, the extinguisher was more likely to be in the same room (presumably the kitchen) and, if so, was more than twice as likely to be used than if in a different room. Note that despite lack of usage, in 9.3 percent of other appliance incidents, 13.8 percent of lighting and wiring incidents, and 35.7 percent of heating and cooling fire incidents, the extinguisher was in the room where the fire began.

When used in stove and range fires, the extinguisher put out the fire completely in 2.5 percent of incidents and minimized the fire in the remaining 1.6 percent. In other cooking equipment incidents, the extinguisher put out the fire in 7.1 percent of the 9.9 percent of fires when it was used.

Non-appliance Fires

Tables 8-16 to 8-20 display smoke alarm and extinguisher information for unattended non-appliance fires. These include candle fires, lighter, cigarette and match fires, and other fires.

Table 8-16
Method of Discovery for Non-appliance Fires
(Percent of Unattended Fires)

Method of Discovery	Candle	Lighter, Cigarette, Match	Other
Nobody home	14.3	2.6	-
Person present at fire origin	11.4	24.3	3.3
Other evidence of fire			
Smelled smoke	14.2	22.0	1.2
Saw flames	12.6	12.5	-
Saw smoke	20.8	-	20.6
Heard fire	15.2	-	-
Felt heat	9.3	-	-
Smoke alarm alerted	6.9	7.9	2.7
Someone else provided an alert	-	5.9	0.7
Something else provided an alert	4.1	-	13.2
Estimated number of unattended fires (thousands)	*465*	*380*	*119*

Notes: See Table 8-1. Other includes the following heat sources: torch, spark from a fireplace, fireworks, other open flame, a fire that started somewhere else and spread to the home, lightning, and the response of “something else,” “don’t know,” or “refused.”

Table 8-16 shows that residents were less likely to be home in candle fires (not home in 14.3 percent of incidents) than in unattended fires in general (not home in 2.8 percent of incidents, as shown in Table 8-1). Among the different heat sources, this was only exceeded by heating and cooling fire incidents (20.9 percent, Table 8-12). For candle fires, people reported seeing smoke as evidence of the fire most often (at 20.8 percent of the incidents), and hearing the fire second most often (at 15.2 percent of incidents). Smelling smoke was the most frequent evidence of fire for lighter, cigarette, and match fires, while seeing smoke was most frequent for other fires. The smoke alarm alerted people to the fire in 6.9 percent of candle fires, 7.9 percent of lighter, cigarette and match fires, and in 2.7 of the other non-appliance fires.

Table 8-17
Smoke Alarm Operation for Non-appliance Fires
(Percent of Unattended Fires)

Smoke Alarm Operation	Candle	Lighter, Cigarette, Match	Other
When the fire started			
Someone was at home	85.7	97.4	100.0
Nobody was home	14.3	2.6	-
If somebody was home			
There was a smoke alarm	85.7	93.4	41.9
There was no smoke alarm	-	0.1	58.1
If there was a smoke alarm and someone home			
The alarm sounded	19.5	27.7	19.4
The alarm did not sound	66.2	65.7	22.4
If people were home and the alarm sounded			
It alerted people to the fire	6.9	7.9	2.7
Something else alerted people	12.6	19.8	16.7
If the smoke alarm alerted people			
It provided the only alert	6.2	7.9	2.7
Something else also alerted people	0.7	-	-
Estimated number of unattended fires (thousands)	*465*	*380*	*119*

Notes: See Table 8-2.

In Table 8-17, the estimates indicate that people were home and the smoke alarm sounded in 19.5 percent of candle fires; 27.7 percent of lighter, cigarette and match fires; and 19.4 percent of other fires. The sounding alarm alerted people in 6.9 percent of candle fire incidents; 7.9 percent of lighter, cigarette, and match fires; and 2.7 percent of other fires. In all three types of non-appliance fires, if the alarm alerted people, in almost every case, it provided the only alert.

Table 8-18
Reasons for Non-operating Smoke Alarm for Non-appliance Fires
(Percent of Unattended Fires)

Reason for Non-operating	Candle	Lighter, Cigarette, Match	Other
If alarm did not sound			
Enough smoke reached the alarm	6.3	6.2	0.7
Not enough smoke	59.8	59.5	21.7
Don't know/refused	-	-	-
If enough smoke reached the alarm			
Alarm was in working order	6.3	6.2	0.7
Alarm was not in working order	-	-	-
Alarm tested last			
Less than a month before the fire	0.2	27.4	0.5
1-6 months before	47.9	15.0	17.8
7-12 months before	8.7	7.0	3.9
One year or more before	0.2	1.2	-
Alarm has not been tested	9.2	-	0.2
Don't know/refused	-	15.1	-
Estimated number of unattended fires (thousands)	465	380	119

Notes: See Table 8-3.

As shown in Table 8-18, when people were home and the alarm did not sound, respondents reported that there was not enough smoke to trigger the alarm in all three categories of non-appliance fires. This is similar to responses shown earlier for other heat sources. Respondents believed, in all cases, that when enough smoke reached the alarm and it did not sound, that it was in working order. Most reported having tested their alarms during the previous year.

Table 8-19
How the Fire Was Extinguished for Non-appliance Fires
(Percent of Unattended Fires)

Extinguishment Method	Candle	Lighter, Cigarette, Match	Other
Nobody home	14.3	2.6	-
What was done to put out fire			
Put water on the fire	43.6	27.2	1.9
Turned off power to appliance	-	-	13.0
Smothered	11.6	6.0	62.1
Separated from heat source, moved outside	15.2	-	3.9
Used baking soda, salt, flour, etc.	-	-	-
Blew out the fire	6.1	31.2	-
Used an extinguisher	9.5	4.6	19.4
Other	-	-	0.5
How was fire ultimately extinguished			
Someone in the household	74.3	93.4	60.7
Went out by itself	17.0	3.1	39.1
Somebody else put it out	8.7	3.5	0.2
Estimated number of unattended fires (thousands)	*465*	*380*	*119*

Notes: See Table 8-4.

Table 8-19 shows that water was used to put out candle fires more frequently than with any other heat source (43.6 percent of incidents). It is likely that the fires started with lighters, cigarettes, and matches probably were of smaller sizes than most fires, because residents indicated that they were able to blow out these fires in almost one-third of incidents. Water was also used frequently with such fires (27.2 percent of incidents). For the other non-appliance incidents, smothering the fire was the most frequent method of extinguishment, followed by the use of a fire extinguisher. Of particular note, while extinguishers were used in 4.6 percent of all unattended fires, extinguishers were used twice and four times as frequently in candle fires and other fires at 9.5 and 19.4 percent, respectively.

Table 8-20
Location and Use of Fire Extinguisher for Non-appliance Fires
(Percent of Unattended Fires)

Extinguisher Location and Use	Candle	Lighter, Cigarette, Match	Other
Nobody home	14.3	2.6	-
Someone home and extinguisher available			
In same room where fire started	12.6	8.6	29.7
In different room	70.4	21.9	26.6
No extinguisher present	2.8	66.8	43.6
Someone tried to use an extinguisher			
Extinguisher was in room of fire origin	-	-	16.7
Extinguisher was in a different room	9.5	4.6	2.7
Results from using the extinguisher			
Put out the fire completely	0.2	4.6	2.7
Minimized but did not put out fire	-	-	16.7
Had little or no effect	9.3	-	-
Estimated number of unattended fires (thousands)	*465*	*380*	*119*

Notes: See Table 8-5.

For candle fires and lighter, match, or cigarette fires, accessibility of the extinguishers did not appear to play an important role as related to their usage, as shown in Table 8-20. For these types of fires in which extinguishers were used, the extinguishers were located in different rooms from where the fire started. In the other non-appliance incidents, extinguishers that were used were much more likely to be in the room where the fire started.

Table 8-20 shows that extinguishers were not very effective in putting out candle fires but, in contrast, they were completely effective in putting out lighter, match, and cigarette fires. Extinguishers were moderately effective by minimizing but not extinguishing completely most other non-appliance fires.

Alarm Configurations

Tables 8-21 through 8-25 show the operation of smoke alarms as related to how the alarms were configured in the residence. The responses provide insight into whether residents with more complete alarm configurations were more likely to be alerted to the fire.[185]

Table 8-21
Method of Discovery by Smoke Alarm Configuration
(Percent of Unattended Fires)

Method of Discovery	Interconnected		In All Bedrooms		On All Floors	
	Yes	No	Yes	No	Yes	No
Nobody home	0.1	3.1	2.1	3.0	2.6	3.4
Person present at fire origin	39.1	21.2	21.4	23.8	25.9	13.5
Other evidence of fire						
Smelled smoke	23.9	18.2	20.3	18.4	20.6	12.6
Saw flames	1.3	18.5	17.1	16.4	18.2	10.8
Saw smoke	6.5	14.9	16.2	13.2	14.9	10.6
Heard fire	-	3.6	3.7	3.1	3.7	1.6
Felt heat	-	2.0	2.5	1.6	1.0	4.7
Smoke alarm alerted	26.0	10.0	16.0	10.4	14.5	1.9
Someone else provided an alert	3.3	3.8	9.1	2.0	4.8	-
Something else provided an alert	-	0.9	1.8	0.4	1.0	-
Estimated number of unattended fires (thousands)	*805*	*6,370*	*1,779*	*5,397*	*5,618*	*1,557*

Notes: See Table 8-1.

Table 8-21 shows how a fire was discovered as related to the different smoke alarm configurations.[186] Only the pairs in complementary columns in the table are mutually exclusive. For example, a fire incident can be entered in either the Interconnected-Yes column or the Interconnected-No column but not both. However,

[185] NFPA 72 requires smoke alarms to be installed outside each sleeping area and on every level of the home. In new construction, smoke alarms are also required in every sleeping room. Alarms must be hard wired with battery backup in new construction but may be battery powered in existing homes. For details see National Fire Protection Association (2007), *National Fire Alarm Code, 2007 Edition*. Quincy, MA.
[186] In Chapter 5, it was shown that 82.4 percent of fire households had smoke alarms on all floors, 21.7 percent had smoke alarms in all bedrooms, and 18.3 percent of households with at least two smoke alarms had their alarms interconnected. These estimates are somewhat different from the statistics presented in Table 8-21 because the estimates in Chapter 5 were based on the number of households and used the full 91-day survey period. The statistics presented in this chapter are based on the number of fires and use the 14/21-day recall period.

some of the fires in the In All Bedrooms-Yes column may have been in houses with interconnected alarms and some in houses without interconnected alarms.

In comparing fires where residents had interconnected alarms, the table shows that the interconnected smoke alarms alerted residents to the fire more than twice as often as non-interconnected alarms (26.0 percent versus 10.0 percent). This occurred despite the fact that a person was present at the fire origin almost twice as often in interconnected alarm residence fires than non-interconnected alarm residence fires.

Similar but smaller benefits in terms of the smoke alarm alerting residents are found in the incidents where the alarms were in all bedrooms and the alarms were on all floors. For incidents where there were alarms in all bedrooms, people were alerted to the fire in 16.0 percent of the incidents in contrast to 10.4 percent of the incidents with alarms in some or no bedrooms. When the alarms were on all floors in the residence, a situation that characterized most residences where fire incidents occurred, residents were alerted 14.5 percent of the time by the sounding alarm, in contrast to 1.9 percent of the incidents when the alarms were not on all floors.

Table 8-22
Smoke Alarm Operation by Smoke Alarm Configuration
(Percent of Unattended Fires)

Smoke Alarm Operation	Interconnected		In All Bedrooms		On All Floors	
	Yes	No	Yes	No	Yes	No
When the fire started						
Someone was at home	99.9	96.9	97.9	97.0	97.4	96.6
Nobody was home	0.1	3.1	2.1	2.9	2.6	3.4
If somebody was home						
There was a smoke alarm	99.9	84.7	97.1	82.9	97.4	46.8
There was no smoke alarm	0.0	11.3	-	13.4	-	46.4
If there was a smoke alarm and someone home						
The alarm sounded	53.3	27.0	35.9	28.0	37.1	4.1
The alarm did not sound	46.7	57.7	61.1	54.9	60.3	42.7
If people were home and the alarm sounded						
It alerted people to the fire	26.0	10.0	16.0	10.4	14.5	1.9
Something else alerted people	27.3	17.0	20.0	17.6	22.7	2.1
If the smoke alarm alerted people						
It provided the only alert	26.0	7.6	12.6	8.8	11.9	1.9
Something else also alerted	-	2.3	3.4	1.6	2.6	-
Estimated number of unattended fires (thousands)	*805*	*6,370*	*1,779*	*5,397*	*5,618*	*1,557*

Notes: See Table 8-2.

In Table 8-22, alarms were reported to have sounded in 53.3 percent of incidents where alarms were interconnected, in contrast to 27.0 percent where alarms were not interconnected. When the sounding alarm alerted people to fires in residences with interconnected alarms, they provided the only alert in every case. In fires in residences lacking interconnected alarms, the comparable statistic for sounding alarms in fires was 7.6 percent.

In comparing between residences with alarms on all floors with those without alarms on all floors, the distinctions were also very sharp. Alarms sounded in 37.1 percent of incidents when alarms were located on all floors, in contrast to 4.1 percent of incidents when they were not on all floors. The alarm provided the only alert in 11.9

percent of incidents where alarms were on all floors, in contrast to 1.9 percent of incidents in residences without alarms on all floors.

The differences were not as sharp for the comparison between fires occurring in residences where alarms were in all bedrooms with those occurring in residences without alarms in all bedrooms. The alarms sounded in a larger proportion of incidents with alarms in all bedrooms (35.9 percent of incidents) compared with residences without alarms in all bedrooms (28.0 percent of incidents). Also with alarms in all bedrooms, the alarm provided the only alert in 12.6 percent of incidents compared with 8.8 percent of incidents when there were not alarms in all bedrooms.

Table 8-23 presents results on why alarms did not operate by the different alarm configurations.

Table 8-23
Reasons for Non-operating Smoke Alarm by Smoke Alarm Configuration
(Percent of Unattended Fires)

	Interconnected		In All Bedrooms		On All Floors	
Reason for Non-operation	Yes	No	Yes	No	Yes	No
If alarm did not sound						
Enough smoke reached the alarm	17.0	4.5	6.7	5.6	5.7	6.7
Not enough smoke	29.7	52.9	53.4	49.3	54.6	35.0
Don't know/refused	-	0.3	1.0	-	0.1	1.0
If enough smoke reached the alarm						
Alarm was in working order	16.9	3.8	6.7	4.7	5.7	3.7
Alarm was not in working order	0.1	0.7	-	0.9	-	3.0
Alarm tested last						
Less than a month before the fire	0.1	13.0	18.3	9.3	10.7	14.6
1-6 months before	26.9	29.2	27.9	29.3	30.3	23.8
7-12 months before	11.9	6.1	8.2	6.3	7.5	4.2
One year or more before	4.0	6.2	4.9	6.3	7.6	0.1
Alarm has not been tested	3.7	1.9	1.7	2.2	2.6	-
Don't know/refused	-	1.4	-	1.6	1.5	-
Estimated number of unattended fires (thousands)	*805*	*6,370*	*1,779*	*5,397*	*5,618*	*1,557*

Notes: See Table 8-3.

Table 8-23 shows that in 17 percent of incidents with interconnected alarms present, residents reported that enough smoke reached the alarms for the alarms to have operated. In contrast, in 4.5 percent of fires in homes without interconnected alarms, residents reported that there was enough smoke. Because there were likely to be more alarms in homes that had interconnected alarms, it is possible that residents believed such alarms should have sounded, in contrast to homes where there were fewer alarms.

Similar to previous tables for interconnected alarms and alarms in all bedrooms, most respondents reported that in incidents when enough smoke reached alarms so that the alarms should have sounded, that before the fire, respondents believed that almost all alarms were in working order. The exception to this was in the case where alarms were not on all floors. The 3.0 percent of incidents where enough smoke reached the alarms but they did not operate were attributed to the alarms not being in working order.

Similar to most of the previous tables, residents reported that most alarms were tested within the year.

Table 8-24
How the Fire Was Extinguished by Smoke Alarm Configuration
(Percent of Unattended Fires)

Extinguishment Method	Interconnected		In All Bedrooms		On All Floors	
	Yes	No	Yes	No	Yes	No
Nobody home	0.1	3.1	2.1	3.0	2.6	3.4
What was done to put out fire						
Put water on the fire	28.2	18.1	27.3	16.5	21.1	12.4
Turned off power to appliance	13.5	18.9	10.4	20.9	22.6	3.1
Smothered	4.8	17.5	8.7	18.5	13.1	26.8
Separated from heat source, moved outside	21.6	10.6	16.5	10.3	12.3	10.3
Used baking soda, salt, flour, etc.	7.4	6.8	7.1	6.8	7.4	4.9
Blew out the fire	9.7	6.0	3.5	7.4	7.7	1.8
Used an extinguisher	0.1	5.1	8.4	3.3	4.1	6.0
Other	7.7	1.5	5.1	1.2	2.4	1.4
How was fire ultimately extinguished						
Someone in the household	80.4	79.6	68.6	83.3	84.0	64.1
Went out by itself	15.9	18.1	29.5	14.0	13.7	32.7
Somebody else put it out	3.7	1.7	1.9	2.0	2.3	0.8
Estimated number of unattended fires (thousands)	*805*	*6,370*	*1,779*	*5,397*	*5,618*	*1,557*

Notes: See Table 8-4.

Table 8-24 shows that fires in residences with interconnected alarms were extinguished about the same way as those without interconnected alarms, except that there was more use of water and separation of heat source and fuel in the interconnected alarm residence fires, and more use of removal of power and smothering in non-interconnected alarm residence fires. Also, in residences with interconnected alarms, there was almost no use of extinguishers in contrast to residences that did not have interconnected alarms.

In comparing residences with alarms in all bedrooms against residences with at least one bedroom without an alarm, the pattern was almost the same as with interconnected alarms. The most frequent extinguishment method in residences with alarms in all bedrooms was to put water on the fire followed by separating the ignited item from the heat source, in contrast to turning off the power and smothering the fire in residences without alarms in all bedrooms. Residences with alarms in all bedrooms were more likely to use an extinguisher than residences without alarms in all bedrooms.

However, even in those residences, extinguisher use was limited, at 8.4 percent of incidents.

This pattern was very similar to the comparison between fires in residences with alarms on all floors and those in residences without alarms on all floors. When alarms were not on all floors, the most frequent way fires were put out was by smothering, while when alarms were on all floors, power was removed and water was used to put out the fire most frequently. Extinguishers were used in a slightly larger percentage of fires in homes where alarms were not on all floors. When the residence did not have alarms on all floors, residents were less likely to put out the fire. As shown in Table 8-24, residents were able to extinguish the fire in 84.0 percent of incidents in homes with alarms on all floors in contrast to 64.1 percent of incidents without alarms on all floors.

Table 8-25
Location and Use of Fire Extinguisher by Smoke Alarm Configuration
(Percent of Unattended Fires)

Extinguisher Location and Use	Interconnected		In All Bedrooms		On All Floors	
	Yes	No	Yes	No	Yes	No
Nobody home	0.1	3.1	2.1	3.0	2.6	3.4
Someone home and extinguisher available						
In same room where fire started	61.9	29.1	39.3	30.6	35.6	22.5
In different room	27.1	28.7	29.5	28.2	31.9	16.2
No extinguisher present	10.9	39.1	29.0	38.2	29.9	57.9
Someone tried to use an extinguisher						
Extinguisher was in room of fire origin	-	3.8	4.8	2.9	4.0	1.1
Extinguisher was in a different room	0.1	1.3	3.6	0.4	0.2	4.9
Results from using the extinguisher						
Put out the fire completely	0.1	2.8	5.9	1.4	2.3	3.2
Minimized but did not put out fire	-	1.3	-	1.5	1.4	-
Had little or no effect	-	0.7	2.4	-	-	2.8
Estimated number of unattended fires (thousands)	*805*	*6,370*	*1,779*	*5,397*	*5,618*	*1,557*

Notes: See Table 8-5.

Table 8-25 shows that, for most alarm configurations (interconnected, in all bedrooms, on all floors), extinguishers were more frequently used when located in the same room as where the fire started. The only exception to this was in homes where alarms were not on all floors. In such cases, the extinguisher was more frequently used when it was stored in a different room than the fire.

Tables 8-24 and 8-25 begin to investigate if having a better alarm configuration makes it more likely that extinguishers will be used and, if so, if extinguishers will be more likely to put out the fire. In the best alarm configuration (alarms interconnected), there seemed to be almost no use of extinguishers, despite that there were more incidents in residences that have extinguishers. In the least desirable alarm configuration, that of not having alarms on all levels, extinguishers were used in 6.0 percent of incidents. It therefore appears that the presence of interconnected alarms is not associated with an increased use of extinguishers.

Conclusion

In summary, smoke alarms were present in homes and were known to have sounded in an estimated 30.3 percent of fire incidents (30.0 percent of unattended fires and 40.0 percent of attended fires).

The remaining statistics presented in this chapter apply to fires that were not attended by fire departments. The percent of fires with someone home when the alarm sounded varied substantially by the area where the fire began, on average ranging from 0.8 percent of fires starting in the bathroom to 36.9 percent of fires in the kitchen. Fires involving stoves had the highest proportion of alarms sounding at 40.9 percent of incidents, followed by other cooking equipment at 30.4 percent, heating and cooling equipment at 17.9 percent, lighting and wiring at 6.4 percent, and other appliances at 3.7 percent. Among lighter, cigarette, and match fires, the alarm was reported to have sounded in 27.7 percent of fires, while in candle fires it was 19.5 percent, and in other non-appliance fires it was 19.4 percent.

When alarms were interconnected, respondents indicated that the alarm sounded in 53.3 percent of incidents in contrast to 27.0 percent of incidents when not interconnected. With alarms in all bedrooms, in 35.9 percent of incidents the alarm sounded; while with alarms not in all bedrooms, they sounded in 28.0 percent of incidents. When the alarms were on all floors, they sounded in 37.1 percent of incidents, in contrast to 4.1 percent otherwise.

Why did alarms not sound more frequently in unattended residential fires? Residents suggested that in most cases where the alarm did not sound, it was because not enough smoke had reached the alarm. In most cases, when the alarm did not sound, respondents believed that the alarm was in working order. Also, when enough smoke reached the alarm but it did not sound, most respondents reported that the alarm had been tested during the previous year.

The 1992 Smoke Detector Operability Study suggested that household residents overstate the proportion of alarms that were in working order. An estimated 78 percent of households thought all their household smoke alarms worked, but tests showed that in 12 percent of these households, at least one alarm did not work.[187] Moreover, more than half the non-working alarms were repaired by either installing new batteries or restoring AC power, implying that residents should have known that the alarms were not working because the alarms did not sound when the test button was operated.[188] There is no reason to believe that residents in the current survey had not similarly overestimated the percent of alarms that were working.

As mentioned in the introduction to this chapter, smoke alarms can provide three levels of benefits. First, the alarm can sound with or without alerting people. If it sounds but people have already become aware of the fire, say by smelling smoke, the sounding alarm can provide confirmation of the fire or can indicate that the fire is of sufficient seriousness for households to activate their escape plans. Second, the alarm can sound at the same time as they become aware of the fire in different ways, which then confirms that there is a fire, not just a nuisance alarm. Third, the alarm can provide the only alert of the fire. This does not mean that there would have been no other evidence of the fire if the alarm had not sounded, just that the other evidence might have occurred later.

Alarms alerted people to the fire in 11.8 percent of incidents, providing the only alert of the fire in 9.8 percent of incidents.[189] The sounding alarm alerted residents in 14.9 percent of fires starting in the kitchen, providing the only alert in 12.0 percent of those incidents. When the fire started in the basement, the sounding alarm alerted people in 12.4 percent of incidents, and the sounding alert was the only alert of those fires. Similarly, in 11.6 percent of fires starting in the bedroom, the alarm alerted residents and, again, the alarm provided the only alert in such cases. In stove/range fire incidents and other cooking equipment incidents, the alarm alerted residents in 15.7 percent and 16.0 percent of incidents, respectively, and was the only alert in 13.4 percent and 10.7 percent of incidents. In electrical lighting and wiring incidents, the alarm alerted people in 5.2 percent of incidents, always providing the only alert. In heating and cooling equipment fire incidents, the alarm alerted people in 4.1 percent of incidents, providing the only alert in 0.6 percent. It appears that alarms did not provide as much warning for heating and cooling incidents because (1) fewer household members were home when this type of fire started and (2) if someone was home, they were likely to be present at the fire origin.[190]

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[187] Smith, CL (1994), *op cit.*, page 15.
[188] *Ibid*., page 13. A small number of alarms failed the smoke test. Residents would not be expected to have tested their alarms with such a kit.
[189] This is similar to the experience in the United Kingdom where the sounding smoke alarm led to discovery of the fire in 12 percent of incidents. The most frequent reasons were someone in the room when the fire started, smelled smoke, and saw smoke/flames/sparks. Office of the Deputy Prime Minister (2006), "Fires in the Home: Findings from the 2004/05 Survey of English Housing." ODPM Publications, West Yorkshire, England.
[190] As discussed previously in the section about appliance fires, about one-third of the heating and cooling incidents involved central heating and cooling equipment, one-third portable heaters, and one-third were unspecified. Central heating equipment would usually be found in the basement. Portable heaters would

With non-appliance fires, alarms alerted people in 7.9 percent of lighter, cigarette, and match incidents and provided the only alert in all those incidents. In candle fires, the alarm alerted people in 6.9 percent of incidents and the only alert in 6.2 percent of incidents. For other non-appliance incidents, alarms alerted people in 2.7 percent of incidents and provided the only alert in 2.7 percent.

Did having alarms in all bedrooms, on all floors, and/or interconnected provide residents with additional warning of the fire? For interconnected alarms, the alarms alerted people in 26.0 percent of incidents in comparison with 10.0 percent for non-interconnected alarms. When the interconnected alarm alerted people, the alarms provided the only alert in those 26.0 percent of incidents, while the non-interconnected alarms provided the only alert in 7.6 percent of incidents.

When residents had alarms on all floors, alarms alerted people in 14.5 percent of unattended fire incidents, while if alarms were not on all floors, people were alerted in 1.9 percent of incidents. When on all floors, the sounding alarm provided the only alert in 11.9 percent of incidents compared with 1.9 percent of incidents when the alarms were not on all floors. It is worth noting that the category alarms on all floors, not only describes the placement of the alarms, but also suggests that residents may have had more alarms than those who did not have alarms on all floors.

Alarms in all bedrooms alerted people to the fire more frequently (16.0 percent vs. 10.4 percent), also providing the only alert more frequently (12.6 percent as compared with 8.8 percent).

Most unattended fires were put out by putting water on the fire, removing power, smothering, separating the fuel from the heat source, or some other method. Fire extinguishers were used in 5 percent of fire incidents (4.5 percent of unattended and 17.7 percent of attended fires), sometimes in combination with other methods. Fire extinguishers put out the fire completely in 2.5 percent of incidents, minimized the fire in 1.1 percent, and had little or no effect in 1.0 percent of incidents. Extinguishers were used in other non-appliance fires (19.4 percent of incidents), fires in other cooking equipment (9.9 percent), candle fires (9.5 percent), bedroom fires (8.6 percent of incidents), kitchen fires (5.2 percent), and lighter, cigarette, and match fires (4.6 percent).

There was a somewhat higher likelihood of the extinguisher being used when the extinguisher was located in the room where the fire started. In 45 percent of kitchen fires, the extinguisher was in the kitchen. Someone tried to use an extinguisher in almost 4.8 percent of kitchen fire incidents when it was in the same room and 0.4 percent of incidents when not in the same room. The extinguisher put out the fire completely in 3.1 percent of kitchen fires and minimized but did not put out the fire in the remaining 1.6 percent of kitchen fires when used. Used in lighter, cigarette, and match fires,

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be less likely to be found in the basement and more likely in the living room, dining room, or bedroom; i.e., that is where household members are likely to be. As a result, someone would be likely to be present when the fire started in fires involving portable heating equipment.

extinguishers put out the fire completely in 4.6 percent of incidents (all the incidents when used). Extinguishers were less effective against candle fires, putting out such incidents in 0.2 percent of cases and having little or no effect in 9.3 percent of incidents.

To sum up the findings in this chapter, more smoke alarms were better than fewer alarms in alerting residents to a fire. Alarms on all floors provided better alerting of fires than alarms on some floors, and alarms installed in all bedrooms provided better alerting than alarms in some bedrooms. Interconnected alarms, however, appeared to be best in alerting residents of a fire incident and, in particular, in providing the only alert of the incident.

Fire extinguishers helped in putting out some fires, although, as shown in the survey, their use was somewhat limited to certain types of fires. Also, extinguisher use depended on the location of the extinguisher. When located near the fire origin, extinguishers tended to be used more frequently than in fires that began far from the location of the extinguisher.

References

Ahrens M (2007a), "Home Structure Fires." National Fire Protection Association, Quincy, MA.

Ahrens M (2007b), "U.S. Experience with Smoke Alarms and Other Fire Detection/Alarm Equipment." National Fire Protection Association, Quincy, MA.

Ahrens M, Hall JR Jr., Comoletti J, Gamache S and LeBeau A (2007), "Behavioral Mitigation of Cooking Fires Through Strategies Based on Statistical Analysis," FEMA, Washington, DC.

American Association for Public Opinion Research (2000), "Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys," AAPOR, Ann Arbor, MI.

Audits and Surveys, Inc. (1985), "1984 National Sample Survey of Unreported, Residential Fires." Final Technical Report Prepared for the U. S. Consumer Product Safety Commission. Princeton, NJ.

Ballesteros M and Kresnow MJ (2007), "Prevalence of Residential Smoke Alarms and Fire Escape Plans in the U.S: Results from the Second Injury Control and Risk Survey (ICARIS-2)," *Public Health Reports*, Vol. 122, pp. 224-231.

Centers for Disease Control, National Center for Chronic Disease Prevention and Health Prevention (2005), "Smoking Prevalence Among U.S. Adults," available at www.cdc.gov/tobacco/research_data /adjults_prev/prevali.htm.

Centers for Disease Control (2007), "Cigarette Smoking Among Adults." *Morbidity and Mortality Weekly,* 56(4), 1157-1161.

Chowdhury R, Greene M and Miller D (2007), "2002-2004 Residential Fire Loss Estimates," U.S. Consumer Product Safety Commission, Washington, DC.

Chowdhury R, Greene M and Miller D (2008), "2003-2005 Residential Fire Loss Estimates," U.S. Consumer Product Safety Commission, Washington, DC.

Cummings P, Rivara FP, Thompson RS and Reid RJ (2005), "Ability of Parents to Recall the Injuries of Their Young Children," *Injury Prevention*, 11, pp. 43-47.

Department of Statistics University of Wisconsin (1977), "Statistical Analysis of the National Household Fire Survey," Madison, WI.

Fire Protection Association Australia (2005), "Fire Safety Data Sheet: Fire Extinguishers," Victoria, Australia.

Hall JR Jr. (2005), "Home Cooking Fire Patterns and Trends." National Fire Protection Association, Quincy, MA.

Hall JR Jr. (2004), "The Smoking-Material Fire Problem." National Fire Protection Association, Quincy MA.

Hall JR Jr. and Harwood B (1989), "The National Estimates Approach to U. S. Fire Statistics," *Fire Technology,* pp 99-113.

Harel Y, Overpeck MD, Jones DH, Scheidt PC, Bijur PE, Trumble AC and Anderson J (1994), "The Effects of Recall on Estimating Annual Nonfatal Injury Rates for Children and Adolescents," *American Journal of Public Health,* 84, 4, 599-605.

Hastie TJ and Tibshirani RJ (1990), *Generalized Additive Models,* Chapman and Hall, NY.

Karter MJ Jr. (2008), "Fire Loss in the United States 2007," National Fire Protection Association, Quincy, MA.

Karter MJ Jr. (2007), "Fire Loss in the United States 2006," National Fire Protection Association, Quincy, MA.

Karter MJ Jr. (2006), "Fire Loss in the United States 2005," National Fire Protection Association, Quincy, MA.

Karter MJ Jr. (2005), "Fire Loss in the United States 2004," National Fire Protection Association, Quincy, MA.

Karter MJ Jr. (2003), "U. S. Fire Experience by Region." National Fire Protection Association, Quincy, MA.

Khare M (2006), "Sample Design and Issues with Telephone Multi-Mode Surveys." Paper presented at the National Center for Health Statistics Data Users Conference, Washington, DC.

Landen DD and Hendricks S (1995), "Effect of Recall on Reporting of at-Work Injuries," *Public Health Reports,* 110:3, pp. 350-354.

Mah J (2001), "1998 Residential Fire Loss Estimates: U. S. National Estimates of Fires, Deaths and Property Losses from Non-Incendiary, Non-Suspicious Fires." U.S. Consumer Product Safety Commission, Washington, DC.

Market Facts (1993), "Smoke Detector Operability Study Final Report," Washington, DC.

Massey JT and Gonzalez JF (1976), "Optimum Recall Periods for Estimating Accidental Injuries in the National Health Interview Survey." Proceedings of the American Statistical Association, Social Statistics Section, Boston, MA, pp. 584-588.

Mobley C, Sugarman JR, Deam C and Giles L (1994), "Prevalence of Risk Factors for Residential Fire and Burn Injuries in an American Indian Community," *Public Health Reports, 109,* 5, 702-705.

Mock C, Acheampong F, Adei S and Koepsell T (1999), "The Effect of Recall on Estimation of Incidence Rates for Injury in Ghana," *International Journal of Epidemiology*, 28, 4, pp. 750-755.

Moshiro C, Heuch I, Astrom AN, Setel P and Kvale G (2005), "Effect of Recall on Estimation of Non-Fatal Injury Rates: A Community Based Study in Tanzania," *Injury Prevention,* 11, pp 48-52.

NFPA (2007), *NFPA 72, National Fire Alarm Code 2007Edition*. National Fire Protection Association, Quincy, MA.

Office of the Deputy Prime Minister (2006), "Fires in the Home: Findings from the 2004/05 Survey of English Housing." ODPM Publications, West Yorkshire, England.

Public/Private Fire Safety Council (2006), "Home Smoke Alarms." Washington, DC. Available at http://www.firesafety.gov/programs/alarms.shtm.

Rao JNK and Scott AJ (1984), "On Chi-Squared Tests for Multiway Contingency Tables with Cell Properties Estimated from Survey Data," *The Annals of Statistics*, 12, 46-60.

Rao JNK and Scott AJ (1987), "On Simple Adjustments to Chi-Square Tests with Survey Data," *The Annals of Statistics*, 15, 385-397.

Rohr K and Hall JR Jr. (2005), "U. S. Experience with Sprinklers and Other Fire Extinguishing Equipment," National Fire Protection Association, Quincy, MA.

Runyan CW, Bangdiwala SI, Linzer MA, Sacks JJ and Butts J (1992), "Risk Factors for Fatal Residential Fires," *New England Journal of Medicine, 12,* 327: 859-863.

SAS Institute Inc. (2004), *SAS/STAT® 9.1 Users Guide.* SAS Institute, Cary, NC.

Shah BV, Barnwell BG and Bieler GS (1996), *Sudaan User's Manual, Release 7.0*, Research Triangle Park, NC.

Schaefer JL (1997), *Analysis of Incomplete Multivariate Data*, Chapman and Hall, New York, pp. 134-135.

Smith CL (1994), "Smoke Alarm Operability Survey—Report on Findings." U.S. Consumer Product Safety Commission, Washington, DC.

Smith L, Monticone R and Gillum B (1999), "Range Fires: Characteristics Reported in National Fire Data and a CPSC Special Study." U.S. Consumer Product Safety Commission, Washington, DC.

Technology and Economics (1978), "Special Report: Results of National Household Fire Survey." Cambridge, MA.

Tourangeau R, Rips U and Rasinski K (2000), Chapter 4, "The Role of Memory in Survey Responding," in *The Psychology of Survey Response,* New York, Cambridge University Press.

U. S. Consumer Product Safety Commission (2008), "Smoke Alarms – Why, Where and Which." CPSC Document #559. Available at http://www.cpsc.gov/ CPSCPUB/PUBS/559.pdf.

Warda L, Tenenbein M and Moffatt MEK (1999), "House Fire Injury Prevention Update. Part I. A Review of Risk Factors for Fatal and Non-fatal House Fire Injury." *Injury Prevention* 5: 145-150.

Warner M, Schenker N, Heinen MA and Fingerhut LA (2005), "The Effects of Recall on Reporting Injury and Poisoning Episodes in the National Health Interview Survey," *Injury Prevention*, 11, pp. 282-287.

Wolter KM (1985), *Introduction to Variance Estimation*. Springer-Verlag, NY.

U.S. Census Bureau (2006a), "Table 3: Annual Estimates of the Population by Sex, Race and Hispanic or Latino Origin for the United States: April 1, 2000 to July 1, 2005." Available from http://www.census.gov/popest/national/asrh/NC-EST2005-srh.html.

U.S. Census Bureau (2006b), Current Housing Reports, Series H150/05, *American Housing Survey for the United States: 2005.* U. S. Government Printing Office, Washington, DC.

U.S. Consumer Product Safety Commission (1978), "Special Report: Results of National Household Fire Survey." HIA Special Report, U. S. Consumer Product Safety Commission, Washington, DC.

United States Fire Administration (1997), *Fire in the United States 1985-1994, Ninth Edition*. U.S. Fire Administration, Emmitsburg, MD.

United States Fire Administration (2003), "NFIRS 5.0 Complete Reference Guide." Emmitsburg, MD.

U.S. Fire Administration (1997), "The Many Uses of the National Fire Incident Reporting System." U.S. Fire Administration, Emmitsburg, MD.

U.S. Fire Administration (2006), “Investigation of Fatal Residential Structure Fires with Operational Smoke Alarms.” Topical Fire Research Series, U.S. Fire Administration, Emmitsburg, MD.

NATIONAL SAMPLE SURVEY OF RESIDENTIAL FIRES

Hello, I'm ____________________ calling on behalf of the Consumer Product Safety Commission in Washington, DC. We are conducting a voluntary nationwide survey on residential fires and your responses will be kept completely confidential.

IF REFUSAL OR UNWILLING, SAY:
Your telephone number was selected at random. Your answers to these few questions will provide vital information on the danger of household fires. I will try to keep the interview as brief as possible.

IF BUSY, SAY: I would be glad to call you back. What time would be most convenient for you?

DATE: __________ TIME: __________

IF FURTHER CLARIFICATION NEEDED, SAY:
The Consumer Product Safety Commission is trying to learn more about the kinds of fires people have so it can identify better ways to prevent injuries and deaths that occur in fires. In order to get scientifically accurate results, we are selecting telephone numbers randomly in your community and others across the nation. Under the terms of the Privacy Act of 1974, we are required to treat your answers as completely confidential. The information you give us will be greatly appreciated.

1. Have I reached you at home?

   Home 1
   Business or elsewhere............. 2 →**TERMINATE**

2. Are you one of the heads of this household?

   Yes.. 1
   No .... 2 →May I speak with her/him? REPEAT INTRODUCTION. IF NOT AVAILABLE: What time would be most convenient to call back?

DATE: __________ TIME: __________

We are interested in learning about any fires – large or small – that you have had in or around your home. By "fire" I mean any incident – large or small – that resulted in unwanted flames or smoke, and could have caused damage to life or property if left unchecked.
IF RESPONDENT UNSURE OF WHAT WE MEAN BY "HOME" SAY: By "home", I mean your house, apartment, or other residence where you live.

OMB 3041-0132 Expires 4/30/07

5. Have any of the following incidents occurred in or around your home in the past three months, that is since **(DATE THREE MONTHS AGO)**? **(ASK EACH, RECORD YES/NO) (AS NECESSARY:)** Have you had any fires due to (INSERT) in the past three months?

	Yes	No	DK	Ref
Unwanted flaming or smoking on the stove or another cooking appliance	1	2	8	9
A smoking electrical appliance	1	2	8	9
Burning or smoldering clothing, either being worn or not being worn	1	2	8	9
Smoldering fabric, mattress, rug, or upholstered furniture	1	2	8	9
A child igniting something with a match or lighter	1	2	8	9
A candle igniting something	1	2	8	9
A fire that started outside your home, and spread to the home	1	2	8	9
Any other fire – large or small - that produced unwanted flames or smoke	1	2	8	9

IF YES TO ONE OR MORE ITEMS ON Q5, THIS IS A FIRE HOUSEHOLD - CONTINUE.

EVERYONE ELSE, THIS IS A NON-FIRE HOUSEHOLD. A 1/40th SUBSAMPLE SHOULD GO TO Q81; THE REMAINING 39/40ths SHOULD BE THANKED AND TERMINATED.

RECORD: FIRE HOUSEHOLD 1
NON-FIRE HOUSEHOLD 2

6. How many fires – that is unwanted flames or smoke – have you had in your home or on your property since **(DATE 90 DAYS AGO)**?

One	1
Two	2
Three	3
Four	4
Five	5
Six	6
Seven	7
Eight	8
Nine	9
Ten or more	10
Don't know	11
Refused	12

PROGRAMMER NOTE: IF Q6 = 2 – 10, ASK Q7-Q102, THEN RETURN TO Q7 AND REPEAT QUESTIONS Q7 – 82b DESCRIBING EACH FIRE WITHIN THE PAST 3 MONTHS.

7. **(IF Q6 = 1)** Now I have some questions to ask you about the fire or incident. What was the date of the fire?
(IF Q6 = 2 - 10) Now I have some questions to ask you about the most recent fire or incident you mentioned. What was the date of the fire?
(IF Q6 = 11 or 12, READ:) Let's talk about the most recent one. What was the date of the most recent fire?
(FOR 2nd, 3rd, etc. fire:) Now I'd like to ask some questions about the fire before the one you just described. What was the date of that fire?
(PROBE: During which month did the fire occur?)

_____ (month)
Don't know **(GO TO Q7a)**
Refused **(GO TO Q7a)**

_____ (Date)
Don't Know **(GO TO Q7a)**
Refused **(GO TO Q7a)**

7a. Just to confirm, the fire did take place on or after **(DATE 90 DAYS AGO)**.

Yes 1
No .... 2 → **1/40th SUBSAMPLE GO TO Q81; OTHERWISE TERMINATE**
Don't know .... 3 →**1/40th SUBSAMPLE GO TO Q81; OTHERWISE TERMINATE**
Refused .... 4 →**1/40th SUBSAMPLE GO TO Q81; OTHERWISE TERMINATE**

8. About what time of day did the fire start? **(INTERVIEWER: IF NOON, ENTER 12:00PM. IF MIDNIGHT, ENTER 12:00AM)**

ENTER TIME ____________

Don't know **(GO TO Q8a)**
Refused **(GO TO Q8a)**

8a. **(IF Q8 = DK, REF:)** Could you tell me if the fire happened: **(READ CATEGORIES)**

In the morning (**DO NOT READ:** from 6am until before noon) 1
In the afternoon (**DO NOT READ:** from noon until before 5 PM) 2
In the evening (**DO NOT READ:** from 5 PM until before 9 PM) 3
At night (**DO NOT READ:** from 9 PM until before midnight) 4
Or, overnight (**DO NOT READ:** from midnight until before 6 AM) 5

Don't know 6
Refused 7

9. Did the fire involve the inside of your home, the exterior of your home, or did it happen somewhere else?

Inside your home .... 1 **GO TO Q12**
Exterior of your home .... 2 **GO TO Q12**
Somewhere else **(SPECIFY)** ____________________ 3
Don't know 8
Refused 9

IF Q9 = 3, 8, OR 9, ASK:

10. Did the fire spread to your home? **(IF RESPONDENT SEEMS UNAWARE OF FIRE DETAILS, ASK FOR ANOTHER ADULT WHO MAY KNOW MORE ABOUT THE FIRE)**

Yes .... 1 **GO TO Q10-1**
No .... 2 **1/40th SUBSAMPLE GO TO Q81; OTHERWISE TERMINATE**
Don't know .... 3 **ASK FOR OTHER ADULT; IF NO OTHER, GO TO 1/40TH SUBSAMPLE OR TERMINATE**
Refused .... 4 **ASK FOR OTHER ADULT; IF NO OTHER, GO TO 1/40TH SUBSAMPLE OR TERMINATE**

IF OTHER ADULT IS BROUGHT TO THE PHONE, REINTRODUCE: We are calling from Synovate on behalf of the Consumer Product Safety Commission and would like to ask you some questions about the fire at your home on (DATE FROM Q7) . (IF NO DATE PROVIDED IN Q7, READ: about the recent fire at your home; GO BACK TO Q7 to start the interview).

IF DATE IS PROVIDED, RE-ASK Q9 WITH THE NEW RESPONDENT.

Q10a. **(IF NEW RESPONDENT IS ON THE PHONE)** To confirm, the fire **started (POP-IN RESPONSE FROM Q8 or Q8a)**. Is this correct?

Yes (GO TO Q9) 1
No (GO BACK TO Q8) 2
Don't know (GO TO Q9) 3
Refused (GO TO Q9) 4

Q10-1. (ASK IF Q10 =1) And did the fire reach: **(READ LIST)**

The outside of the house only 1
The inside of your house only 2
Both the inside and the outside of your home 3
DO NOT READ: Did not reach my home .... 4 **1/40TH SENT TO Q.81, 39/40TH THANK & TERM**
Don't know .... 5 **1/40TH SENT TO Q.81, 39/40TH THANK & TERM**
Refused .... 6 **1/40TH SENT TO Q.81 39/40TH THANK & TERM**

ASK Q12 IF Q9=1 or 2, OR Q10-1 = 1, 2 , 3 DK, or REF:

12. (IF Q9 = 1, ASK:) In which room of your home did the fire start?
(IF Q9 = 2, ASK:)What part of the exterior of your home caught fire first?
(IF Q9 = 3, 8, OR 9 ASK:)Where did the fire start?

(DO NOT READ RESPONSES; ACCEPT ONE RESPONSE) (IF RESPONDENT SEEMS UNAWARE OF FIRE DETAILS, ASK FOR ANOTHER ADULT WHO MAY KNOW MORE ABOUT THE FIRE)

INTERVIEWER NOTE: IF NEEDED ASK: In which room or area of your home did the fire start?

Attached garage or carport.. 1
Attic 2
Basement 3
Bathroom 4
Bedroom 5
Dining Room / area.. 6
Kitchen 7
Laundry room 8
Living room (including Den, Rec Room, and Family Room) 9
Porch or deck 10
Roof 11
Siding of the home.. 12
Storage area 13
Utility Room (including heating area/furnace room).. 14
Within enclosed wall space or space within ceiling and floor above 15
Crawl space, including under mobile home.. 16
Other exterior locations **(Please Specify)**: ____________________________.... 17
Hall, entryway.. 18
Other **(Please Specify)**: ____ 19
Don't know 20
Refused 21

14. Which of the following categories best describes the source of heat that started the fire? **(READ CATEGORIES 1 – 9) (INTERVIEWER: PROBE RESPONSE, IF NECESSARY) (IF RESPONDENT SEEMS UNAWARE OF FIRE DETAILS, ASK FOR ANOTHER ADULT WHO MAY KNOW MORE ABOUT THE FIRE)**

A cooking appliance, such as a stove, toaster, or coffee maker
(IF NECESSARY: including parts such as pipes, wiring, and power cords) 1
Heating or air conditioning equipment, such as a furnace or air conditioner
(IF NECESSARY: including parts such as pipes, wiring, and power cords) 2
Electrical lighting or wiring 3
Another household appliance
(IF NECESSARY: Such as a TV, washer/dryer, iron, hair dryer or power tools) 4
A lit cigarette, cigar, or other smoking materials 5
An open flame, such as a candle, match, torch, or lighter.. 6 **(GO TO Q14a)**
A fire that started somewhere else and spread to your home 7
Lightning, or.. 8
Something else (SPECIFY)... 9
Don't know 98
Refused 99

Q14a. **(ASK IF Q14 = 6:)** Specifically, what was the source of the heat? **(READ CODES ONLY IF NECESSARY)**

Candle 1
Match... 2
Lighter 3
Torch 4
Spark from a fireplace 5
Other open flame (SPECIFY) 6
Don't know.. 8
Refused.. 9

ASK Q15 IF Q14 = ALL RESPONSES EXCEPT 8; ELSE GO TO Q17a

15. Was a child younger than age 10 involved in starting this fire?

Yes .... 1 **GO TO Q15a**
No .... 2 **GO TO Q17a**
Don't know .... 3 **GO TO Q17a**
Refused .... 4 **GO TO Q17a**

15a. How old was the child? **(RECORD IN YEARS, IF CHILD IS LESS THAN 1 YEAR OLD, ENTER 0, AND GO TO Q15B)**

ENTER NUMBER 0 – 9 ______
Don't know 98
Refused 99

15b. **(IF AGE IS LESS THAN 1 YEAR OLD) RECORD AGE IN MONTHS RANGE 1 - 11**

ENTER NUMBER 1 – 11 ______
Don't know 98
Refused 99

17a. Now please think of the items that caught on fire. What item caught fire first? **(RECORD RESPONSES VERBATIM; ACCEPT ONE RESPONSE ONLY)**

17. What other items caught fire? **(RECORD RESPONSES VERBATIM) (PROBE TO GET UP TO 3 RESPONSES: Anything else?)**

IF "2" IN Q14, CONTINUE;
IF "4, OR 9" ON Q14, SKIP TO Q23;
IF "1" ON Q14 GO TO Q25;
IF "3" ON Q14, SKIP TO Q29;
IF "5, 6, 7, 8, 98, 99" ON Q14, SKIP TO INSTRUCTION BEFORE Q31

20. What kind of heating or air conditioning appliance or equipment was involved in starting the fire? **(DO NOT READ RESPONSES; ACCEPT ONE RESPONSE)**

Central Air Conditioner (except heat pump) 1
Central heating furnace 2
Chimney, chimney connector 3
Fireplace 4
Heat Pump 5
Heating stove 6
Other fixed local heater 7
Portable heater (including kerosene heater) 8
Room Air Conditioner 9
Water Heater 10
Other **(Please Specify)**: ____________________ . 11
Don't know 12
Refused 13

20a. **(IF Q20 = 2,4,6, OR 7:)** Did the fire involve the product itself or an attached chimney or vent?

The product / equipment 1
The chimney / vent 2
Both (DO NOT READ) 3

Don't know 4
Refused 5

20b. **(IF Q20 = 3:)** What kind of heating equipment was the chimney attached to – **READ CODES**

A central heating furnace... 1
A fireplace 2
A heating stove 3
Some other fixed local heater 4
Or something else (SPECIFY) ___________________....................................... 5

Don't know 6
Refused 7

21. What kind of fuel/source of power did it use? **(DO NOT READ RESPONSES; ACCEPT ONE RESPONSE) (IF RESPONDENT SAYS "GAS" PROBE WITH:** What type of gas is that?**)**

Battery only 1
Coal... 2
Electricity (including with a battery backup)..... 3
Fuel Oil 4
Gas (type unknown).. 5
Gasoline 6
Kerosene 7
Natural gas.. 8
Propane, butane (liquid petroleum gas) 9
Wood, pellets 10
Other **(Please Specify)**: _________________ 11
Don't know 12
Refused 13

ASK IF Q20 = 2, 4, 5, 6, 7 OR 8; ELSE GO TO INSTRUCTION BEFORE Q31

22. Was this the main source of heat for your home at the time of the fire?

Yes 1
No .... 2 →**SKIP TO INSTRUCTION BEFORE Q31**
Don't know 3
Refused 4

23. What kind of item or equipment provided the heat or flame that started the fire? **(DO NOT READ RESPONSES; ACCEPT ONE RESPONSE)**

Clothes dryer... 1
Clothes washer... 2
Dishwasher 3
Fan 4
Home entertainment (radio, CD, DVD, VCR players,
speakers – excluding TV) 5
Home office equipment such as a computer, printer, fax, etc...... 6
Iron (such as an iron used for clothing or textiles) 7
Lawn equipment 8
Other fixed / installed equipment (e.g. trash compactor)
(Please Specify): _________... 9
Personal grooming equipment (hair dryer, curling iron, etc.).... 10
Power tools 11
Refrigerator or freezer 12
Television 13
Toys 14
Other portable appliance / equipment **(Please Specify)**: ____ .. 15
Other (Please specify) _________.. 16
Don't know 17
Refused 18

24. What kind of fuel/source of power did it use? **(DO NOT READ RESPONSES; ACCEPT ONE RESPONSE) (IF RESPONDENT SAYS "GAS" PROBE WITH:** What type of gas is that?**)**

Acetylene 1
Battery only 2
Coal... 3
Electricity (including with a battery backup).............................. 4
Fuel Oil 5
Gas (type unknown)... 6
Gasoline 7
Kerosene 8
Natural gas 9
Propane, butane (liquid petroleum gas) 10
Wood 11
Other **(Please Specify)**: ______________________________. 12
Don't know 13
Refused 14

→**SKIP TO INSTRUCTION BEFORE Q31**

25. Did this fire involve food, cooking oil, or grease catching on fire?

Yes 1
No 2
Don't know 3
Refused 4

27-1. Did the fire involve a cooking stove, range, built-in oven or a cook top?

Yes .... 1 **(GO TO Q28)**
No .... 2 **(GO TO Q27-2)**
Don't know .... 3 **(GO TO Q27-2)**
Refused .... 4 **(GO TO Q27-2)**

27-2. **(ASK IF Q27-1 NE 1:)** What kind of cooking or food preparation appliance or equipment provided the heat that started the fire? **(IF UNSURE OF RESPONSE, PROBE: Is this item supposed to produce heat?) (DO NOT READ RESPONSES; ACCEPT ONE RESPONSE)**

Coffeemaker, teapots 1
Deep fryer, crock pot 2
Frying pan/Skillet 3
Hot Plate 4
Indoor grill (countertop) 5
Microwave oven 6
Oven - countertop 7
Pressure cooker/Canner 8
Rotisserie (countertop)..................................... 9
Toaster oven.. 10
Toaster 11
Turkey fryer 12
Other appliance intended to provide heat for
cooking **(SPECIFY)**.................................... 13
Outdoor grill 14
Other **(Specify)** 15
Don't know 16
Refused 17

28. What kind of fuel/source of power did it use? **(DO NOT READ RESPONSES; ACCEPT ONE RESPONSE) (IF RESPONDENT SAYS "GAS" PROBE WITH:** What type of gas is that?**)**

Aerosol 1
Battery 2
Charcoal 3
Coal 4
Electricity (including battery backup) 5
Fuel Oil 6
Gas (type unknown) 7
Gasoline 8
Kerosene 9
Lighter fluid 10
Natural gas 11
Propane, Butane (liquid petroleum gas) 12
Wood 13
Other **(Please Specify)**: _______________ 14
Don't know 15
Refused 16

SKIP TO INSTRUCTION BEFORE Q31

29. What part of the electrical wiring or lighting system was involved in starting the fire? **(DO NOT READ RESPONSES; ACCEPT ONE RESPONSE)**

Lamp cord 1
Extension cord 2
Fuse, circuit breaker panel 3
Light fixture 4
Other installed wiring 5
Portable lamp, light bulb 6
Power strip / surge protector 7
Switch or outlet 8
Other **(Please Specify)**: ______________________________ ... 9
Don't know 10
Refused 11

ASK IF Q14 = 1,2,3,4, 6, OR 9; ELSE, GO TO Q34

31. Did the source of heat that started the fire seem to be working properly just before the fire?

Yes 1
No 2
Don't know 3
Refused 4

IF Q25 = 1, SKIP TO Q34

32. Did any flammable liquids, gases, or vapors ignite?

Yes 1
No .... 2 **SKIP TO Q34**
Don't know .... 3 **SKIP TO Q34**
Refused .... 4 **SKIP TO Q34**

IF YES, ASK;
33. What kind of flammable liquids, gases, or vapors were involved in the fire? **(DO NOT READ RESPONSES; ACCEPT ONE RESPONSE)**

Adhesives.. 1
Aerosol 2
Cleaning materials 3
Gasoline 4
Kerosene 5
Natural gas 6
Propane, butane (liquid petroleum gas) 7
Gas (type unknown).. 8
Lighter fluid 9
Other **(Please Specify)**: _________________ 10
Don't know 11
Refused 12

34. How many people were in the home when the fire started?

ENTER NUMBER ____________

IF 0, SKIP TO Q36 IF FIRST FIRE DISCUSSED; Q35a FOR ALL OTHER FIRES.
IF 1, SKIP TO Q35a5 IF FIRST FIRE DISCUSSED THEN GO TO Q36. FOR ALL OTHER FIRES THEN GO TO Q35a.
IF MORE THAN 1, CONTINUE WITH Q35.

Don't know .... 98 **(SKIP TO Q36/35a)**
Refused .... 99 **(SKIP TO Q36/35a)**

35. Of the (POP-IN) people in the home at the time of the fire, how many were between the ages of 18 and 64?

ENTER NUMBER ____________

Don't know .... 98 **(SKIP TO Q35a1)**
Refused .... 99 **(SKIP TO Q35a1)**
IF RESPONSE AT Q35 EQUALS RESPONSE AT Q34, GO TO Q36/35a. IF RESPONSE AT Q35 IS LESS THAN RESPONSE AT Q34, ASK Q35a1.

35a1. Were there any people in the home under the age of 18?

Yes .... 1 **(GO TO Q35a2)**
No .... 2 **(SKIP TO Q35a3)**
Don't know .... 3 **(SKIP TO Q35a3)**
Refused .... 4 **(SKIP TO Q35a3)**

IF YES, ASK:
35a2. How many were: **ENTER NUMBERS**

Less than 5 years old.......... ____
5 to 9 years old.................. ____
10 to 14 years old.............. ____
15 to 17 years old.............. ____

Don't know 98
Refused 99

IF SUM OF RESPONSES AT Q35 AND Q35a2 EQUALS RESPONSE AT Q34, GO TO Q36/35a. IF Q35a1 = 2,3,4 OR SUM OF RESPONSES AT Q35 AND Q35a2 IS LESS THAN RESPONSE AT Q34, ASK Q35a3.

35a3. Were there any people in the home over the age of 64?

Yes .... 1 **(GO TO Q35a4)**
No .... 2 **(SKIP TO Q36/35a)**
Don't know .... 3 **(SKIP TO Q36/35a)**
Refused .... 4 **(SKIP TO Q36/35a)**

IF YES, ASK:
35a4. How many were: **ENTER NUMBERS**

65 – 74 years old .... ____
75 or older .... ____

Don't know 98
Refused 99

IF THIS IS THE FIRST FIRE DISCUSSED, GO TO Q36; ASK Q35a – Q35c WHEN ASKING ABOUT ALL SUBSEQUENT FIRES

35a5. **(ASK IF Q34 = 1)** What was the age of this person? **DO NOT READ LIST. ONLY READ LIST IF NEEDED.**

Less than 5 years old................1
5 to 9 years old………………..2
10 to 14 years old……………..3
15 to 17 years old……………..4
18 to 64 years old……………..5
65 – 74 years old 6
75 or older 7

Don't know.............................8
Refused...................................9

IF THIS IS THE FIRST FIRE DISCUSSED, GO TO Q36; ASK Q35a – Q35c WHEN ASKING ABOUT ALL SUBSEQUENT FIRES

Q35a. Did this fire occur in the same property as the fire we just discussed?

Yes..1 **(GO TO Q35B)**
No...2 **(SKIP TO Q36)**
Don't know.............................3 **(SKIP TO Q36)**
Refused...................................4 **(SKIP TO Q36)**

Q35b. Did you make any changes in the number or type of smoke detectors in this property between this fire and the last fire discussed?

Yes..1 **(GO TO Q35C)**
No...2 **(SKIP TO Q42)**
Don't know.............................3 **(SKIP TO Q42)**
Refused...................................4 **(SKIP TO Q42)**

Q35c. Did you make any changes to the detectors on the (lowest/next) level?

Yes..1 **(GO TO Q38 and Q39)**
No...2
Don't know.............................3
Refused...................................4

REPEAT Q35C / Q38-Q39 FOR ALL LEVELS. THEN GO TO INSTRUCTION BEFORE Q42

36. Did you have any smoke detectors in this home or apartment at the time of the fire? Do not include heat detectors or CO detectors.

Yes..1
No...2
Don't know.............................3
Refused...................................4

37. **(READ INTRO IF Q36 = 1:)** Now I would like to find out how many smoke detectors you had on each level of your home at the time of this fire…

INTERVIEWER NOTE: IF NEEDED FOR PEOPLE WHO LIVE IN SHARED HOUSING SITUATION, SAY: I only need to know about your unit, not the entire building.

How many levels does your home or apartment have? Please include an unfinished basement, but do not include an unfinished attic.

ENTER NUMBER ____________

Don't know .... 98 **(SKIP TO INSTRUCTION BEFORE Q42)**
Refused .... 99 **(SKIP TO INSTRUCTION BEFORE Q42)**

IF Q36 NE 1, GO TO Q39a

38. **(IF MORE THAN ONE LEVEL, ASK:** How many smoke detectors did you have in the lowest level of your home or apartment at the time of the fire? / How many smoke detectors did you have on the (other / next) level of your home) at the time of the fire?
(IF ONE LEVEL IN HOME, ASK: How many smoke detectors did you have in your home or apartment at the time of the fire?

ENTER NUMBER ____________

Don't know .... 98 **(SKIP TO INSTRUCTION BEFORE Q42)**
Refused .... 99 **(SKIP TO INSTRUCTION BEFORE Q42)**

39. We're now going to ask you about how the smoke detectors on this level of your home or apartment are powered. Smoke detectors can be powered by battery, by AC connection, or by a combination of battery and AC connection. Thinking about this level of your home… **(READ INTRO ONLY WHEN RESPONDENT ASKED Q39 FOR THE FIRST TIME. DO NOT READ INTRO FOR SUBSEQUENT TIMES Q39 IS ASKED.)**

(IF MORE THAN ONE DETECTOR, ASK:) How many of the (POP-IN) detectors on this level were
(IF ONE DETECTOR ON THIS LEVEL, ASK:) Was your detector on this level **(READ OPTIONS, ENTER A "1" FOR THE POWER SOURCE.)**

Operated only by battery .... ________
Operated by AC connection without battery back-up.... ________
Operated by a combination of AC and battery .... ________

Don't Know 98
Refused 99

(ASK 39_1 IF ANSWERED 98 OR 99 WHEN ASKED Q39 FOR THE 1ST TIME. IF DID NOT ANSWER 98 OR 99 WHEN ASKED FOR THE 1ST TIME, REPEAT Q's 38 and 39 for each level in the home); ASK Q39_1 ONLY ONCE.

39_1 Are you familiar with how any of the smoke detectors in your home are powered?

Yes 1
No 2
Don't know 3
Refused 4

IF Q39_1 = 1, REPEAT Q38 AND Q39 FOR EACH LEVEL IN THE HOME. IF Q39_1 = 2,3,4 REPEAT ONLY Q38 FOR EACH LEVEL IN THE HOME. THEN GO TO Q39A IF THIS IS THE FIRST FIRE IN THIS PROPERTY; ELSE GO TO INSTRUCTION BEFORE Q42.

39a. Did you make any changes in the number or type of detectors in this property since this fire?

Yes .... 1 **(GO TO Q39B)**
No .... 2 **(IF Q36 = 1, SKIP TO Q42; ELSE SKIP TO Q50)**
Don't know .... 3 **(IF Q36 = 1, SKIP TO Q42; ELSE SKIP TO Q50)**
Refused .... 4 **(IF Q36 = 1, SKIP TO Q42; ELSE SKIP TO Q50)**

39b. How many detectors do you have now on the (lowest/next) level?

ENTER NUMBER ____________

Don't know .... 98 **(SKIP TO INSTRUCTION BEFORE Q42)**
Refused .... 99 **(SKIP TO INSTRUCTION BEFORE Q42)**

39c. **(IF MORE THAN ONE DETECTOR, ASK:)** How many of the (POP-IN) detectors on this level are **(IF ONE DETECTOR ON THIS LEVEL, ASK:)** Is your detector on this level **(READ OPTIONS, ENTER A "1" FOR THE POWER SOURCE.)**

Operated only by battery .... ________
Operated by AC connection without battery back-up.... ________
Operated by a combination of AC and battery .... ________
Unknown .... ________

Refused 99

REPEAT Q39B and Q39C for each level in the residence, then go to instruction before Q42

ASK Q42 – Q49 ONLY IF SOMEONE WAS HOME WHEN THE FIRE STARTED – Q 34 = 1 OR MORE; ELSE GO TO INSTRUCTION BEFORE Q50

42. What alerted someone in the household to respond to the fire? **(DO NOT READ, RECORD ALL THAT APPLY) (NOTE: APPLIES TO THE PERSON WHO RECOGNIZED THE FIRE)**

INTERVIEWER NOTE: PROBE WHEN NECESSARY: Did anything happen before that? Anything else?

Animal alerted person………………………………………… 1
CO detector sounded.. 2
Felt heat from the fire 3
Heard fire burning.. 4
Heat detector sounded.. 5
Noticed/smelled smoke.. 6
Person was there when fire started 7
Saw flames... 8
Saw smoke 9
Smoke detector alarm sounded 10
Someone in the house noticed the fire 11
Someone outside the house alerted 12
Some other way **(Please Specify)**: ______________________.. 13
Don't know 14
Refused 15

Now let's talk about flames and smoke
42a. When the fire was discovered, were there… **(READ RESPONSES)**

No flames visible 1
Flames visible but confined to one item 2
Flames spread to several items 3
Flames spread to whole room 4
Flames spread beyond the room 5
Don't know 6
Refused 7

42b. Tell me about the smoke. When the fire was discovered, was there… **(READ RESPONSES)**

No visible smoke 1
Smoke only around the fire source 2
Smoke filled the room of origin........................ 3
Smoke spread outside the room of origin 4
Don't know 5
Refused 6

IF Q36 = 2,3, OR 4, GO TO INSTRUCTION BEFORE Q50
IF Q10-1 = 1 , SKIP TO INSTRUCTION BEFORE Q50
IF RESPONSE 10 NOT MENTIONED IN Q42, ASK Q42c – Q49a; ELSE GO TO Q50

42c. Was there a detector in the room where the fire started?

Yes .... 1 **(SKIP TO Q43)**
No .... 2 **(CONTINUE)**
Don't know .... 3 **(SKIP TO Q43)**
Refused .... 4 **(SKIP TO Q43)**

42d. Was there a door between the location where the fire started and the nearest detector?

Yes .... 1 **(GO TO Q42e)**
No .... 2 **(GO TO Q43)**
Don't know .... 3 **(GO TO Q43)**
Refused .... 4 **(GO TO Q43)**

42e. And was this door: **(READ CODES 1 – 3)**

Fully open 1
Partially closed, or 2
Fully closed........ 3

Don't know 4
Refused 5

Now I have some questions about the smoke detector closest to the fire's origin, or the one you think was most likely to have been exposed first to smoke from the fire.

43. Did that smoke detector sound an alarm at any time during the fire?

Yes .... 1 **SKIP TO Q49a**
No .... 2 **CONTINUE**
Don't know .... 3 **SKIP TO Q49a**
Refused .... 4 **SKIP TO Q49a**

44. Do you think that enough smoke reached the smoke detector that it should have sounded?

Yes .... 1 **CONTINUE**
No .... 2 **SKIP TO Q48**
Don't know .... 3 **SKIP TO Q48**
Refused .... 4 **SKIP TO Q48**

45. Before the fire, did you think that this smoke detector was in working order?

Yes .... 1 **SKIP TO Q48**
No .... 2 **CONTINUE**
Don't know .... 3 **SKIP TO Q48**
Refused .... 4 **SKIP TO Q48**

46. Why do you think the smoke detector was not in working order? **(DO NOT READ)**

Had a dead battery	1	**SKIP TO Q48**
No battery or power	2	**CONTINUE**
It was just broken	3	**SKIP TO Q48**
Some other reason **(SPECIFY)** __________	4	**SKIP TO Q48**
Don't know	5	**SKIP TO Q48**
Refused	6	**SKIP TO Q48**

47. Why was there no battery or power to this smoke detector? **(DO NOT READ) (RECORD ALL THAT APPLY)**

The alarm sounded continuously	1
Nuisance alarms	2
It was beeping / chirping	3
Took the battery for something else	4
Needed to buy a new battery	5
Some other reason **(SPECIFY)**__________	6
Don't know	7
Refused	8

48. When was the last time before the fire that you tested this smoke detector to see if it worked? Would you say… **(READ CATEGORIES)**

Less than 1 month before the fire	1
1 to 6 months before the fire	2
7 months to a year before the fire	3
More than one year before the fire	4
Had not checked the smoke detector	5
Don't know	6
Refused	7

49a. Did this detector contain a long-life battery that does not need to be replaced every year?

Yes	1
No	2
Don't know	3
Refused	4

(ASK IF Q36 = 1 OR Q39a = 1; ELSE GO TO Q51)

50. Is there a smoke detector in the bedroom where you sleep?

Yes .... 1 GO TO Q50o
No .... 2 GO TO INSTRUCTION BEFORE Q50a
Don't know .... 3 GO TO INSTRUCTION BEFORE Q50a
Refused .... 4 GO TO INSTRUCTION BEFORE Q50a

50o. **(ASK IF Q50 = YES:)** Currently, do you have a smoke detector in every bedroom in your home or apartment?

Yes 1
No 2
Don't know 3
Refused 4

ASK Q50a ONLY IF THE HOUSE HAS MORE THAN ONE DETECTOR; ELSE GO TO Q51

50a. Are your detectors connected to each other, so that if one sounds, they all sound?

Yes 1
No 2
Don't know 3
Refused 4

50a1. Are your detectors connected to a home security service?

Yes 1
No 2
Don't know 3
Refused 4

51. Did you have any fire extinguishers in your home at the time of the fire?

Yes .... 1 **(CONTINUE)**
No .... 2 **(SKIP TO Q57)**
Don't know .... 3 **(SKIP TO Q57)**
Refused .... 4 **(SKIP TO Q57)**

51a. How many fire extinguishers did you have?

ENTER NUMBER _______
(RANGE 1 – 9)

Don't know 98
Refused 99

52. Where (was/were) the fire extinguisher(s) kept? **(DO NOT READ; RECORD ALL THAT APPLY)**

Basement	1
Bathroom	2
Bedroom	3
Car	4
Closet / hall closet	5
Garage	6
Kitchen	7
Laundry room	8
Other **(Please Specify)**: ____________________	9
Don't know	10
Refused	11

(ASK IF Q34 = 1 OR MORE; ELSE GO TO Q57)

53. Did anyone attempt to use a fire extinguisher to put out the fire?

Yes	1	**CONTINUE**
No	2	**SKIP TO Q57**
Don't know	3	**SKIP TO Q57**
Refused	4	**SKIP TO Q57**

54. Did the fire extinguisher…**(READ CATEGORIES 1 - 3)**

Put out the fire entirely	1	**GO TO Q56**
Minimize the fire, but not put it out completely, or	2	**GO TO Q55**
Have little or no impact on the fire	3	**GO TO Q55**
Don't know	4	**GO TO Q56**
Refused	5	**GO TO Q56**

55. **ASK IF Q54 = 2 OR 3; ELSE GO TO Q56:** Why didn't the fire extinguisher put out the fire completely? **(DO NOT READ; RECORD ALL THAT APPLY)**

Didn't know how to use it	1
It wasn't charged / it was empty	2
It was used incorrectly	3
It was partially empty	4
The equipment failed / didn't work	5
The fire was too large	6
Other **(Please specify)**	7
Don't know	8
Refused	9

56. How many fire extinguishers did you try to use on this fire?

One	1
Two	2
Three	3
Four or more	4
Don't know	5
Refused	6

57. How many fire extinguishers do you currently have in your home?

ENTER NUMBER ____________

Don't know 98
Refused 99

IF Q10-1 = 1, SKIP TO Q63

58. At the time of the fire, was there a sprinkler system installed in your home?

Yes .... 1 **CONTINUE**
No .... 2 **SKIP TO Q63**
Don't know .... 3 **SKIP TO Q63**
Refused .... 4 **SKIP TO Q63**

58a. Was your sprinkler system connected to a home security service?

Yes 1
No 2
Don't know 3
Refused 4

59. Did the sprinkler system spray water at the time of the fire?

Yes 1
No 2
Don't know 3
Refused 4

59a. Was there a sprinkler head in the room or immediate area where the fire started?

Yes 1
No .... 2 **(GO TO INSTRUCTION BEFORE Q61)**
Don't know .... 3 **(GO TO INSTRUCTION BEFORE Q61)**
Refused .... 4 **(GO TO INSTRUCTION BEFORE Q61)**

IF Q12 = 15, SKIP TO INSTRUCTION BEFORE Q61

60. Did the flames spread beyond the room where the fire started or were the flames kept just to the room where the fire started?

Spread beyond 1
Kept to room where it started 2
Don't know 3
Refused 4

ASK IF Q59 = 2, THEN GO TO Q63

61. To the best of your knowledge, at the time of the fire, was the water supply to your sprinkler system turned on?

Yes 1
No 2
Don't know 3
Refused 4

ASK IF Q59 = 1; ELSE GO TO Q63

62. Did the sprinkler system…**(READ CATEGORIES 1 - 3)**

Put out the fire entirely 1
Minimize the fire, but not put it
out completely, or 2
Have little or no impact on the fire 3
Don't know 4
Refused 5

63. Do you currently have a sprinkler system installed in your home?

Yes 1
No 2
Don't know 3
Refused 4

ASK IF Q34 = 1 OR MORE; ELSE GO TO Q67

Now I'd like to talk about some of the things people do or actions they take when they discover a fire. Again, by fire, we mean any unwanted flames or smoke.

(ASK IF Q53 NE 1) (IF Q53 = 1, GO TO Q64a)

64. Did anyone in the house try to put out the fire?

Yes 1
No .... 2 |
Don't know .... 3 | →**SKIP TO Q66**
Refused .... 4 |

64a. In addition to using a fire extinguisher, did anyone do anything else to put out the fire?

Yes .... 1 **(CONTINUE)**
No .... 2 **(GO TO Q66)**
Don't know .... 3 **(GO TO Q66)**
Refused .... 4 **(GO TO Q66)**

65. What did that person do to try to put out the fire? **(DO NOT READ; ENTER ALL THAT APPLY)**

Brought burning item to tap water 1
Brought tap water to burning item 2
Cut off power to involved equipment 3
Moved burning item outside 4
Separated burning/smoldering material and heat source 5
Smothered with pot lid, blanket, etc. 6
Used baking soda, salt, other common product 7
Used flour 8
Used home fire extinguisher 9
Used hose 10
Other **(Please Specify)**: ______________________________ . 11
Don't know 12
Refused 13

66. Was the fire serious enough to cause people to leave the residence, or try to leave?

Yes 1
No 2
Don't know 3
Refused 4

67. Did the fire department come?

Yes 1
No 2
Don't know 3
Refused 4

68. Who finally put out the fire?

Fire Department 1
Household member 2
Neighbor 3
Went out by itself 4
Other person **(Please Specify)**: ____________ . 5
Don't know 6
Refused 7

69. By the time the fire was put out, how would you describe the extent of flame damage? Would you say there was **(READ CATEGORIES 1 – 7)**

No flame damage 1
Flame damage but confined to first item 2
Flame damage spread to several items 3
Flame damage spread to whole room 4
Flame damage spread beyond the room 5
Flame damage through the whole house……… 6
Flame damage only to the outside of the house. 7
Don't know 8
Refused……………………………………….9

70. And by the time the fire was put out, how would you describe the extent of the smoke damage? Would you say there was: **(READ CATEGORIES 1 – 6)**

No smoke damage..1
A little smoke damage 2
Smoke damage in most of the room 3
Smoke damage spread to another room or area .4
Smoke damage spread through the whole house5
Smoke damage only to the outside of the house 6
Don't know ....….7
Refused 8

70a. Did you and your family need to stay somewhere other than your home or apartment for one night or more because of the fire?

Yes 1
No .... 2 **(GO TO Q71)**
Refused .... 4 **(GO TO Q71)**

IF SECOND OR SUBSEQUENT FIRE, GO TO Q70B

70a1. And are you back in your home now?

Yes .... 1 **(GO TO Q70b)**
No .... 2 **(GO TO Q70a1)**
Refused .... 4 **(GO TO Q71)**

70a1. How long do you expect it will be before you will move back into your house? (READ CATEGORIES 1 - 6)

Less than one week 1
1 – 2 weeks 2
3 – 4 weeks 3
5 – 6 weeks 4
More than 6 weeks 5
Will not be able to move back into the home ... 6
Don't know 7
Refused 8

70b. How long did you have to stay somewhere other than your home? (READ CATEGORIES 1 - 5)

Less than one week 1
1 – 2 weeks 2
3 – 4 weeks 3
5 – 6 weeks 4
More than 6 weeks 5
Had to move permanently .... 6 **(DO NOT READ)**
Don't know 7
Refused 8

71. What was the total dollar value of the property loss or damage to your household from the fire? Please include the cost of repairing your home and replacing the contents of the damaged area. **(PROBE: All we need here is your best estimate) (AS NECESSARY: Please include your out-of-pocket costs plus whatever costs are covered by insurance. We're interested in the total amount of damage caused by the fire.)**

$____________________
RANGE (0 – 9,999,999)

Don't know
Refused

72. Was anyone in your home hurt, get sick, or die as a result of the fire?

Yes	1	**CONTINUE**
No	2	**GO TO Q81**
Don't know	4	**GO TO Q81**
Refused	5	**GO TO Q81**

73. Were there any deaths as a result of the fire?

Yes	1	
No	2	→**SKIP TO Q76**
Don't know	3	→**SKIP TO Q76**
Refused	4	→**SKIP TO Q76**

74. How many deaths were a result of the fire?

ENTER NUMBER 1 – 10 ___________

Don't know	11	→**CONTINUE WITH Q75**
Refused	12	→**SKIP TO Q76**

75. What was/were the age(s) of each person who died? **(ALLOW UP TO 10 MENTIONS)**

	Person 1	Person 2	Person 3	Person 4	Person 5
ENTER AGE	____	______	_____	______	_______

(RANGE 0 – 96) (ENTER 0 IF CHILD IS LESS THAN 1 YEAR OLD; ENTER 97 IF AGE IS 97 OR MORE)

Don't know	98	98	98	98	98
Refused	99	99	99	99	99

76. How many people were hurt or got sick as a result of the fire?

ENTER NUMBER 0 – 97 __________

VERIFY ANY NUMBER OVER 10

Don't know	98
Refused	99

IF Q76 = 0, SKIP TO INSTRUCTION BEFORE Q81

Let's talk about each person injured or ill.

Person No. 1

77. What type of medical attention was required? **(DO NOT READ CATEGORIES; RECORD ALL THAT APPLY)**

None.. 1
Call to the doctor 2
Visit to the doctor's office / clinic / HMO.................................. 3
Treatment in the emergency room 4
Admitted to the hospital.. 5
First aid at site... 6
Other **(Please Specify)**: _______________________________... 7
Don't know 8
Refused 9

78. What type of fire-related injury or illness did this person have? **(READ CATEGORIES IF NECESSARY, RECORD ALL THAT APPLY)**

Burns 1
Smoke inhalation 2
Cuts and bruises.. 3
Broken bones / fractures 4
Other **(Please Specify)** _______________________..................... 5
Don't know 6
Refused 7

79. What is his/her age?

ENTER AGE _____________
RANGE (0 – 97) (ENTER 97 IF AGE IS 97 OR MORE; ENTER 0 IF LESS THAN 1 YEAR OLD)

Don't know 98
Refused 99

80. As a result of the fire-related injury or illness, did he/she cut down on the things he/she usually does for one or more days?

Yes 1
No 2
Don't know 3
Refused 4

REPEAT Q77 – Q80 FOR ALL INJURED/ILL

If Q6 = 1, 11, OR 12 OR (NON-FIRE HOUSEHOLD – ALL ITEMS IN Q5 = NO, DK, REF, OR ALL ITEMS IN Q5a = NO, DK, REF, READ:) These last few questions are about your home and your household.
IF Q6 = 2 – 10, READ: These questions are about your home and your household.

READ Q81 FOR ALL FIRST-FIRE RESPONDE NTS AND THOSE NON-FIRE HOUSEHOLDS THAT ARE CONTINUING THROUGH THE DEMOGRAPHIC SECTION.

IF Q35A NOT EQUAL TO YES, AND THIS IS THE SECOND OR SUBSEQUENT FIRE, ASK Q81 AND Q82/82A. IF Q35A = YES, THEN GO TO Q82B.

81. IF NON-FIRE HOUSEHOLD: Is your home a…
IF FIRE HOUSEHOLD: What type of home was involved in the fire we've been discussing? Would you say it is a …**(READ CATEGORIES 1 – 5; ACCEPT ONE RESPONSE)**

Detached single family home 1
Mobile home or manufactured home 2
Two-family dwelling 3
Apartment building 4
Townhouse or rowhouse 5
Other **(Please Specify)**: ______________________________________... 6
Refused 7

82. About how old is your home? **ASK ONLY IF NEEDED:** Would you say…**(READ CATEGORIES 1 - 6) (IF RESPONDENT SAYS THE HOME WAS BUILT AT DIFFERENT TIMES, READ:** How old is the part where the fire started?**)**

5 years old or less 1
6 to 15 years old....................... 2
16 – 25 years old...................... 3
26 – 35 years old...................... 4
36 – 45 years old...................... 5
46 years old or older 6
Don't know 7
Refused 8

IF DON'T KNOW OR REFUSED IN Q82, ASK

82a. Could you estimate in what year your home was built?

RECORD YEAR ___________

Don't know 9998
Refused 9999

82b. **IF FIRE HOUSEHOLD:** At the time of the fire, how many people in your household smoked tobacco at least once a day?

IF NON-FIRE HOUSEHOLD: How many people in your household smoke tobacco at least once a day?

ENTER NUMBER _________

(RANGE 0 – 8) (ENTER 8 IF 8 OR MORE)
Refused 9

FIRE HOUSEHOLDS – FIRST FIRE DISCUSSED – SKIP TO Q91;
FIRE HOUSEHOLDS – ALL OTHER FIRES, THANK AND TERMINATE
NON-FIRE HOUSEHOLDS CONTINUE

83. Do you have any smoke detectors in your home or apartment?

Yes 1
No .... 2 **(SKIP TO Q89)**
Don't know .... 3 **(SKIP TO Q89)**
Refused .... 4 **(SKIP TO Q89)**

84. How many levels does your home or apartment have? Please include an unfinished basement, but do not include an unfinished attic.

ENTER NUMBER ____________
Don't know .... 98 **(SKIP TO Q87)**
Refused .... 99 **(SKIP TO Q87)**

85. **IF MORE THAN ONE LEVEL, ASK**: How many smoke detectors do you have in the lowest level of your home or apartment? Do not include heat detectors or CO detectors.
IF ONE LEVEL IN HOME, ASK: How many smoke detectors do you have in your home or apartment? Do not include heat detectors or CO detectors.

ENTER NUMBER ____________
Don't know .... 98 **(SKIP TO Q87)**
Refused .... 99 **(SKIP TO Q87)**

86. **(IF MORE THAN ONE DETECTOR, ASK:)** How many of the **(POP-IN)** detectors on this level are **(IF ONE DETECTOR ON THIS LEVEL, ASK:)** Is your detector on this level **(READ OPTIONS, ENTER A "1" FOR THE POWER SOURCE.)**

Operated only by battery .... ________
Operated only by a connection to the electrical system. ________
Operated by a combination of battery and connection to the electrical system ________
Unknown .... ________

Refused 99

REPEAT Q's 85 and 86 for each level in the home; ELSE GO TO Q87

ASK Q87 ONLY IF THE HOUSE HAS MORE THAN ONE DETECTOR; ELSE GO TO Q88

87. Are your detectors connected to each other, so that if one sounds, they all sound?

Yes 1
No 2
Don't know 3
Refused 4

87a. Are your detectors connected to a home security system?

Yes 1
No 2
Don't know 3
Refused 4

88. Is there a smoke detector in the bedroom where you sleep?

Yes .... 1 GO TO Q88o
No .... 2 GO TO Q89
Don't know .... 3 GO TO Q89
Refused .... 4 GO TO Q89

88o. **(ASK IF Q88 = YES:)** Do you have a smoke detector in every bedroom in your home or apartment?

Yes 1
No 2
Don't know 3
Refused 4

89. How many fire extinguishers do you currently have in your home?

ENTER NUMBER ____________
(RANGE 0 – 9)
Don't know 98
Refused 99

90. Do you currently have a sprinkler system installed in your home?

Yes 1
No 2
Don't know 3
Refused 4

91. Do you own or rent this home?

Own 1
Rent.. 2
Other **(Please Specify)**: _________________ .. 3
Refused 4

93. How many people live in this household?

ENTER NUMBER ___________
(RANGE 1 – 20)

Refused 99

IF ANSWER IS ONE SKIP TO Q.94a5.

94. Of the **(POP-IN)** people living in your household, how many are between the ages of 18 and 64?

ENTER NUMBER ____________

Don't know .... 98 **(SKIP TO Q94a1)**
Refused .... 99 **(SKIP TO Q94a1)**

IF RESPONSE AT Q94 EQUALS RESPONSE AT Q93, GO TO Q95. IF RESPONSE AT Q94 IS LESS THAN RESPONSE AT Q93, ASK Q94a1.

94a1. Are there any people in the household under the age of 18?

Yes .... 1 **(GO TO Q94a2)**
No .... 2 **(SKIP TO Q94a3)**
Don't know .... 3 **(SKIP TO Q94a3)**
Refused .... 4 **(SKIP TO Q94a3)**

IF YES, ASK:
94a2. How many are: **ENTER NUMBERS**

Less than 5 years old.......... ____
5 to 9 years old.................. ____
10 to 14 years old.............. ____
15 to 17 years old.............. ____

Don't know 98
Refused 99

IF SUM OF RESPONSES AT Q94 AND Q94a2 EQUALS RESPONSE AT Q93, GO TO Q95. IF Q94a1 = 2,3,4 OR SUM OF RESPONSES AT Q94 AND Q94a2 IS LESS THAN RESPONSE AT Q93, ASK Q94a3.

94a3. Are there any people in the household over the age of 64?

Yes .... 1 **(GO TO Q94a4)**
No .... 2 **(SKIP TO Q95)**
Don't know .... 3 **(SKIP TO Q95)**
Refused .... 4 **(SKIP TO Q95)**

IF YES, ASK:
94a4. How many are: **ENTER NUMBERS**

65 – 74 years old .... ____
75 or older .... ____

Don't know 98
Refused 99

94a5. What is the age of this person?
DO NOT READ LIST. ONLY READ LIST IF NEEDED.

Less than 5 years old................ 1
5 to 9 years old………………..2
10 to 14 years old……………..3
15 to 17 years old……………..4
18 to 64 years old……………..5
65 – 74 years old 6
75 or older 7

Don't know 8
Refused 9

95. What is the highest grade in school that you or another head of household completed?
NOTE: ONLY READ LIST IF NEEDED.

Less than high school.. 1
Some high school.. 2
High school graduate 3
Technical/Vocational school training 4
Some College... 5
College Graduate 6
Postgraduate work 7
Don't know 8
Refused 9

96. Please tell me which of the following categories best describes your household income for 2003? **(READ CATEGORIES 1 –4)**

Less than $15,000 1
$15,000 to less than $35,000 2
$35,000 to less than $75,000 3
$75,000 or more.. 4
Don't know 8
Refused 9

98. Is any head of the household of Hispanic or Latino descent?

Yes 1
No 2
Don't know 3
Refused 4

99. What do you consider to be the race of the heads of household? Is any head of household…**(READ CATEGORIES 1 – 6) WHEN FIRST "YES" RESPONSE IS OBTAINED, ASK:** Are there any other races that might apply to one of the heads of household? **(ENTER ALL THAT APPLY)**

White 1
Black or African-American 2
Asian 3
Native Hawaiian or Pacific Islander 4
American Indian 5
Alaskan native 6
Or some other race **(Please specify)**................. 7
Refused 8

101. Not including the telephone number which I called you on, how many additional phone numbers do you have in your household? Please do not count numbers for cellular phones, or phone lines that are exclusively for computer or fax use.

ENTER NUMBER OF PHONE LINES _______
(RANGE 0 – 8) (ENTER 8 IF 8 OR MORE LINES)

Refused 9

102. **INTERVIEWER: INDICATE SEX OF RESPONDENT**

Male 1
Female 2

(IF Q6 = 2 – 10:) Now I'd like to ask some questions about the (other / next most recent) fire you mentioned. **(INTERVIEWER: OFFER TO CONTINUE OR RESCHEDULE AT RESPONDENT"S CONVENIENCE) (IF RESCHEDULING, GET FIRST NAME AND SCHEDULE TIME FOR THE INTERVIEW)**

RETURN TO Q7

ELSE, THANK AND TERMINATE:

I'd like to thank you for taking the time to help us answer these important questions. The information you have given us will be very helpful. Thank you for your cooperation.

COMPLETION CODES

Subsample – Non-fire household that was asked demographic section
Subsample – Non-fire household that was immediately terminated
Complete – Fire household that had a full and/or abbreviated interview

NOTE: Q50a, Q50a1, Q57, and Q63 ONLY ASKED DURING FIRST TIME THROUGH THE SURVEY. NOT ASKED FOR SECOND, THIRD, etc. FIRE.

AN EVALUATION OF THE ROLE OF FIRE EXTINGUISHERS

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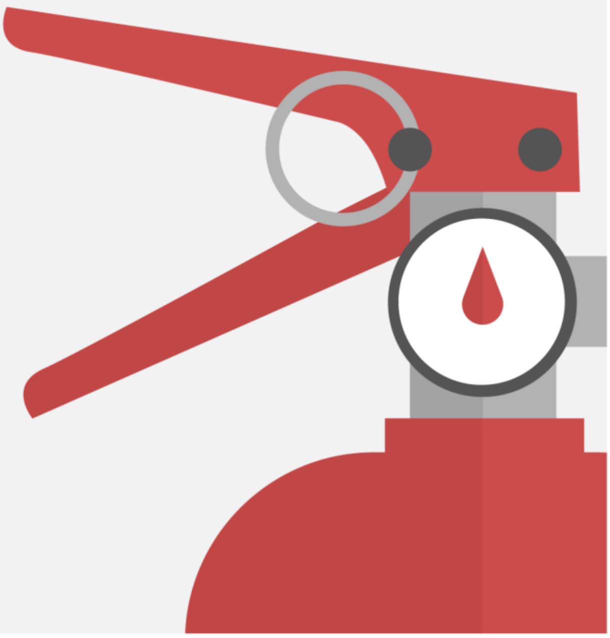

Aim and audience

This report was produced with the aim of providing an evidence-based assessment of the role of portable fire extinguishers within dwellings. This includes both single private dwellings and houses in multiple occupation (HMO), or other places where some form of accommodation is provided. Its value stems from its adoption, as far as possible, of a user-informed view of their benefit and operation.

The report is intended to inform discussions and present a currently underrepresented perspective: that of the public. It explores both what is known about their behaviour/motivations when encountering a dwelling fire and considers how they are represented in official policies.

As such, it will be of specific interest to those who produce guidance in relation to portable fire extinguishers, professionals involved anywhere in the lifecycle of portable fire extinguishers and to those with responsibility for fire safety in a property. It will also be relevant to policy makers, academics and others interested in the relationship between guidance, professions and the public.

However, it has also been written in the hope it will also be accessible for the lay reader. Authentic two-way engagement with the public is essential for any meaningful and effective fire safety strategies, and more needs to be done to ensure their voice is heard.

Evidence base

This report is not the result of a systematic review, but one in which, within the confines of the remit, evidence was sought to illustrate specific issues. The results help to build an 'as is' description of the role of portable fire extinguishers as seen from a user perspective.

As far as possible, the evidence was sourced from academic studies, recognised sector publications and published data sources (see Bibliography). Each of these has its strengths and weaknesses along with various factors that influence its content and reliability. Individual assessments are not given for each evidence source, but, in combination, they were sufficient to develop a broad understanding in most areas and detailed insight in others.

Throughout the report, reference is made to information that appears to be unavailable. It is accepted that some of these sources may exist, but were either not discovered by the author, or may be held within private domains, e.g. companies. Unless otherwise stated, their omission does not undermine the findings.

In general, this report refers to both dwelling (single) and HMO premises without distinction. This is because the evidence either, does not reveal notable differences, or is too scarce to form a view. However, the application of the findings of this report are not always of equal significance to each property type. Each section identifies any important features applicable primarily, or solely, to an HMO.

In recognition of the limited and fragmented evidence, it is a recommendation of this report that more be done to build a comprehensive and integrated understanding of the public experience of using a portable fire extinguisher. Without this, it appears impossible to have confidence that those charged with making decisions about portable fire extinguishers are doing so based on a full and current knowledge. Where public safety is at stake, this should be a minimum requirement.

Where opinion is offered, it is that of the author's alone unless otherwise stated. Readers are welcome to disagree and, in doing so, may find it helpful to consider why. Is it due to their experience, knowledge or assumptions? A curiosity-driven mindset will enhance the value of the report far beyond its stated content and will hopefully lead to discussions that continuously drive improvement.

Definitions

Dwelling fires – fires in properties that are a place of residence, i.e. places occupied by households such as houses and flats, excluding hotels/hostels and residential institutions. Dwellings also includes non-permanent structures used solely as a dwelling, such as houseboats and caravans.

Houses in multiple occupation (HMO) – is a property rented out by at least three people who are not from one 'household' (for example, a family), but share facilities like the bathroom and kitchen. It is sometimes called a 'house share'.

Non-residential buildings – includes properties such as offices, shops, factories, warehouses, restaurants, public buildings, religious buildings, etc.

Primary fires – are potentially more serious fires that harm people or cause damage to property and meet at least one of the following conditions: any fire that occurred in a (non-derelict) building, vehicle or (some) outdoor structures; any fire involving fatalities, casualties or rescues; any fire attended by five or more pumping appliances.

Response time – the 'total response time' measures the minutes and seconds taken from time of call to time of arrival at the scene of the first vehicle.

Risk – a function of the combined effects of hazards, the assets or people exposed to hazards and the vulnerability of those exposed elements.

Other building fires – fires in other residential or non-residential buildings. Other (institutional) residential buildings include properties such as hostels/hotels/B&Bs, nursing/care homes, student halls of residence, etc.

Sources: all definitions are from Fire Statistics definitions except for 'houses in multiple occupation' from www.gov.uk and 'risk' from Sendai framework (see Bibliography).

Executive summary

1. This report considers the use of portable fire extinguishers in dwellings/HMO. It does so by drawing largely on evidence and data that provide a human or public perspective on their use and benefit.

2. It finds that the contribution of the extinguisher and the public in using them, attracts little attention and is poorly recorded within academia, government or the wider fire safety sector. And yet, it is this perspective which ultimately identifies their true contribution and value.

3. The report identifies that there is a fundamental discrepancy between official/policy assumptions and the public in relation to priorities in the event of a fire. Government and professionals focus on avoiding injuries and see that as the sole aspiration, in the pursuit of which everything else is secondary. As a result, they consider the public role to be one of compliance in which they simply exit the premises on becoming aware of a fire. If true, this would require little, if any, decision-making by the public.

4. In contrast, the public have a wide and largely unrecognised range of priorities when encountering a fire, based on their individual circumstances. These include: the avoidance of embarrassment/inconvenience; mitigating the impact of damage to the property, e.g. avoiding the risk of being unable to remain in their home; and their concern for the wellbeing of other people, pets or valued possessions. Pursuing these priorities requires numerous decisions, and yet they are not aided in this by any guidance from the professional services either before, or during the event.

5. A desire to achieve their self-appointed tasks is a strong motivation for the public's behaviour when encountering a fire. For most, this will involve an active response of on average five actions, although for some it will be as many as 11. This includes investigating the initial cues and tackling the fire, often using improvised means. They are usually successful in doing so, with 70% to 80% of fires dealt with by the public without requiring professional assistance. It is important to note that in doing so, they are willingly acting against official advice and are not being coerced into this. The evidence shows the public to be effective and capable in tackling fires, even in the absence of any professional support, or often without specialist equipment.

6. The size of fires is decreasing – both those the fire and rescue service (FRS) attends and those that the public deal with. In either case, the early interventions of the public are likely to be the most significant determinant of the outcome.

7. The FRS response time to dwelling fires has increased by nearly 50% over the past 25 years. As the FRS does not routinely provide any support or intervention until their arrival, the reduction in fire size, etc. must be attributable to other factors, including the role of the public. The continued focus on the FRS response time diverts from the exploration of other policy options to share their professional expertise in the absence of a physical attendance, e.g. remote assistance.

8. Literature shows the relatively small and distinct section of the public at risk of a fatal outcome in a dwelling fire generally has specific characteristics. These characteristics make them vulnerable by leaving them to be unable to respond to a fire or causing them to do so in an appropriate way.

9. However, most people do respond appropriately, and the literature confirms that they do not panic. Typically, most people are at risk of a minor injury at worst, due to the low risk from the fire and their own ability to assess and act in accordance with the situation. Where a minor injury is incurred, the public almost unequivocally see it as a reasonable trade-off for whatever activities they were undertaking.

10. There is limited literature and data readily available regarding the public experience of dwelling/HMO fires, particularly of tackling fires and extinguisher use. The value of available dwelling fire research is often diminished by numerous studies failing to understand and distinguish between different types of risk, e.g. the risk of a fire starting or of it causing an injury. Instead, they often use the term interchangeably and generically.

11. This is further compounded by official advice that at times confuses and exaggerates the risks to people encountering a fire and overstates the influence of equipment such as smoke detectors. This is likely to be a self-perpetuating process due to inherent biases, which, in turn, inform and limit the nature of data collection and analysis providing a partial and skewed perspective. This undermines credible risk communication and may explain the limited the impact of official advice.

12. This report identifies that the provision of fire extinguishers in private dwellings is generally low and, as such, improvised means are often used for fighting fires. Extinguishers are more prevalent in HMO because of legislative requirements for the common areas. Several publications identified vandalism as a significant issue affecting extinguishers in common areas. However, this could not be verified in either its potential nature or scale due to a lack of data/evidence.

13. Training in the use of extinguishers is an important issue and one in which opinion appears more influential than the evidence. Whether purchased for a private dwelling or provided through regulatory processes, there is no mandatory requirement for training to use an extinguisher, and studies do not reveal training to be a requirement for their safe or effective use. In fact, the available data and studies demonstrate the opposite to be the case.

14. Despite this, the potential for them to be used by untrained people is stated in some codes of practice/guides as a sufficient reason to not install (or remove existing) extinguishers in common areas. The evidence to support this claim could not be identified, and yet it continues to be repeated. For example, the advice given by experts to the Grenfell Inquiry led it to feel unable to recommend the use of extinguishers in its Phase 1 report. Unfortunately, the potential for the absence of extinguishers to create a more significant risk does not seem to merit consideration.

15. Various documents from professional bodies identify that competent risk assessors should have a knowledge of human behaviour. However, little evidence was found to identify human behaviour as an active and influential component of the sector. Fire safety is grounded in the engineering discipline, and this brings many strengths. But it is insufficient, and fire safety effectiveness is limited by ignoring, or insufficient incorporation of, other disciplines, including the social sciences.

16. Overall, this report finds that the use of fire extinguishers suffers from several systemic issues which adversely distort their true role and influence. Some of the key ones are:

   a. Too many false assumptions and evidence gaps in influential policy areas.
   b. A disconnect between the fire safety profession (in both public and private sectors) and the public it serves. The latter being poorly represented (directly or indirectly) in policy and guidance creation.
   c. The dominance of the engineering discipline to the detriment of a broader multi-disciplinary and user-centred model.
   d. A paternalistic approach by which government and the fire safety sector seek to change, rather than work with the public. This, despite the evidence that public behaviours are safe, effective, and largely unaltered by current guidance and campaigns.

3. The Public View of a Good Outcome

The public view of a good outcome

17. A portable fire extinguisher is an item which allows for small fires to be tackled by members of the public. Despite the apparent simplicity of that statement, the risks and benefits of using one are complex and extend beyond the immediate point of operation to include long-term and consequential outcomes.

18. To make an informed decision regarding the suitability and use of extinguishers requires that a full appreciation of risk and benefit sought be incorporated into any calculation/decision. That does not appear to be the case currently, and the public perspective is absent or at least poorly represented in available literature and data. Neither do they (directly or indirectly) seem to be well represented in design/planning structures.

19. Beyond extinguishing a fire to remove the immediate threat, defining a 'good outcome' when a fire occurs is surprisingly an area that has not received much attention. In the absence of a common understanding, the answer will often be closely aligned to the viewpoint and interests of specific stakeholders. However, with so many different stakeholders, there is clearly not a single answer, and each claim will have its own legitimacy. But the central theme of this report, is that the public view is poorly known and under-represented. And that has important consequences for their safety.

20. As such, this report starts by considering the public view of what a good outcome looks like. This then frames and informs the remainder of the report content and allows consideration of the extent to which current arrangements reflect their needs. It is important to appreciate that whilst different to official assumptions, the research shows the public's priorities to be rational and appropriate.

21. The public experience of fire is vastly different to that of the professionals involved in planning for, responding to and recovering from dwelling/HMO fires. This is at the same time obvious and yet not fully appreciated in practice. Some key findings from research studies are set out below and briefly identify desirable public-oriented outcomes under the headings of 1) avoidance of embarrassment/inconvenience; 2) damage to premises; 3) injuries; 4) people, pets and possessions and 5) consequential impact.

22. Avoidance of embarrassment/inconvenience – Recent studies have demonstrated the important influence of emotion in how the public react. For many people, calling the FRS is a last resort as they are aware it will attract potentially unwanted attention from neighbours due to the visibility of the emergency response presence. Others stated concerns that they would be diverting the FRS from more important incidents. Some still believed they would be charged for calling the FRS.

23. Therefore, the potential to avoid the need to call 999, by tackling the fire themselves, prevents exposing them to these negative emotions. So, one driver of behaviour at the early stage of a fire is the desire to avoid certain perceived social consequences or unwanted attention from official agencies (for which there can be many reasons).

24. Damage to premises – Recording the extent of damage to a premises is clearly an important and useful indicator. However, its perceived value appears more geared towards internal use by the various professions than to considering it to inform and optimise public outcomes. For that, consideration must be given to the possible impacts of damage to the premises.

25. Limiting the fire to the smallest area within a premises is a sensible aspiration, but of itself is potentially insufficient to achieve the best possible outcome. From the public perspective, the function of the rooms affected also matters. A fire affecting two rooms may seem relatively minor for official recording purposes. But if they are the kitchen and/or bathroom, then rehousing may be necessary, even if the remainder of the house is unaffected. Awareness of the potential consequences of fire damage is likely to be more intuitive and important to those present/affected than to professionals. As such it guides their actions in a way that is not recognised in fire safety guidance or emergency response tactics.

26. If a dwelling/HMO is made untenable because of the fire, then those affected may have to stay with family/friends, pay for temporary accommodation or be allocated social housing intended for others. All these eventualities can disrupt normal patterns of life in areas such as schooling, work and social life. Where the fire affects someone in a house adapted to their specific needs, the disruption and distress is even more acute. Therefore, avoiding the need for re-homing or other consequences is, of course, a desirable outcome for most people and may lead them to act to preserve key rooms. With many fires starting in the kitchen, this is an important consideration for why people may tackle fires themselves.

27. Injuries – Official policy and attitude is almost singularly directed at avoiding the risk of injury when the public encounter a fire. This is well meaning, but research has shown that it does not align with the public attitude or ability. This reality gap reduces the relevance and impact of fire safety measures.

28. Most of the public do avoid injury, not by luck, but through active decision-making and because of the relatively low level of risk they encounter in dwelling/HMO fires. And where incurred, most injuries are of a minor nature. The relatively small group at risk of dying, tend to have specific characteristics which prevent them responding to the fire either through physical or mental limitations. This means those most at risk are unlikely to use fire extinguishers.

29. The evidence further identifies that the public are willing to accept minor injuries (e.g. small burns or smoke inhalation) in pursuit of achieving their priorities. Even in hindsight, few, if any of those injured, would change anything. Avoidance of any injury is not therefore of itself sufficient to be considered a good outcome, although, clearly, a serious injury would be an undesirable outcome in most circumstances.

30. People, pets, and possessions – Concern for people, pets and possessions are strong and established drivers of behaviour in the event of a fire. In fact, this can be instinctively appreciated as the desire to protect things people cherish from any form of harm is a natural tendency. It is therefore no surprise to see it as an influential feature of people's response to dwelling fires.

31. Mass casualty studies show that sustained concern and care for other people can also result from relatively minor associations, or even where there has been no previous contact. Selfish behaviour is, in fact, rare. Dwelling fire studies identified ensuring the welfare of family and friends is something that people would view as a good outcome. However, the research also identified that warning other residents in a multi-occupied property (e.g. flats) was important. This suggests a sense of concern for others and potentially a personal desire to know they have done the right thing, which is also an important outcome for most.

32. Pets were also found to be very influential in driving behaviours. For some, they are their only companion and were afforded the same importance as a person would be. Their wellbeing and how they were treated (even if they did not survive) matter.

33. The importance of possessions can easily be overlooked and dismissed as most objects are replaceable. Whilst that is true for many items, not all possessions are equal. For some people, a laptop may just be an easily replaced entertainment device, storing nothing of importance. For others, it may contain the only record of their personal or business records, which if lost, would severely impair their future prosperity. Mobile phones may be important both for what they contain but also because the occupier may foresee the need for one to stay in contact with friends/families during and post-fire.

34. Items which cannot be replaced are also highly valued and may result in attempts to preserve them from the effects of a fire. These may include obvious items such as photos, high-value items or something with sentimental value. Other categories include those where replacement represents significant perceived effort or inconvenience if lost, e.g. a passport or other formal documents. Preservation of valued items, as determined by the owner, is an important outcome.

35. Long-term consequences – There are also other less obvious or longer-term consequences incurred by the public. These are often invisible as they are not captured by routine data collection, potentially due to perceived difficulties in obtaining or sharing information or even institutional bias which does not recognise its value and importance.

36. This is compounded by the limited number of studies that have looked at dwelling/HMO fires from the survivor perspective to understand, amongst other aspects, the emotional/psychosocial experience and personal/extended impact. The public are exposed to many of the same (and some unique) experiences as the professional responders. And whilst the potential mental health risks to the latter are recognised, this is not the case for the public. As a result, they are unlikely to receive the support they need after the fire. Studies have shown that even small fires can have long-term or life-changing consequences and the impact of a fire is not always linearly proportional to its size.

37. It has also been found that for some people, the effects of a fire, in isolation or in combination with other life events, can be overwhelming. They then experience various degrees of difficulty dealing with everyday life and/or recovery from the fire. As a result, they suffer a form of vulnerability which is greater than the sum of its parts and can affect every part of their life.

38. Linked to emotional wellbeing is the fact that people believe they did the right thing and all within their ability to reduce the harm caused by a fire, particularly if they felt some degree of responsibility for its cause or development. How people feel about their actions is an important outcome and influence. This can be either positive or negative and relates to their own assessment and the judgement of others.

39. Avoidance of the longer-term or consequential effects is clearly a good outcome for the individual and others impacted as a result. Unlike the other categories, these long-term consequences are likely to be less appreciated at the time by the public. As such, it may not influence their behaviour during a fire, and it could be some time before they realise the true impact it has had on them.

40. To capture the concept of indirect harm, the definition of risk adopted by the Sendai Framework (see definitions) is helpful because of its inclusion of 'vulnerability'. This recognises that events can have an immediate impact but also make those affected vulnerable to secondary or consequential harms.

41. Other stakeholders – Raising awareness of the public need is not denying the legitimate interests of the other/professional stakeholders. Each is invested in the fire safety ecosystem and has a vital role to play. Each will also understand what a good outcome looks like for them, both as individuals and organisations.

42. For some, compliance with legislation, regulation or technical standards will be important, others will have financial incentives or considerations, and some may need to act in accordance with client requirements. Ideally these will all align or can at least co-exist.

43. Each of these participants will usually have the means and opportunity to bring their valuable organisational and professional perspectives to the debate where necessary. Unfortunately, that is not the case for the public who rarely, if ever, directly participate in policy/industry forums and whose accounts are poorly documented in evidential or data sources. That means many decisions are made without being informed by those most impacted by the decisions: the public.

44. As such, understanding and aligning the needs of all stakeholders, or at least finding a shared aim, is a prerequisite to getting the optimal outcome for all. This requires purposeful design and cannot be left to chance or be assumed to be a natural and self-organising outcome.

45. It should also be noted that in such a complex environment, there is always the potential for conflicts of interests at an organisational and personal level. These may occur where compliance with the stated (or assumed) common purpose is detrimental, or where deviance from it provides the opportunity for benefit to individual stakeholders. Considering the presence or extent of conflicts of interest was not a feature of this research or report. It is highlighted to acknowledge they exist and are likely to have at least some influence on all stakeholders within the fire safety domain. No organisation (public or private) is entirely neutral or without their own agenda.

4. The Characteristics of Dwelling Fires

The characteristics of dwelling fires

Introduction

46. The previous section addressed a public-oriented view of what a good outcome looks like when a dwelling/HMO fire occurs. Many of their priorities will be achieved, or strongly influenced, by restricting the damage caused by a fire. Typically, that means tackling it as soon as possible after discovery. The evidence identifies that this occurs in most fires, mainly due to the actions of the public. This section attempts to understand the characteristics of dwelling fires from published data and, in doing so, to identify the nature of the risk in terms of fires encountered by the public.

47. Portable fire extinguishers are intended for use on small fires. Similar generic descriptions (e.g. they are for 'first aid firefighting') are frequently used but not particularly helpful, as they are subjective and may mean different things to different people. Therefore, this section seeks to quantify the size of real fires encountered, albeit based on an estimation of the post-fire damage.

48. The location of fires has not been included although it does, of course, influence some features of the fire and its behaviour. However, it is assumed that where extinguishers have been professionally commissioned, the appropriate extinguisher would have been selected for the risk profile.

The likelihood of experiencing a dwelling fire

49. The number of dwelling fires attended by the FRS has been on a long downward trend, in absolute terms, despite a rising population size and an increased number of dwellings. Official FRS data identifies that:

    a. In Great Britain (GB), the FRS attended 64,032 dwelling fires in 1994/95; a figure which had fallen to 36,283 in 2018/19.

    b. For England, there were 44,601 recorded dwelling fires in 1981/82, which then rose to a peak of 58,280 in 1999/00, from which it has subsequently maintained a general downward trend to the 2018/19 figure of 29,592.

    c. In Scotland dwelling fires also decreased, from 9,811 in 1990/91 to 5,137 for 2018/19.

    d. Wales has followed a similar trend with 3,030 recorded in 1994/95 falling to 1,554 in 2018/19.

50. It should be noted that these figures identify fires attended by the FRS but not the actions taken. A proportion of these fires will be 'out on arrival' and would not have required an active intervention by the FRS.

51. Data in relation to dwelling fires that the FRS does not attend is not routinely collected. However, the results of periodic sample surveys such as the British Crime Survey (BCS) and English Housing Survey (EHS) do, at least, provide some insight. The figures from these provide a national estimate derived from the survey results, and so care must be taken in using them. However, at face value they do suggest a downward trend in the number of fires, like that seen in fires attended by the FRS.

52. Between 2001/02 and 2002/03, the BCS recorded an estimated drop in the number of dwelling fires from 383,000 to 372,000 in England and Wales. The English Housing Survey for 2013/14 recorded an estimated 206,980 dwelling fires in England compared to 273,000 in its 2004/05 survey.

53. In summary, whether attended by the FRS or dealt with by the public, dwelling fires have exhibited a sustained downward trend. As such, the likelihood of any person, household or other dwelling experiencing a fire is also decreasing.

Dwelling fires rarely extend beyond the room of origin

54. In respect of the fire size, official published data relates to the end state after the fire has been extinguished. For this report, it is a proxy indicator as it does not directly identify the conditions at the time the fire was discovered, and/or when attempts were made to tackle it by the public.

55. Overall, the data reveals that the size of dwelling fires is relatively small. Two FRS data sets have been used as indicators for the purpose of this assessment - fire spread and area of fire damage. And data from the BCS relating to financial loss provides some insight in to fires that were not attended by the FRS.

<u>Fire spread</u>

56. Of the dwelling fires attended by the FRS in England during the 12-month period in 2018/19:

- 30% resulted in no fire damage
- 32% resulted in the fire being limited to the item first ignited
- 25% resulted in the fire being limited to the room of origin

This means that in 87% of cases the fire did not spread beyond the room of origin.

57. This data was first published for the year 2010/11 and during that period the findings were similar:

- 32% resulted in no fire damage
- 28% resulted in the fire being limited to the item first ignited
- 27% resulted in the fire being limited to the room of origin

This means that, again, in 87% of cases the fire did not spread beyond the room of origin.

58. Of the dwelling fires attended by the Scottish FRS during the 12-month period in 2018/19:

- 47% were recorded as causing smoke and heat damage only
- 26% were confined to the item of origin
- 16% were confined to the room of origin.

This means that in 89% of cases the fire did not spread beyond the room of origin.

59. In 2009/10 the figures for the same were:

- 45% resulted in no damage,
- 21% were limited to the item first ignited
- 19% did not extend beyond the room of origin

This means that in 85% of cases the fire did not spread beyond the room of origin.

60. Of the dwelling fires attended by the Welsh FRS in the 12-month period 2018/19:

- 25% were recorded as causing no fire damage
- 39% were limited to the item first ignited
- 23% were confined to the room of origin.

This means that in 87% of cases the fire did not spread beyond the room of origin.

61. In the 2009/10 period, the corresponding figures were:

- 35% caused no fire damage
- 34% were limited to the item first ignited
- 21% were confined to the room of origin

This means that in 90% of cases the fire did not spread beyond the room of origin.

62. For the years shown, the percentage of fires that either caused no damage or did not extend beyond the item first ignited ranged from 60% to 73%. And in a further 25% to 26% of incidents attended by the FRS, the fire did not spread beyond the room of origin. The data suggests a stable but downward trend for the spread of fire.

<u>Area of fire damage</u>

63. In England, the average area of fire damage for all dwelling fires in 2001/02 was 26.3 m2. With minor fluctuations, this has gradually decreased to an average of 16.2 m2 in 2018/19 (Home Office, 2019). This represents a reduction in average area of fire damage of 38% in just 17 years.

64. In Scotland:

- the proportion of fires resulting in no damage increased from 11% to 14% in the period 2009 to 2019
- those causing smoke and heat damage only (no fire damage) accounted for 38% in 2009/10 and 43% in 2018/19.
- Fires causing under 5 m2 of damage decreased from 25% to 22% and
- Fires causing between 6 m2 to 10 m2 of damage remained at 4%.
- Larger fires of 11 m2 or above fell from 22% in 09/10 to 16% by 2018/19.

Overall, the proportion of fires attended by the Scottish FRS resulting in no damage, smoke and heat damage only or under 5 m2 of fire damage accounted for 75% in 2009/10 and 80% in 2018/19. The data shows an increase in smaller fires and a decrease in larger ones.

65. In Wales:

- the proportion of fires resulting in no damage increased from 10% in 2009/10 to 20% in 2018/19
- fires causing under 5 m2 increased from 47% to 49%,
- Fires causing between 6 m2 and 10 m2 decreased slightly from 11% to 9%.

Larger fires appear to be decreasing as a proportion of dwelling fires attended. Grouping the categories for damage in the range of 51 m2 to 1000 m2 identifies a reduction from accounting for 10% of dwelling fires in 2009/10 to 8% in 2018/19.

Overall, the proportion of fires attended by the Welsh FRS resulting in no damage or under 5 m2 of fire damage accounted for 57% in 09/10 and 69% in 2018/19.

66. For the years shown, the size of fire by average area of damage has shown a substantial reduction in England. Scotland and Wales have shown more moderate changes, but the trend in each is that the size of fires is decreasing. In turn the proportion of small fires is increasing, and the proportion of larger fires is decreasing.

Financial estimates

67. The BCS did not record the area of physical damage due to fire. Instead, it used a cost-based measure. In the three surveys covering the period, 2001 to 2005, between 42% and 48% of fires resulted in no financial loss. The two surveys between 2001 and 2003 both identified that a further 19% caused only a minimal financial loss.

68. Whilst not directly comparable to FRS data, this does provide some degree of consistency in suggesting that most dwelling fires are small. Of note is that the majority of the BCS respondents did not call the FRS, and so, within reason, the data provides an insight into the experience of this important group.

Characteristics of HMO fires

69. It is not clear how many fires in an HMO do not result in calling the FRS, and whether the ratio between those they attend and do not attend corresponds with that of dwelling fires in general. There are factors which could potentially influence it to be higher or lower. Further data and studies from real fires are needed to improve the evidential basis for this area and any implications resulting.

70. However, data recorded by the FRS does identify how many properties providing some form of accommodation other than single private dwellings they attended. The figures below are for fires attended by the FRS in England in the period from 1994/95 to 2018/19.

- Fires in Hospital and medical care facilities have decreased from 1006 to 636
- Fires in Education premises have decreased from 884 to 582
- Fires in Hotels and Boarding premises have decreased from 1018 to 613
- Fires in Communal Living have decreased from 2348 to 1168

Note: Communal living includes: Boarding school accommodation, Military/barracks, Monastery/convent, Nurses'/Doctors' accommodation, Other residential home, residential home, Sheltered housing and Student hall of residence.

71. All categories are exhibiting pronounced downward trends with the number of fires in communal living premises attended by the FRS falling by 50%.

The role and influence of fire growth modelling

72. Published data regarding the size of a fire is helpful in providing a reference point for the final extent of a dwelling fire. If the fire was extinguished quickly by whatever means, then the end state may closely resemble the fire as it was on discovery or when being tackled. However, if there were delays in sourcing/preparing extinguishing medium or its application was ineffective in tackling the fire for any reason, then it may not. Given that most fires are contained to the item first ignited or the room of origin, it is likely that there is not much difference between size at discovery and when extinguished.

73. Only one study was found that provided an insight into the size of fire from discovery onwards, capturing this information in survey form. The lack of data from real fires, despite its ready availability and benefits, means reliance is placed on other means. And yet, an accurate knowledge of typical fire development behaviour is an essential requirement for meaningful risk assessments.

74. Within the literature, there is an active and extensive body of work addressing various aspects of fire and fire development, either as a natural or applied science. A number of these seek to develop a 'standard' fire growth curve model. This is clearly an extensive subject, but a brief overview of its role is useful in considering dwelling/HMO fires.

75. By necessity, the models are usually underpinned by data collected from fires created for the purpose and set under controlled but often artificial conditions. This approach obviously has many advantages. Not least, the ability to install equipment to record different aspects of the fire and to plan when the fire will occur. However, they do have limitations in their ability to replicate real fire conditions and development. Some of these discrepancies have been exposed through the ongoing Grenfell Inquiry.

76. Typically, controlled tests produce a pattern of fire growth and decay, often with indicative timings for the duration of each phase. Examples of the application of the resultant fire development models include testing scenarios in relation to fire safety for new building designs or to assess mass evacuation plans. As many of these relate to unique premises with customised fire safety arrangements, the modelling approach is an appropriate, proportionate and cost-effective option.

77. Quantifying and standardising predicted fire development also underpins influential concepts such as the 'Available Safe Egress Time' (ASET) or 'Required Safe Egress Time' (RSET). Their efficacy relies largely on the assumption that the public/occupants would respond in line with official assumptions. Further, they assume the fire development to be the dominant feature, and one largely unaffected by the actions of the occupants/public, which is not supported by the evidence.

78. The models are also used to identify the time after which it is believed anyone trapped in the building is unlikely to survive. This is informed mainly from fatal fire studies and knowledge about survivors is notably limited. For example, a recent literature review found no studies that focussed on the behaviours and motivations of children who survived fires. This has important ramifications for fire safety across multiple policy areas.

79. This quantified modelling approach and resultant timings are very influential on thinking, policy and the planning of fire safety services. For example, they underpin the assumptions made in the provision of fire cover by the FRS. However, in relation to dwelling/HMO fires, the evidence from real fires does not seem to accord well with the models in predicting fire behaviour. It has been seen that many fires do not develop beyond the item first ignited, and the proportion of larger fires is decreasing.

80. As the data shows the trend in fire development to be dynamic (e.g. the fire size is decreasing), test fire conditions and modelling should be regularly reviewed, and cross-referenced to real fire data to ensure their representativeness and appropriateness. This should include the known influence of human behaviour and activity in relation to fire behaviour. Many tests fail to incorporate this and present a potentially false model in which the fire and building alone are presented as the key and unconstrained determinants of fire development. This can lead to worst case and atypical results being misrepresented as a standard and common scenarios. This has serious and often harmful repercussions on subsequent thinking and practice.

The average FRS response time is increasing

81. In England, the average response time to primary fires in 2018/19 was 8 minutes and 49 seconds. This is an increase of 11 seconds since 2017/18 and 33 seconds since 2013/14.

82. The latest published average response time for a dwelling fire in England is 7 minutes and 47 seconds which is a one-second improvement on the previous year but an increase of 18 seconds since 2013/14, and a significant increase from the 5 minutes and 33 second average recorded in 1994/95.

83. The response time is a longstanding and important measure for the FRS, which is used as a proxy for effectiveness. It is assumed that the quicker the professional emergency response, the better the outcome, and this is a key factor for planning emergency cover.

84. However, caution is suggested in the application and interpretation of this measure, as it is, in many ways, misleading and insufficient on its own. It assumes that the public, on becoming aware of a possible or actual fire, immediately call 999. Studies refute this, demonstrating that the public are active and calling 999 is their penultimate action, although in the majority of dwelling/HMO fires they do not need to do so.

85. There is also an assumption or expectation that, the public, having called 999 and exited the dwelling/HMO, will wait passively until the FRS arrives. Again, studies demonstrate this to be untrue, with the public often remaining active, including re-entering the property. As data is not routinely collected on these public actions and interventions, it is not possible to fully understand the relationship between them, fire development and the response time.

86. A further caveat is that the response time simply means the first appliance arrived at the scene. For a dwelling/HMO fire, at least two appliances will typically be mobilised, and the time until the full required attendance is at the scene is not published. As such, the response time does not provide any insight into how long after arrival after the first appliance it takes for the FRS to have sufficient resources present to carry out any meaningful interventions. This is compounded by the absence of any published data regarding the post-arrival activity and performance of the FRS.

87. As set out above, the correlation between response time and specific outcomes is questionable and not established by the available data, which fails to provide a complete picture. That is not so much an argument against the response time, but recognition that on its own, it provides little in the way of meaningful information to predict the outcome of a dwelling/HMO fire. Other important data is required to achieve this.

5. Human Behaviour and Motivation in Dwelling Fires

Human behaviour and motivation in dwelling fires

Introduction

88. In this section, an outline of some of the important and relevant findings from the available literature regarding human behaviour in dwelling/HMO fires are set out.

89. There is a specialised but active field of study that considers the public experience and role in relation to mass casualty or large-scale events. These studies increasingly recognise the positive contribution made by the public prior to the arrival of the emergency services.

90. Conversely, relatively little is known about how people respond as individuals or in small groups in domestic settings to what may be considered normal or everyday dwelling fires. Pioneering studies of the public experience of dwelling fires were undertaken by Bryan (1977) and Wood (1972) in the USA and UK, respectively. They found that the public undertook a range of self-appointed tasks including investigating and tackling fires. Recent studies have confirmed similar findings and these behaviours appear consistent over time.

91. Where undertaken, many studies that try to identify risk factors in relation to dwelling/HMO fires erroneously assume a 'flight' response as the sole intended aim of the public. This is often accompanied by a degree of paternalism that assumes that where the public behaviour differs from official guidance, it is wrong and can be changed. As a result, these studies focus more on how to segment the public or change public behaviour rather than how to adapt policies and practice to better accord with the public.

92. Whether this approach influences, or is influenced by, official policy which takes the same view is not clear. But it does compound the failure to appreciate the wider scope of public priorities and their contribution prior to, or in the absence of a professional response.

93. This reality gap was recognised by a Dutch study which recommended 'understanding how individuals behave in the case of fire and fire evacuation is essential if we are to bring fire safety measures into line with occupants' needs during an incident.'

94. The lack of academic grounding, in favour of assumptions about human behaviour for key policy areas and practice is concerning and potentially harmful. The belief that 'undesirable' behaviour can be changed by advice, campaigns or other measures has been shown to be inaccurate. Instead, fire safety policies must adapt to work with the evidenced and generally beneficial behaviours of the public.

Injuries

95. In fire safety literature and guidance, there is a tendency to refer to injury risk as a single and generic classification. This is an inaccurate simplification and has detrimental consequences.

96. Due to their higher profile and the subsequent investigations providing abundant data, fatal fires tend to be well studied. As a result, the characteristics of those likely to die in a fire are relatively well known and generally consistent. Most studies identify that these characteristics mean this group is poorly disposed (through mental or physical impairment) towards responding appropriately in the event of a fire. As such, they are unlikely to use an extinguisher, or if they did, could not be relied upon to do so safely and effectively.

97. Instead, they need different interventions to keep them safe, and are better served by enhanced fire prevention measures or automated protection in the event of a fire, e.g. sprinklers. However, they are excluded as potential extinguisher users for the purpose of this report.

98. Literature and guidance do not adequately recognise that this is a relatively small and specific risk group. Instead, there seems to be an implicit assumption that everyone starts with an equal risk of dying in a fire, and only an intervention of some sort prevents them all from that fate. This can be seen where fire safety messaging to the general public still relays the 'Fire Kills' message suggesting everyone is at risk of this outcome.

99. Fortunately, most people encountering a fire will avoid any injury or will be exposed to a low, and often considered risk of a minor injury at worst. This is not a matter of luck but due to a combination of their own abilities and to the low level of risk presented by most fires.

100. This is even allowing for the fact that compared to other fire types attended by the FRS, accidental dwelling fires are responsible for a disproportional number of injuries. They account for between 8% and 20% of all fires but are responsible for between 58% and 70% of all fire-related injuries and deaths. This trend has been consistent for many years and suggests a failure of policy for this group. Whilst the likelihood of having a dwelling fire has decreased, the potential for it to cause an injury has not altered. This may again suggest the need to rethink the current reliance on a professional response model rather than an integrated model that works with the public by design.

101. However, the total number of injuries has been falling for many years. Dwelling fires attended by the FRS in 2018/19 accounted for 5,239 non-fatal injuries compared to 5,458 in the preceding year and 7,455 in 2008/09. This is at least partly explained by the decrease in the overall number of dwelling fires which has led to a related drop in injuries. Unlike fatalities, the circumstances leading to an injury are rarely, if ever, recorded meaning little is known about how they are incurred

102. As the FRS only attends 20%–30% of all dwelling fires, its data does not provide a true or full means by which to assess the risks associated with a dwelling/HMO fire. For that, the EHS and BCS are useful additions as their random sampling means that it includes both fires attended by the FRS and those dealt with by the public. Their data identifies that between 89% and 93% of the dwelling fires resulted in no injuries at all. Where an injury occurred, it was most likely to be due to smoke inhalation with burns/scalds being another reported, but lower frequency type of injury.

103. Headline injury trends from 2018-19 FRS data identify that there were 2 fatalities in communal living premises and 279 non-fatal casualties.

104. A 2015 study identified that there was a disconnect between the government/FRS and the public in terms of what they referred to as 'risk tolerance'. This was most evident in attitude to injuries. Official policy seems to place avoidance of any injury as its highest priority and assumes this to also be the public's main motivation and enough to dictate any response to the discovery of a dwelling/HMO fire. However, the same study found that almost all those who incurred a minor injury accepted it as a reasonable cost in relation to pursuing or achieving their personal priorities. Further, they stated, in hindsight, they would do the same again.

105. This willingness of the public to accept minor injuries to protect loved ones, the home or its contents is understandable. This may, on the face of it, seem problematic for services trying to avoid this outcome. But the literature and data show these to be well established behaviours which policy makers need to work with, rather than against.

106. It is a dilemma found in many other areas, where a balance must be found between personal freedom and risk. Generally, it is accepted that people may choose to incur reasonable risk to themselves but should avoid placing others at risk through the consequences of their actions.

107. Numerous every day and discretionary activities carry similar or higher levels of risk to those resulting from using an extinguisher. DIY and sport for example are frequently responsible for injuries or even fatalities. In response, the government and industry seek to help make products safer or provide advice. This is preferred to denying people the option to participate in either activity by withdrawing public access to tools or sports equipment, which would be a last resort, and unpopular, option. The benefits achieved by the public using extinguishers are significant, given the potential for a fire to otherwise lead to detrimental and life-changing outcomes. A low and calculated level of personal risk willingly accepted by an individual tackling a fire can avoid, or reduce, a much higher risk to others should they ignore the fire and allow it to develop. Where current guidance discourages the provision of extinguishers in public spaces, this policy is neither supported by the evidence or justifiable through a consensus from the public. Rather it is imposed on them and is inconsistent with other approaches to public health.

108. As well as the evidence of risk presented in this report, there is, of course, an ethical dimension to the above that can only be highlighted but not discussed in depth. However, it is clearly important to find a proportional and consistent balance between personal freedoms and interventions which prevent or limit that ability. Where this is done in the name of public safety, the evidence and case should be robust and transparent.

The myth of panic

109. Despite the media's enthusiasm for portraying the public as prone to panicking when faced with an emergency, the literature does not support this. This was found to be true for dwelling/HMO fires and by others who have studied the public's response to emergencies.

> 'People's disaster response actions differ significantly from disaster myths that commonly portray victims as dazed, panicked, or disorganised.' (Fischer, 2008). 'Instead, most people respond adaptively, albeit somewhat delayed because normalcy bias stimulates confirmation (milling) before initiating protective action.' (Lindell, 2013).

110. In another study, the influence of the media in promoting the idea of a panic response was highlighted, but it concluded that, 'After five decades studying scores of disasters…one of the strongest findings is that people rarely lose control'. (Clarke, 2002: 21).

111. The Kerslake Arena Review (2018: 212), following the Manchester bombing also commented positively on the public contribution to the response.

> 'The Panel found that many unsung heroes played an important role in providing first aid, care and reassurance and in assisting with moving people from the foyer to the Casualty Clearing Station. In addition to members of the public who ran to help, staff with no formal remit in this role selflessly and bravely did their best to provide care and support and undoubtedly made an important contribution to the response. Others also played a part away from the Arena whether providing shelter in local hotels or donating food and drink. Every one of them is owed a debt of gratitude.'

112. That people's behaviour changes in response to a threat and that they may experience some distress, does not mean they are not rational or capable. Emotions have understandably been shown to play a strong role in the public's response and experience of a fire or emergency (as they can for professionals). But this does not incapacitate the public in terms of taking rational and beneficial self-appointed actions.

113. Their concern for, and desire to help others is not lost to selfish behaviour, beyond a few exceptional and, generally extreme, circumstances. However, in most dwelling/HMO fires the threat is low to moderate and the public exercise sensible and appropriate risk judgement, achieving positive outcomes for themselves and others.

The public response versus official advice

114. 'Government policy seeks to improve fire safety in the home, reducing the incidence of fire and associated injuries and deaths' (English Housing Survey 2015: 13).

115. This policy appears to dominate official fire safety guidance and advice in multiple guises. Whilst it is an important focus, it has already been shown that it does not reflect the full range of public aspirations in relation to dwelling/HMO fire outcomes.

116. Furthermore, it does not seem to offer any view on whether there are specific priorities for interventions within a range of injuries, which extend from the very minor to serious or fatal. This simplistic tendency to treat all injuries the same is reflected in other areas of fire safety. It masks the need to recognise the different risk characteristics and behaviours associated with various injury types. Rather than being seen in generic terms, each will require different strategies and interventions to engage the relevant groups. The evidence shows that a reliance on the FRS response time is not an appropriate focus or strategy to achieve this.

117. The policy also fails to accord with the public who have been shown to be tolerant, or accepting, of the incurrence of minor injuries in pursuit of their personal priorities. It is important to acknowledge that the public will trade off some injury risk (or occurrence) for the attainment of personally valued rewards. In not recognising, or aiding this process, the public may be put at greater risk. For example, if an appropriate means of tackling the fire (extinguisher) is not readily available, they will improvise with whatever they can, which can cause delay in tackling the fire or mean using something that is unsuitable for the task.

118. Reflecting official policy, national and local fire safety messaging has, for some time, urged the public, on discovering a fire in the home, to 'get out, stay out and call us out', 'Don't put yourself at risk', 'Never tackle a fire yourself' and 'Leave it to the professionals'.

119. This paternalistic messaging confirms the government and FRS' belief that a professional response is the only intervention capable of safely tackling dwelling/HMO fires. Again, this starkly contrasts with the reality that between 70% and 80% of dwelling fires are tackled effectively and at low risk, by the public. The public success in extinguishing fires and, in most cases, avoiding any injury is something that should be worthy of greater study. In that way it would be possible to develop relevant messaging based on positive actions the public can adopt to tackle the fire and stay safe. Improving the relevance and usefulness of the advice to the target group in this way may help close the gap between official guidance and what people actually do.

120. Surveys from the National Association of Fire Equipment Distributors (NAFED) in America reveals the same trend of public firefighting, with even higher percentages not needing the FRS.

> 'In both the 1979 and 1985 surveys, the fire department was only called for 13% of the reported fires. In the 1996 survey, the fire department was called in 24% of the reported fires. However, in the 2010 survey the number dropped to 17% of the time'. And 'These results are not unique to NAFED surveys. A 1978 publication by the U.S. Department of Commerce stated that about 90% of fires in households are not reported, based on their survey of 33,000 fires.' (NAFED, 2010: 9)

121. Dwelling/HMO fires have a very personal impact, and it is not surprising that most people are strongly motivated to try and tackle it themselves. The importance attached to people, pets, and possessions is again emphasised. Any policy or intervention which fails to recognise this will be ineffective from the start and may leave the public exposed to greater and avoidable risks.

122. In fact, if the public did follow official advice, it is unlikely that the FRS would welcome or be able to deal with a potential increase of up to 500% in calls to attend dwelling/HMO fires. The policy default of assuming every fire is immediately high risk is evidently untrue both in practice, and in the public assessment. Fortunately, the public use their own initiative to assess which fires they can tackle and when to call the FRS. And yet they are still not aided in this process as any professional guidance continues to be withheld in favour of repeating the 'get out…' message. In that respect, the public are an integral but invisible, and neglected, part of the response to dwelling/HMO fires. For those who do so, calling the FRS is usually the penultimate action, after various self-appointed investigation, mitigation, or preservation tasks.

123. A recent study also showed that the public do not just get out, with 49% never leaving the property during the fire. Whilst this may surprise or concern many professionals, it is likely to be explained by a difference between the fire as perceived by professionals and the lived experience of the public. There is nothing to suggest that the public routinely take unnecessary risks. A more likely explanation is that the fire was small and not sufficiently well-developed to pose an imminent injury or life threat. As such, they were able to remain in the premises safely and relatively comfortably, which is supported by the evidence in relation to the majority of fires not spreading beyond the item first ignited or the room of origin. Inclement weather or other factors may also make remaining in the premises a safer or more comfortable option. Fires, like other emergencies, must also be understood in human terms.

124. Not only do many people not leave the premises, but a further group (21%) will re-enter one or more times having initially exited. This is not something which is recognised in guidance or standards but is an evidenced and rational behaviour. Again, in most cases this is not due to reckless risk taking by the public but a sensible (and intuitive) assessment that the conditions present a low level of risk. They will then exit and re-enter as they undertake their various tasks (investigation, warning, firefighting, salvage, etc.).

125. For some, re-entering may even result from a sense of frustration during what can be, or just seem, a long wait for the FRS, if called. Current FRS procedures typically do not retain communications with those at the scene between the conclusion of the 999 call and appliances arriving. Sometimes, a change in circumstances may dictate the need for urgent action before the FRS arrives, or the urge to 'do something' is overwhelming. Not much is known about this group but again these nuances highlight the need to move away from a generic and assumption-led behavioural model.

126. In summary, there is a significant difference between official assumptions/guidance and actual public behaviour. However, the government and FRS seek to deter this behaviour, and, in singularly promoting their ‘get out’ message, they exclude recognition of any other course of action or advice. What is clear is that limited numbers follow their advice and ignoring it may even provide better outcomes for most. Many policies in this area are demonstrably failing and need to better reflect the public’s priorities and the contribution.

How the public tackle fires

127. Despite tackling most dwelling/HMO fires, little is known about the public’s experience in doing so. Further, there seems to be limited and sporadic interest from academia or the fire sector in researching this subject, particularly in terms of building a detailed and objective knowledge of how the public tackle fires.

128. For example, the FRS does not publish (or possibly even record) information regarding any attempts to tackle the fire prior to their arrival at those they are called to. This is a missed and readily available opportunity to capture important data, particularly when they arrive to find the fire already extinguished. Equally, where they arrive to find an active fire, understanding what took place before and its impact on the circumstances of the fire would be insightful not just for operational reasons, but to enhance professional knowledge. Capturing this would aid them and others to drive forward public safety. The general lack of curiosity or professional interest in the public’s capability and experience undermines the relevance and effectiveness of many fire safety arrangements.

129. Encouragingly, a recent study made an important start on understanding the fire conditions the public encountered at different stages of interaction with a dwelling/HMO fire. For example, the flame size and smoke volume when they entered a room and when they exited. From this, some insight could be gained into the potential risk and how the public assess it. Much more remains to be done on this topic, but if progressed, it would make a meaningful contribution to a range of areas, e.g. improving risk communication between the services and the public.

130. Studies also identify other findings which differ from official guidance. For example, they show that the most common way in which the public are alerted to something being different (i.e. before they know it is a fire), is through either smelling or seeing smoke. Actuation of a smoke alarm was third, accounting for about one third of occurrences. It is known that the public’s initial response is typically to investigate and then undertake a range (between one and 11, with an average of five) of other actions. This typically includes tackling the fire. Their response behaviour is the same regardless of how they are first made aware of the fire or its effects.

131. The public are likely to encounter a fire that is relatively small and often contained to the item first ignited. They are often present when it starts, e.g. whilst cooking. The evidence also suggests that very few fires develop rapidly in the way perhaps anticipated by legislation and fire models.

132. The EHS and BCS do not describe the way in which individual fires were tackled by the public or the FRS but do identify what fire safety measures the respondents had in their homes, including extinguishers. During the period 2002/03 to 2016/17, fire extinguisher ownership fell from 18% to 11%, possibly due to official discouragement. In not having access to purpose-designed equipment, it is likely most would have used water as an extinguishing medium and applied it by means of improvising with household items.

133. A 2003 UK survey found that private houses accounted for only 3.3% of extinguisher use. However, across all categories of location, extinguishers were successful in extinguishing 79.9% of fires, which seems to correlate with the dwelling fire data. It reported that 58.6% were operated by trained staff, 36.4% were operated by untrained staff and in 5% of incidents, this was unknown. Data from the National Association of Fire Equipment Distributors (NAFED) provides even more robust validation of the influence of fire extinguishers as used by ‘ordinary civilians’.

> ‘The combined results of the 34 years of data are based on the performance of 32,756 fire extinguishers used on 13,453 incidents. Of the 13,221 fire incidents reported, portable fire extinguishers successfully extinguished 12,505 fires (95%).’ (NAFED 2010: 2)

134. As previously identified, the government/FRS policy is to actively deter attempts at firefighting by the public, in favour of a default to the professional response model. This has wide ranging consequences including for those who call 999. Even where someone is determined to do so, the FRS will not give them any advice on how to tackle a fire. Instead, it will repeat its advice to get out and wait for the professionals, unless it deems there is an immediate risk to life, in which case, it provides advice on how to avoid the effects of the fire (fire survival guidance). But in either case, the FRS will not share its expertise to help the public to tackle a fire more safely or effectively.

135. Once the FRS has the information it requires, they will end the call. This then leaves the caller and those present unsupported until the physical arrival of the FRS. From a risk management perspective, this seems an unusual and obvious gap. Despite being aware of a high-risk event (accounting for most recorded fire injuries), and which is still in a dynamic stage, the FRS has no risk mitigation interventions for this period, other than rushing to the scene. From a service design perspective, this means there is a neglected, and yet critical, risk period averaging nearly eight minutes. During this period, the incident is left to develop without professional influence. This omission is hard to understand either from a risk management approach or in recognition of the increasing capability of technology to bridge the gap between remote operations.

136. Studies also identify that the public experience time differently depending on what they are doing. They underestimate how long they spent when active with tasks and overestimate how long passes when they are in a passive state, e.g. waiting for help. Again, from a risk management and guidance perspective this is important because it will influence their decisions and behaviours.

137. Historically, FRS policies did include the provision of advice to the public in terms of how to tackle a fire, whether as a free service or for some as a commercial proposition. Anecdotally, the current policy of withholding advice seems to be primarily due to a concern that the FRS could be sued if the person following their advice incurs an injury. By not providing advice the FRS believe it avoids that organisational risk, even though it may leave the public exposed to otherwise avoidable injuries. If true, this is a perverse logic for a service aimed at enhancing public safety. Given the established and beneficial nature of public interventions to tackle fires, the default of repeating ‘get out’ to avoid injuries ignores the reality of the evidence of the public’s motivations and behaviours. The health sector may well offer ready-made solutions for progressing this issue given its experience in providing critical life and health advice by remote means, e.g. phone.

6. Extinguishers

Portable fire extinguishers

Introduction

138. It is assumed that most readers will be familiar with the relevant legislation and guidance regarding portable fire extinguishers (see Bibliography).

139. In combination, the legislation, standards and guidance, etc., are the instruments used to support the ability to create fire-safe premises. They include prescriptive requirements as well as providing scope for judgement/contextual application, usually through the process of industry guidance and tools, such as a risk assessment.

140. Where bibliographies are provided in the guidance documents, they primarily or exclusively refer to other technical guidance or standards. There is a notable absence of qualitative academic studies, referenced data sources or social science contributions relating to real life events. This observation tends to suggest that this type of evidence does not seem to be formally recognised or influential in the fire safety regulation and advice domain. This may reflect the fact that fire safety and its related fields are typically seen as and dominated by engineering-oriented professionals and related disciplines.

141. This relationship is recognised by British Approvals for Fire Equipment (BAFE) which observes,

> ‘It is not expected that the fire risk assessor will have the skills of a behavioural psychologist. However, whilst most other aspects of fire safety are concerned with physical or system-based issues, understanding human behaviour in the event of a fire is an essential part of the knowledge of a fire risk assessor’s role.’ (2011: 13)

This is then qualified by several requirements including, ‘To enable the fire risk assessor to carry out the above, the fire risk assessor should; Be aware of current professional thinking and practical guidance on human behaviour in fire, including case studies.’ (2011: 13)

142. Similar acknowledgements appear in various guises in other publications. However, the study of human behaviour and related social science approaches are a distinct and specialist discipline. And one in which a broad range of expertise is available. Given the fundamental importance of human behaviour, it is not clear to what extent and by what means the fire safety sector actively fulfils the requirement to have a current and sufficient knowledge, either at a national or individual level. Certainly, the composition of committees, bibliographies of key standards and codes and some of the issues raised by this report strongly suggest that the engineering expertise needs to be enhanced by ensuring that human behaviour/social science perspectives are represented and influential throughout the fire safety system.

143. The influence of major fires/case studies is also noted for their tendency to inflate awareness of rare and memorable events rather than put them in context of more typical incidents. This again can have a distorting effect on how people perceive risk.

The role of portable fire extinguishers

144. The role of the fire extinguisher appears to be generally regarded as that of a first aid fire-fighting appliance suited to tackling small fires. Either to deploy against contained fires, or for a quick intervention against one that is still developing. However, terms such as 'small' are of course subjective and will vary in interpretation between individuals and within the context of a specific fire. Whether there is a good correlation between the meaning of these terms as used in fire safety publications and in practice by the public is not clear.

145. Recognition of the valuable role of extinguishers came from a 2003 report which concluded, 'Fire extinguishers are designed to prevent relatively minor incidents becoming major conflagrations.' It is, of course, difficult to prove how many and which fires would have developed to pose a serious risk if not tackled and contained early on. Events such as the Grenfell fire are a reminder of the consequences when this happens.

146. It would be inappropriate to comment in detail on the Grenfell fire. However, it is important to learn from all fires, and whether a fire was contained or not, the contribution of the public and portable extinguishers should be routinely recorded. Over time, the data would highlight both the critical risks and the opportunities for effectively intervening to prevent catastrophic fire spread.

147. For professionals, compliance with industry regulations and standards in terms of fire extinguisher provision can be important objectives. Given their influence, it is useful to understand how the guidance anticipates the extinguisher may be used at a practical level. Within the various publications, there appear to be three underpinning principles relating to the use of extinguishers.

<u>To protect the escape route</u>

148. As would be expected, government policy and the widespread assumption that the singular aim of the public is, or should be, to quickly get out of a premises when encountering a fire, is reflected in the relevant standards and guides.

149. Both the legislation and standards/code of practice typically identify the fundamental role of the portable fire extinguishers as being to protect escape routes from the effects of fire. This is expected to facilitate evacuation and discourage people from deviating from escape routes.

150. For example, BS 5306-8 encourages their prominent use on escape routes and specifically discourages installation where a fire could compromise access to them. It also cautions against use in locations that are not on an exit unless it is required for a specific hazard.

151. The 'Fire safety in shared or rented accommodation' guide does not make any reference to tackling a fire or the provision/use of portable fire extinguishers but offers the following advice to the public: 'Plan an escape route and make sure everyone knows how to escape. It could save your life.'

152. In relation to dwellings/HMO the public seem to disagree. It does not appear that data in relation to the use of escape plans is routinely collected following a fire, even to inform campaign evaluations. However, periodic surveys identify that only 5% – 7% of households had prepared an escape plan. Neither does it accord with the research regarding risk profiles which identifies that those at greatest risk of dying are typically unable to respond (through physical or mental impairment) to the fire cues. As such, an escape plan is unlikely to be an appropriate option for this group.

To avoid injury

153. The disparity between government/professional policy and the public in relation to injuries has already been outlined. It is reiterated that avoidance of an injury (minor) in most dwelling/HMO fires is not a key driver for the public, even in retrospect when asked if they would do anything differently. Despite this, there are frequent references in the various guides to this being an aim that extinguishers can facilitate. The removal or non-provision of extinguishers in HMOs may even increase the risk of injury to the public. This results from increased time to source a means of fighting the fire and the risk of using improvised rather than purpose-designed equipment.

154. There is also a wider cost/benefit dimension. In exposing themselves to the low likelihood of a minor injury, the fire extinguisher user is likely to extinguish or potentially delay the fire development. In doing so, they may reduce the subsequent risk to many others including professional responders. Thus, the risk exposure is moderate and tolerable in relation to the benefit achievable, including avoiding a higher risk to greater numbers of people.

A default position of 'do not trust the public'

155. The view regarding the general public's capability is to some extent ambiguous and conflicting in the various documents. Overall, it tends towards a default position of not trusting them to use extinguishers, with many publications specifically stating this as a reason not to install them.

156. It is not clear what the origin or continued justification is for this distrust of the public's capability. Studies consistently demonstrate this view to be incorrect. No information was found (or provided in response to enquiries made) of the specific evidence base used to justify the advice that it is unsafe for untrained members of the public to use extinguishers. Whilst sources were limited, the available survey data and literature overwhelmingly identified the opposite to be true. They are used safely and effectively by ordinary and untrained members of the public in ways beyond those anticipated by legislation and guidance. If evidence to the contrary exists, it should be made available or transparent in the appropriate bibliographies. Otherwise, this guidance, wherever it appears, must be urgently reviewed and aligned with the evidence as it has the potential to do harm if perpetuated without sound justification. It clearly conflicts with the public will, need and right to choose for themselves.

Selection and provision of extinguishers

157. Occupiers of single private dwellings are of course free to choose what, if any, fire safety measures they adopt. But for residents in an HMO, the common areas will be subject to fire safety legislation, and through a risk assessment, a decision will be made by third parties whether to provide fire extinguishers in these spaces.

158. Different types (or classes) of fire require the use of an appropriate extinguishing medium. As a result, a range of extinguishers are available to choose from. In most cases, the appropriate provision of extinguishers (e.g. type, number and location) for a specific premises will usually result from professional advice or a risk assessment incorporating a blend of advisory criteria and local circumstances.

159. To help the end user distinguish between the various extinguishers, a system of standardised marking has been adopted. Where the risk profile requires it, there may be different types of extinguisher in the same location. Various means exist, e.g. placement, signage and training, by which any potential confusion for the end user can be reduced. Another approach to reduce the likelihood of confusion is, where appropriate, to provide general purpose extinguishers.

160. The operation of a fire extinguisher has the potential to create some risks to the user. The extinguishing medium of some can present a risk from direct contact during or after use or indirect contact (e.g. contact with the horn of a carbon dioxide extinguisher). An inappropriate choice of medium could also lead to an adverse reaction between the extinguishing agent and fire, e.g. using water on live electrical equipment. Or it could present a risk through an inability to effectively extinguish the fire or by allowing it to re-ignite.

161. The likelihood of these risks or the predicted severity of harm is not clear, due to the lack of data. However, these risks are all reduced by the measures applied to the manufacture, supply and maintenance of extinguishers identified above. In combination they should ensure that, when faced with a fire, the public will find the correct extinguisher in the correct location. Training is cited as another means to reduce the risks and is discussed in more detail in the next chapter.

162. Another concern is that the extinguisher will not be available when required, either through theft or vandalism. The 'Housing – fire safety guide' states: 'The installation of extinguishers can also lead to problems if they are not properly maintained or where equipment is discharged through malice or horseplay. For these reasons extinguishers are not recommended inside units of accommodation unless there are resident staff who are trained in their use (a caretaker, housekeeper, warden or similar).'

163. BS 5306-8 also acknowledges the potential for vandalism but does not consider it a significant issue. It believes that most extinguishers should be on an escape route and so their absence would not put the potential user at enhanced risk. It then identifies that any risk to life would be mitigated by other fire safety arrangements or the attendance of the FRS.

164. Whilst both acknowledge the problem, the difference in guidance is stark, and the BS 5306-8 seems the more logical and measured approach. However, there does not seem to be any compelling evidence to identify the presence, scale or nature of the suggested problem. Neither it is there evidence to suggest that the absence of an expected extinguisher or the failure of one to operate presents a significant risk to life, or of causing an injury.

165. Possibly, the assumption is that in the absence of an extinguisher, people will just evacuate the premises in line with official advice. However, studies suggest that the public are in fact likely to find another extinguisher or an alternative means to tackle the fire. Having decided on a task, or course of action, they will typically persevere and find a way to achieve it unless the circumstances render it impossible.

166. Other cost-effective options for reducing the potential for vandalism or theft, which do not impede the provision of fire extinguishers, include measures such as CCTV and secure access arrangements. Both are frequently found for general security in common areas and can be used to monitor fire safety equipment. Specific solutions such as tracking technology provide a viable option for active management to reduce the potential for theft. Alternatively, the fire safety provision can anticipate some degree of inoperability and incorporate a degree of redundancy allowance. But there are multiple alternative solutions that do not result in denying the public access to extinguishers.

167. A health parallel to extinguishers is the deployment of automatic external defibrillators in public spaces. Recognising that the first few minutes of a cardiac arrest are critical to the outcome, the UK and other countries have recently seen a strategy of placing these portable devices in locations where they can be immediately accessed by the public (untrained users). User-centred design ensures that they are simple to operate with remote assistance provided via the 999 call. Concerns about vandalism were also cited but instead of halting a life-saving programme, they have continued to ensure the equipment is available. It is accepted that, even if occasionally one is not available, the majority will be, and these make an invaluable contribution.

Training

168. The Regulatory Reform (Fire Safety) Order 2005 sec 21 states that the responsible person must make sure that employees are given training to 'include suitable and sufficient instruction and training on the appropriate precautions and actions to be taken by the employee in order to safeguard himself and other relevant persons on the premises.'

169. It does not specifically identify training as a necessity in relation to the use of portable fire extinguishers. In the absence of a legal duty, the issue of whether training is required then becomes a discretionary one. It is in some of the codes of practice and similar documents that the idea of training as essential is created.

170. For example, following revision, PAS 79 was recently published as two codes of practice, part 1 being for 'Premises other than Housing' and part 2 for 'Housing'. The documents both positively recognise the role of the extinguisher. However, in part 2 (which applies to housing), it advises against the provision of extinguishers where untrained users may access them. The justification given is that doing these users may pose a risk to themselves or others when tackling a fire. In part 1, the opposite applies and the risk to the user or others is not accepted as a justifiable reason for not providing extinguishers. On a human level the difference in advice is both confusing and counter intuitive. People will take more risk to protect their homes than they would a place of work and yet this guidance advises the opposite and does not accord with established human traits.

171. Any risk assessor who considers ignoring the advice, in either case, is strongly cautioned against doing so and is expected to provide a justification for their decision. Conversely, compliance with the code of practice requires no justification. Given their influential role, it is crucial then that this and other guidance is fully and transparently evidenced. Where advice reflects professional opinion and is not corroborated by evidence then this must be explicitly stated.

172. The bibliography for parts 1 or 2 did not suggest any evidence source which may inform the strong direction given. They are both limited to listing technical documents and do not include any surveys or social science studies. As such, the underpinning evidence for such important advice remains unclear.

173. It is also important to understand how the content and forceful tone of the advice is understood by risk assessors and other users of the guidance, on a human level. The important influence of human factors is becoming much widely appreciated, having developed from the aviation sector. In this regard, suitable consideration must be given to the intended, and potential unintended, consequences of any directives.

174. BS 5306-8 considers that encountering a fire could cause distress which may impair the decision-making of even someone who has had appropriate training. Whilst studies refute the idea of panic, it is not unreasonable to acknowledge that stress could impair normal abilities to some extent. But this statement by BS 5306-8 suggests a lack of confidence in prior training as the solution. A view reinforced in the same document when it discusses training and cautions that this does not provide sufficient experience for encountering a real fire. Most people will rarely encounter an uncontrolled fire and this, along with the different experience it creates to simulated or contained fires created for training purposes, mean that their response to the two may differ. It is likely that these considerations are more relevant to the few fires which are larger than expected or are developing rapidly. However, as the data has revealed, these are few and seem to be decreasing in number and proportion. Here, again, any discussion should recognise the most likely fires people will encounter rather than a default to the rare and worst-case scenario.

175. Compared to many items routinely used in everyday life, extinguishers are relatively simple and easy to operate. Most fire safety publications seem to recognise this to be the case, with British Standard 5306-8 adding the caveat that, they should be installed and maintained appropriately. In fact, there are many examples of items with comparable or greater technical complexity which pose serious risks, e.g. power tools for which training could be beneficial but is not mandatory.

176. The method of safely tackling a fire is also something which can be covered in training. This can provide an opportunity to use an extinguisher in controlled conditions allowing users to see how different extinguishers discharge. Whilst a jet of water coming from an extinguisher will not surprise most people, the use of dry powder or carbon dioxide may, because of the sounds and sight as it is operated. Familiarisation with this is clearly useful, but no data was found which suggests that it represents a significant risk or that training would reduce it.

177. Training also provides an opportunity to demonstrate how a fire responds to different extinguishing media. Evidence identifies that the public are tackling dwelling/HMO fires regularly, successfully and at low risk using improvised means. Hence, the act of tackling a fire does not seem to pose any training need.

178. Studies relating to the need for, or impact of training are scarce. However, between 2010 and 2012, Eastern Kentucky University and Worcester Polytechnic Institute conducted a joint study on the effectiveness of ordinary people using portable fire extinguishers, and the impact of a minimal amount of training, involving 276 participants. The study concluded that 'the ordinary person is able to use a fire extinguisher without hurting themselves or others', and that 'participants are able to use a fire extinguisher with great effectiveness.' (2012: 3)

179. It further found,

> 'Almost three-quarters (74%) used proper technique of aiming at the base of the fire and used a back and forth motion until the fire was extinguished. On average, users discharged the extinguishers in 13.4 seconds. After just a few minutes of training, 100% of the participants pulled the pin, squeezed the trigger, and discharged the extinguisher, with 96% aiming at the base of the fire and sweeping back and forth.' (undated factsheet)

180. The results from this study are helpful in supporting other evidence source that show that the public are not reliant on training to use extinguishers safely and effectively. However, it remains the case that whether for research or training, it is hard to fully create the conditions of a real fire. As such, the reaction of someone to either event may differ, and it is not clear whether one predicts the other. Pursuing this discussion in generic terms is unhelpful and more needs to be done to understand the difference between a fire that poses little, if any risk, and those with the potential to develop and pose a significant risk.

181. Most dwelling/HMO fires pose a low and tolerable risk to those that encounter them. The evidence shows they are being dealt with effectively, and by people without training or even specialised fire-fighting equipment. There are of course options to further reduce the risks for this group, but these do not seem to be a priority. However, there may be opportunities to enhance the market for domestic fire-fighting equipment by encouraging adoption of extinguishers suited to a domestic environment to reduce reliance on improvised equipment. Instead, an urgent focus should examine why some fires develop to create higher risk and what their characteristics are. This is an area that has the potential to make the greatest contribution to reducing the harm from dwelling/HMO fires and is in need of user-centred and targeted interventions.

182. Overall, the case for training being critical for the safe use of extinguishers (and conversely using a lack of training to justify their non-provision) requires greater scrutiny. Understanding what difference training makes, what it should include and how often it is required are key questions. These, in turn, inform whether it is required and, if so, the burden it places on businesses/organisations because of the scope, duration and frequency required to maintain competence. If the burden is perceived to be unnecessarily high, then from a financial, if not public safety perspective, it may become attractive not to provide extinguishers. But available evidence clearly identifies that extinguishers are being used safely and effectively by untrained persons. Advice to the contrary should be considered unsound unless there is relevant and robust evidence to justify its continuation. Removing, or not installing extinguishers, is not a neutral act. It must be one made from sound evidence and risk management practice if it is to improve, and not be detrimental to, public safety.

183. Despite this lack of evidence, the requirement for training and the risks to untrained users appear to be widely promoted within professional fields in the UK.

7. Research and Data

Research and data

184. The point has been made that the evidence base for some of the fire safety publications is not always clear in relation to portable fire extinguishers, or that it tends to draw on a limited range of material. Consideration of why this is the case is beyond the scope of this report. However, it is appropriate to discuss evidential material relating to dwelling/HMO fires and portable fire extinguishers in general and to highlight some of the sources that could enhance legislation, guidance, and risk assessments. Some of these exist already but are possibly not being referenced. Others are not available but would provide valuable insight.

185. In all professions, academic literature is a core source of knowledge, but fire, unlike crime and health, attracts limited and sporadic interest. Despite various attempts to do so, it still suffers from the absence of a national and co-ordinated research strategy or capability. Many important knowledge gaps remain unexamined, in part due to the limited stimulus to initiate work and partly through the difficulty of working with the sector.

186. Despite the complexities involved in fire safety issues, there is also a reliance on a relatively narrow range of academic disciplines, with engineering tending to dominate. Greater use of other fields, e.g. social sciences, would be insightful and help to narrow the gap between the perceived and real world.

187. There is also a tendency towards deductive studies (starting with a hypothesis and then testing it) and examining issues through the lens of current policy and assumptions. Studies using the grounded theory method (start with the evidence and then construct a theory) are rarer. This is true of research in relation to dwelling/HMO fires and fire extinguishers. Both approaches are necessary, but the limited use of the grounded theory method may restrict an appreciation of different perspectives, such as that of the public and, in turn, impair policy innovation.

188. Despite this, there is a valuable supply of material available for incorporation into standards and guidance publications. However, as with any evidence, it should be assessed for its quality, any influences and to identify further research needs. Whilst the issues in relation to commissioning new research have been outlined above, it is important to at least be transparent and informed about what is known and where assumptions have been made.

189. In addition to literature, data provides an important pool of evidence. Routine administrative data is one useful source, as it is available during everyday operations. For those involved in the fire safety sector, this includes information available throughout the life cycle of risk assessments, commissioning, servicing and use of extinguishers. For the FRS, this includes fire safety planning work and attending fires. Some relevant data is collected but generally relates to the service providers interests rather than seeking to capture the experience and contribution of other parties, including the public.

190. If undertaken in a structured and co-ordinated manner, it is entirely feasible to routinely collect data which would provide primary and cohesive evidence of the customer’s end-to-end needs and experience. In this sense, ‘customer’ is used to describe someone who uses commercial services as well as a user of a public sector service, e.g. someone who calls the FRS.

191. Currently, risk assessments appear to be lacking relevant and up to date knowledge of some safety critical issues including the decisions and actions taken by the public when tackling a fire. For example, were fire extinguishers present and used or not? If not, was anything else used to tackle the fire? how effective were these at tackling the fire? what are type and rates of injury associated with different scenarios? how many people had formal training on firefighting, and what influence did that have on effectiveness/injuries? This type of information seems essential to know before meaningful and credible advice can be given to the public and to inform fire safety strategies and risk assessments.

192. As well as ongoing data collection, sample surveys created for a specific task are also useful in providing a snapshot. Their value can be further enhanced when they are undertaken periodically to track trends and changes.

193. Between research and data there is a vicious cycle at play. The absence of data recording the public's experience, in turn, limits visibility of the public's experience and contribution, which, in turn, hides recognition of the need for academic research. Academia is, in general, poorly engaged with fire-related issues, and whilst major events attract some interest, the everyday emergencies do not. As such, academia is not driving the need for new data to underpin studies, nor does the sector seem to provide sufficient incentives for it to do so.

194. Where there is an absence of evidence, there will be a need to apply some professional judgement to make assumptions. This is sensible, but good practice would see these made explicit. In combination with transparency in the selection and use of evidence, the potential for false assumptions to become embedded and unchallenged would be greatly reduced.

195. Footnote: Being evidence-based is increasingly an expectation and aspiration for many organisations (for example, the National Fire Chiefs Council). However, achieving it requires a strategy, sustained commitment and specialist skills. Fortunately, there are sources of guidance and support available, and it is important that recognised methods are used at all points of the evidence cycle. For example, the quality of evidence varies, and tools such as evidence standards are useful in guiding decision makers on how to understand the merits and limitations of specific types.

8. Key Findings, Discussion, Recommendations

Key findings, discussion, and recommendations

196. This report has taken a public and human perspective towards understanding the role of portable fire extinguishers. A summary of the key findings, along with a discussion and recommendations are set out below.

Defining a good outcome

<u>Findings</u>

197. The evidence shows that a public-informed perspective of what constitutes a good outcome includes a broad range of objectives. For individuals, this will be very much determined by their specific and contemporary circumstances, which only they will be aware of.

198. The public's priorities include avoidance of embarrassment or inconvenience; limiting damage to their premises including avoiding the need for rehousing; avoiding or limiting the severity of injuries (although they will accept minor injuries in pursuit of achieving their goals); saving people, pets and valued possessions; and avoiding or minimising the longer-term consequences including emotional wellbeing and consequential vulnerability.

199. There are multiple stakeholders within the fire safety environment, and each will have their own needs, but the public perspective is poorly known and represented in professional forums.

<u>Discussion</u>

200. The public's needs and perspective in relation to their desired outcomes following a dwelling/HMO fire appears poorly represented in literature, policy, and practice. Officials and professionals tend to focus on the immediate, observable, and quantifiable damage whilst the public have a better appreciation of its impact and consequences, both at the time and in the longer term. The outcomes desired by the public are rational and, if achieved, are likely to reduce the cost (in the widest sense) to those affected, whether directly or indirectly. The public are also unlikely to change their behaviours, and it would be counter-productive to continue attempting to do so, without finding ways to help them address their concerns.

201. The best opportunity to meet the outcomes desired by the public is in minimising the effect of the fire products (fire, heat, and smoke). However, studies identify that even with fires considered minor, there can be life changing effects, and so how fires are tackled is an important but underappreciated consideration.

202. Until the public's requirements in terms of desired outcomes are fully understood and incorporated, any fire safety strategy or risk management plan (including those relating to portable fire extinguishers) can, at best, only be partially effective. Equally, no matter how professionals assess their own performance, failure to acknowledge and contribute towards achieving the public's aspirations means many of the real costs following a dwelling/HMO fire remain hidden, yet influential.

<u>Recommendation 1</u>

203. Policy makers and professionals should recognise, and actively aid achievement of the outcomes that the public seek when encountering a dwelling fire.

Characteristics of dwelling fires

<u>Findings</u>

204. There has been a substantial and sustained reduction in the number of dwelling/HMO fires, both for fires attended by the FRS and for those dealt with by the public. Therefore, the chance of having a dwelling/HMO fire is lower, even allowing for the increase in the number of households and population size over the same time.

205. Most dwelling/HMO fires are relatively small, with the majority not going beyond the item first ignited and few extending beyond the room of origin. The average area of damage caused by the fire is also reducing and financial losses are often minimal. There is no need for the FRS to attend these. Future risk communication and advice to the public should seek to help them understand in what circumstances the FRS should be called.

206. There is evidence to suggest that the use of standard fire growth models in relation to dwelling/HMO fires needs further research to assess their alignment with observations or data from real events.

207. The FRS response time to all fires and dwelling fires has increased substantially from 5 minutes and 33 seconds in 1994/95 to 7 minutes and 47 seconds.

<u>Discussion</u>

208. The characteristics of dwelling fires have been shown to be continually changing with the data identifying a trend of fewer and smaller fires. The causes of this are unknown but are likely to be due to multiple factors. However, there is an opportunity to understand the changing nature of risk and identify relationships indicated by these and other sources of data. This must incorporate what is known about the fires dealt with by the public.

209. It is reasonable to assume that the FRS data is likely to represent the more serious fires where those present felt the situation could escalate or was already beyond their ability to manage. And yet, even allowing for pre-call activity, the FRS response time and then the period until an effective intervention is made, the fires rarely extend beyond the item or room of origin. This challenges the idea that all or even most fires represent a serious risk of injury to the public.

210. The size of fire data and number of fires dealt with by the public also demonstrates that the public can deal with most fires and, in doing so, will achieve the best outcome. This should be the default assumption for planning and guidance. However, little is known about when and why they decide to call the FRS. Ideally, they would call as soon as they recognised a situation had, or was likely to, develop to be beyond their ability to safely tackle. This requires specific and evidence-based guidance. Certainly, a structured and evidence-informed assessment model would be a useful addition to guide the public when they should call the FRS. This would provide a tiered basis upon which the public and FRS could identify and communicate about risks in a meaningful way.

211. Published data regarding the final size of a fire is useful but does not provide any understanding of how the fire developed and over what period. Dwelling/HMO fires are a regular occurrence and are usually witnessed by those present. This presents a valuable and relatively easy means by which the fire development and its association with other activities (e.g. closing doors) could be captured. This could then assess the validity and inform the ongoing development of fire growth models.

212. Response times do not appear to be influential on the fire size as they have increased over the same period, and yet they are still seen as a key performance indicator. The effect is to draw resources to attempts at improving the response time rather than looking at what is happening at the premises during that period and considering other ways to assist the public prior to arrival, or even avoiding the need to attend e.g. remote assistance.

Recommendation 2

213. Information from real fires (whether dealt with by the public or the FRS) should be captured to develop an evidence-based understanding of fire development. Emphasis should be given to understanding the early indicators or specific situations when the public would be placed at risk of a serious injury.

Human Behaviour

Findings

214. Dwelling/HMO fires have attracted limited academic research, and, as a result, there are significant knowledge gaps.

215. Not everyone is at the same risk of injury. Most people are unlikely to be at risk of anything more than a minor injury, as they can assess and react to their environment, and most dwelling/HMO fires pose a low level of risk.

216. Research finds no evidence of panic in the public and in fact demonstrates a rational and often altruistic response.

217. The public do not follow official advice, which is often to their benefit.

218. Once they are aware of a fire, the public will undertake several (between one and 11) self-appointed tasks including tackling the fire. Often this will be with improvised means.

219. FRS policies do not recognise the public outcomes or ability and therefore do not routinely offer any remote support (via the 999 call) despite considering it a high risk and dynamic event.

Discussion

220. There is so much of importance that is known and even more that remains to be researched regarding human behaviour when encountering fires. Perhaps, most significantly, it challenges many of the negative assumptions about the public that are embedded in legislation, guidance and services. The public's behaviour is typically rational, effective and beneficial. The evidence of this cannot keep being ignored in favour of institutional assumptions and paternalism. Yet this finding still struggles to find popular acceptance, which has damaging consequences.

221. By recognising the motivation and capability of the public, professionals should seek to work with their behaviours. Where a specific and unacceptably high risk is identified, officials should work in conjunction (co-create) with the public to find ways to reduce or avoid this. But in deciding the tolerable balance or risk/reward, regard must be given to seeing this from the public's perspective as well. The level of risk the public experience in most dwelling/HMO fires (and their acceptance of incurring minor injuries) is entirely comparable to other everyday activities such as DIY or driving, which individuals are free to undertake, the principle being that people should not unreasonably endanger others. Tackling a fire generally presents a low risk to those undertaking it but is also an activity which can reduce the risk to others if the fire were otherwise allowed to develop. The potential for small fires to develop catastrophically remains, as has been seen in several recent fires, including the one at Grenfell. The longer the period that lapses until an active intervention is made, the greater the risk. Therefore, the early use of portable extinguishers must be considered as an essential option in any objective and evidence-based fire safety strategy.

222. Currently the public are not recognised as the essential component of fire response that they are. If the professional services acknowledged them as partners, fire safety could be enhanced or even transformed. There is an opportunity to build on the public's willingness and capability through taking a user-centred approach to develop the advice, support and equipment they need. In that respect, it is like the model used for cardiac arrest response by placing automated external defibrillators in the community and providing remote assistance by phone. It empowers those first at the scene to get the best possible outcome until professional response arrives, if required. This should be the model and principle for dwelling/HMO fires.

223. Reframing the relationship with the public would have important consequences for the fire extinguisher sector. Not least of which would be to see extinguishers as not just a regulatory requirement but something which is valued by the end-user to reduce or avoid the consequences of a fire. How the public tackle fires and their experience of using an extinguisher needs greater research. But ensuring the public have access to appropriate equipment, such as extinguishers, is key. Despite their success in doing so, the public are having to tackle fires with improvised means too often. Better aligning extinguisher design and marketing with actual customer behaviour and motivations, is likely to create new opportunities to expand the market for them and related services.

224. The use of standards makes an important contribution to the safety and effectiveness of extinguishers by providing a minimum criterion. The potential disadvantage is that these can discourage or impede innovation. Ideally, all standards should strike a balance between maintaining contemporary thresholds whilst encouraging continuous improvement.

<u>Recommendations 3 and 4</u>

225. Legislation, standards, guidance and services in relation to fire safety should be better aligned to the evidence of the public's desires, capability and contribution when encountering a dwelling/HMO fire.

226. Human behaviour knowledge, customer feedback programmes and a user-centred approach should be adopted to provide new insight into the public's requirements in terms of fire extinguisher design, including their aesthetics.

Extinguishers

Findings

227. Standards and guidance in relation to fire safety and fire extinguishers tend to be framed in engineering and compliance terms. Academic and human behaviour references are rare.

228. The role of an extinguisher as stated in guidance is narrow and does not accord with their benefit as identified from real fires and the literature.

229. Concerns about the risk to the public arising from selecting an inappropriate extinguisher or because of one being damaged/stolen, are identified in various codes of practice and the recent Grenfell Inquiry Phase 1 report. The nature and scale of either is not evidenced and solutions are readily available to address both issues.

230. Training is often cited as an essential safety requirement, and some guides advocate restricting or not providing extinguishers solely because untrained personnel are present. And yet, the evidence shows extinguishers to be safe and effective. The requirement for, and benefit of training is not clear and is certainly insufficient for justifying a policy of using training to determine whether extinguishers should be provided or not.

Discussion

231. Fire safety guidance and practice is built upon engineering foundations. This brings many advantages but may have tended to limit an appreciation or the influence of more social oriented or qualitative approaches. The implications of this are seen in numerous areas, the tone and content of standards and guidance being obvious ones. In some publications, strong emphasis is given to the onus placed on risk assessors should they fail to comply with guidance. If official policy and the public’s need/experience aligned, this would be reasonable but in so many areas, the evidence demonstrates that it differs. Without appropriate social science or public input throughout the policy cycle, this will continue to the detriment of the public and the fire safety sector.

232. The practice of referring to an extinguisher as a first aid device may need re-examining as it is potentially misleading. They are rarely used, as suggested in the guidance, just to buy time for escape before professional help arrives to extinguish the fire. Instead, the evidence suggests that the public discover most dwelling/HMO fires at an early stage, and even by using improvised means, they tackle most of them without requiring further assistance. Fire extinguishers, if more widely available, would then in most cases be sufficient to deal with the majority of dwelling/HMO fires. As such, they are not just a first aid product but are effectively a standalone intervention suited to most dwelling/HMO fires. If their contribution and needs are to be recognised, it will be crucial to fully adopt this concept.

233. Training in the use of fire extinguishers is a discretionary and not mandatory requirement, and its contribution towards reducing the potential risk of using one or enhancing the ability to tackle a fire is not clear. In fact, available studies and research find high rates of untrained people safely and effectively using extinguishers. This issue matters because some guidance states that extinguisher access should be restricted or even denied where those present are not trained. Given the evidence about the public ability, fire characteristics and increasing FRS response times, this seems hard to justify practically or ethically. Options exist to make relevant information more accessible to everyone and not just via formal courses. Alternatively, real-time and on demand support could be given to reduce any risks. But their potential for use by untrained personnel is not a viable justification to deny the public access to extinguishers.

Recommendations 5 and 6

234. Social science and customer perspectives need to be better represented in the fire safety sector, informing both guidance and practice, including those in relation to fire extinguishers.

235. The requirement for, and role of training in relation to extinguishers needs to be reviewed. Any claims made about the critical role of training should be supported with evidence or rescinded.

Research and data

Findings

236. The fire sector attracts little and sporadic academic interest, resulting in many knowledge gaps or thin evidence.

237. Data collection represents institutional interests and there is little data relating to the customer/public experience. This is compounded by data silos resulting from multiple stakeholders.

Discussion

238. The recognition that the fire sector attracts limited academic interest is not new but is re-emphasised. Since the demise of the national facility, there have been many attempts to create a research strategy and capability, but none have been realised. This increasingly places the effectiveness and credibility of the sector at risk and undermines any aspiration to be demonstrably evidence-based. It also leaves the sector unable to meaningfully exploit new and transformative technologies such as AI and machine learning. More importantly, it leaves the public exposed to avoidable risks and harm through the failure to collate, assess and disseminate knowledge.

239. Institutionally biased and siloed data collection means the public experience is almost invisible to policymakers and other professionals. In place of knowledge, assumptions are made. Good practice would, as a minimum, see these made explicit as they represent unverified beliefs and therefore cannot be relied upon. Better still, the opportunity to collect relevant data through routine activities (including dwelling/HMO fires) should be exploited to both inform and evaluate interventions.

240. However, the fire sector is not unique in facing these challenges, and, if the will were there, quick progress would be possible by learning from other sectors. Concepts such as the 'What Works' centres may be replicable in part or at reduced scale.

241. Recognition of the influence of what and how data is collected is not entirely new. In 2003, an industry survey identified that the role of extinguishers was not accurately represented and did not accurately convey their important contribution. It is clear, 18 years later, that not much has changed.

Recommendations 7 and 8

242. The fire sector urgently needs to co-operate to develop an integrated and dynamic knowledge management system.

243. A specific focus for the above should be to ensure the customer/public experience and perspective is fully represented.

Risk

Findings

244. The understanding and application of risk in relation to dwelling/HMO fires is varied, confusing and ambiguous both in the literature and in practice. The research finds that there is a need to better align risk theory, evidence, practice and communication between professionals and with the public.

Discussion

245. Throughout the research for this report, references were found to 'risk', which was not unexpected. However, it was clear that this was most often used in a generic and unqualified sense. As the fire sector (including services related to fire extinguishers) is ultimately in the risk business, it would be inappropriate to ignore this observation or to consider its impact.

246. Several studies have identified that even in academic papers, the term risk is used interchangeably and without distinction to variously mean the risk of a fire starting, of it developing, causing an injury or leading to a fatality. These are all very different risks.

247. This oversimplification and failure to convey the complex and layered or nuanced nature of risk is then seen in sector publications and practice. As a result, there is little appreciation that those who incur minor injuries are vastly different to those at risk of a fatal outcome, with each group having different needs and capabilities. This is accompanied by a tendency for policies and interventions to overly focus on the worst-case outcome. Hence, we see the general public discouraged from tackling fires despite the evidence of their effectiveness, low risks presented and benefits achieved.

248. Selectivity about what data is of interest distorts the true picture. In the same way that the police recognised the need to capture the full picture and nature of unrecorded crime, the fire sector would benefit from having a single and full view of all dwelling/HMO fires. This would better inform existing interventions and potentially identify new options/community needs. But certainly, the absence of a complete picture means that the level of risk evident from FRS data, whilst relatively low, is still significantly more than the real risk encountered if all dwelling/HMO fires were included. Risk management cannot be effective if the data or knowledge it is based on is incomplete or flawed. The role of bias (individual and organisational) and assumptions must also be understood in terms of their influence on the interpretation and assessment of risk.

249. The role and influence of case studies may also overly inflate perceived risk, despite the fact that they are highlighted because they are atypical. That is not to say they do not provide a valuable learning opportunity, but so do most events which avoid bad outcomes. The chance to learn from success, when fire spread is limited, and injuries avoided should be of equal interest.

250. There is much more that could be discussed in relation to risk. But for the purpose of this report, it is important to note that the guidance and advice (to professionals and the public) regarding the use of fire extinguishers is not informed by a complete and objective evidence base or risk framework. As a result, insufficient distinction is made of the risks in relation to different groups, and, perversely, it may leave many vulnerable to worse experiences and outcomes than could be achieved for them by a more positive and informed approach to the use of extinguishers.

Recommendations 9 and 10

251. The fire sector needs greater clarity, consistency and transparency in relation to its approach to risk management. This should include areas such as definitions, use of evidence, risk models and evaluation processes.

252. Legislation, standards, guidance and public advice should be amended to provide evidence-based and objective information in relation to the benefits and risks associated with the use of portable fire extinguishers, which are currently misrepresented.

REFERENCES

British Standards Institution (2010) BS EN3-10 Portable fire extinguishers Provisions for evaluating the conformity of a portable fire extinguisher to EN 3-7 [Online]. Available at https://shop.bsigroup.com/

British Standards Institution (2012) BS 5306-8 Fire extinguishing installations and equipment on premises Part 8: Selection and positioning of portable fire extinguishers: Code of Practice [Online]. Available at https://shop.bsigroup.com/

British Standards Institution (2017) BS 5306-3 Fire extinguishing installations and equipment on premises Part 3: Commissioning and maintenance of portable fire extinguishers: Code of Practice [Online]. Available at https://shop.bsigroup.com/

British Standards Institution (2019) BS EN 1869: Fire Blankets [Online]. Available at https://shop.bsigroup.com/

British Standards Institution and Todd, C.S. (2019) PAS 79-1:2020 Fire risk assessment – Part 1: Premises other than housing Code of practice [Online]. Available at https://shop.bsigroup.com/

British Standards Institution and Todd, C.S. (2019) PAS 79-2:2020 Fire risk assessment – Part 2: Housing – Code of practice [Online]. Available at https://shop.bsigroup.com/

Bryan, J.L. (1977) Smoke as a Determinant of Human Behaviour in Fire Situations, Washington DC, National Bureau of Standards.

Centre for risk communication (n.d.) *Community Relations Strategy Consulting* [Online]. Available at http://centerforriskcommunication.org/communication-strategy-services/community-relations-strategy-consulting/

Clarke, L. (2002) 'Panic: Myth or Reality?', *Contexts*, vol. 1, pp. 21-26 [Online]. Available at https://www-jstor-org.ezproxy4.lib.le.ac.uk/stable/41800735

Communities and Local Government (2015) *Fire safety in shared or rented accommodation* [Online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/475170/Fire-Safety-in-Shared-or-Rented-Accommodation.pdf

Communities and Local Government (2015) *Fire Safety in the Home* [Online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/564803/Fire-Safety-in-the-Home.pdf

Department for Communities and Local Government (2006) *A short guide to making your premises safe from fire* [Online]. Available at https://www.gov.uk/government/publications/making-your-premises-safe-from-fire

Department for Communities and Local Government (2014) *English Housing Survey: Fire and Fire Safety 2012/13* [Online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/335757/EHS_Fire_and_Fire_Safety_2012-13.pdf

Department for Communities and Local Government (2015) *English Housing Survey: Fire and Fire Safety 2013/14* [Online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/445702/EHS_Fire_and_fire_safety_2013-14.pdf

Department for Communities and Local Government (2018) *English Housing Survey: Fire and fire safety, 2016/17* [Online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/724327/Fire_and_Fire_Safety.pdf

Department for Local Communities and Government (2011) *The economic cost of fire: estimates for 2008* [Online]. Available at https://webarchive.nationalarchives.gov.uk/20121105004836/http://www.communities.gov.uk/documents/corporate/pdf/1838338.pdf

Drury, J., Cocking, C. and Reicher, S. (2009) 'The Nature of Collective Resilience: Survivor Reactions to the 2005 London Bombings', *International Journal of Mass Emergencies and Disasters*, vol. 27, no. 1, pp. 66–95 [Online]. Available at http://www.sussex.ac.uk/affiliates/panic/IJMED%20Drury%20et%20al.%202009.pdf

Ewen, S. (2006) 'Managing Police Constables and Firefighters: Uniformed Public Services in English Cities, c.1870–1930', *International Review of Social History*, vol. 51, no. 1, pp. 41–67 [Online]. Available at https://www-cambridge-org.ezproxy4.lib.le.ac.uk/core/journals/international-review-of-social-history/article/managing-police-constables-and-firefighters-uniformed-public-services-in-english-cities-c18701930/1A9B1D50CB77E85571C8B26F03619344

Fire and Rescue Services Act 2004 [Online]. Available at https://www.legislation.gov.uk/ukpga/2004/21/contents

Fire Risk Assessment Competency Council (2011) *Competency Criteria for Fire Risk Assessors: Version 1* [Online]. Available at

https://www.nationalfirechiefs.org.uk/write/MediaUploads/Grenfell/111221_FRA_Competency_Council_-_Competency_Criteria_for_Fire_Risk_Assessors_(2).pdf

Fire Sector Federation (2020) *Approved Code of Practice: A national framework for Fire Risk Assessor Competency Version 1* [Online]. Available at FSF_Approved Code of Practice.indd (firesectorfederation.co.uk)

Ghosh, B. (2008) *Assessment of the benefits of Fire Extinguishers as fire safety precautions in New Zealand Buildings* [Online]. Available at https://ir.canterbury.ac.nz/handle/10092/14702

Harpur, A., Boyce, K. and McConnell, N. C. (2013) 'An investigation into the circumstances surrounding fatal dwelling fires involving very young children', *Fire Safety Journal*, vol. 61, pp. 72–82 [Online]. Available at https://doi-org.ezproxy4.lib.le.ac.uk/10.1016/j.firesaf.2013.08.008

Her Majesty's Government (2003) *Fires in the Home: findings from the 2001/2 British Crime Survey* [Online]. Available at https://webarchive.nationalarchives.gov.uk/20090704061118/http://www.communities.gov.uk/documents/fire/pdf/130655.pdf

Her Majesty's Government (2004) *Fires in the Home: findings from the 2002/3 British Crime Survey* [Online]. Available at https://webarchive.nationalarchives.gov.uk/20090704061104/http://www.communities.gov.uk/documents/fire/pdf/130652.pdf

Her Majesty's Government (2006) *Fires in the Home: findings from the 2004/05 Survey of English Housing* [Online]. Available at https://webarchive.nationalarchives.gov.uk/20090704010217/http://www.communities.gov.uk/documents/fire/pdf/143501.pdf

Her Majesty's Government (2018) *Kerslake Report: An independent review into the preparedness for, and emergency response to, the Manchester Arena attack on 22nd May 2017* [Online]. Available at https://www.kerslakearenareview.co.uk/media/1022/kerslake_arena_review_printed_final.pdf

Her Majesty's Government (2019) *Grenfell Tower Inquiry: Phase 1 Report Overview* [Online]. Available at https://assets.grenfelltowerinquiry.org.uk/GTI%20-%20Phase%201%20report%20Executive%20Summary.pdf

Her Majesty's Government (2019a) *Effect of reductions in funding to police, fire and rescue services, House of Commons Debate Pack Number CDP-2019-0043* [Online]. Available at https://researchbriefings.files.parliament.uk/documents/CDP-2019-0043/CDP-2019-0043.pdf

Her Majesty's Inspectorate of Constabulary and Fire & Rescue Services (2020) *State of Fire and Rescue 2019* [Online]. Available at https://www.justiceinspectorates.gov.uk/hmicfrs/wp-content/uploads/state-of-fire-and-rescue-2019.pdf

Hill, R., Andrews, S., Murphy, P. and Lakome, K. (2019) *National Review of Community Risk Methodology across the UK Fire and Rescue Service*, Nottingham, Nottingham Trent University.

Home Office (2018b) *Fire statistics definitions* [Online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/738440/fire-statistics-definitions.pdf

Home Office (2019) *Detailed analysis of fires attended by fire and rescue services, England, April 2018 to March 2019* [Online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831136/detailed-analysis-fires-attended-fire-rescue-england-1819-hosb1919.pdf

Home Office (2020) *Response times to fires attended by fire and rescue services: England, April 2018 to March 2019* [Online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/857924/response-times-fires-england-1819-hosb0120.pdf

Home Office (n.d.) *FIRE0201: Dwelling fires attended by fire and rescue services by motive, population and nation* [Online]. Available at https://www.gov.uk/government/statistical-data-sets/fire-statistics-data-tables#dwelling-fires-attended

Home Office (2018a) *Fire and Rescue National Framework for England* [Online]. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/705060/National_Framework_-_final_for_web.pdf

Hulse, L., Galea, E. R., Thompson, O. and Wales, D. (2019) 'Perception and recollection of fire hazards in dwelling fires', *Safety Science*, vol. 122, no. 104518 [Online]. Available at https://doi-org.ezproxy4.lib.le.ac.uk/10.1016/j.ssci.2019.104518

IFEDA and FETA (2003) *Report on a Survey into Portable Fire Extinguishers and their use in the United Kingdom and other member countries of Eurofeu* [Online]. Available at https://ifeda.org/wp-content/uploads/2015/07/IFEDA-portable-fire-extinguisher-survey-results.pdf

Institute of Lifelong Learning (2011) MSc in Risk, Crisis and Disaster Management, Module 2, Unit 3

Irwin, A. (1995) *Citizen Science*, London, Routledge.

Jennings, C. R. (2013) 'Social and economic characteristics as determinants of residential fire risk in urban neighborhoods: A review of the literature', *Fire Safety Journal,* vol. 62, pp. 13-19 [Online]. Available at https://doi-org.ezproxy4.lib.le.ac.uk/10.1016/j.firesaf.2013.07.002

Jonsson, A. and Jaldell, H. (2018) 'Identifying sociodemographic risk factors associated with residential fire fatalities: a matched case-control study', *Injury prevention*, vol. 24, no. 2 [Online]. Available at https://10.1136/injuryprev-2018-043062

Kahneman, D. and Tversky, A. (1974) 'Judgement under Uncertainty: Heuristics and Bias', *Science*, vol. 185, no. 4157, pp. 1124–1131 [Online]. DOI: 10.1126/science.185.4157.1124

Kobes, M., Helsloot, I., de Vries, B. and Post, J.G. (2010), 'Building safety and human behaviour in fire: A literature review', *Fire Safety Journal*, vol. 45, no. 1 [Online]. Available at https://www-sciencedirect-com.ezproxy4.lib.le.ac.uk/science/article/pii/S0379711209001167

Kuligowski, E. (2013) 'Predicting Human Behaviour During Fires', *Fire Technology,* vol. 49, pp. 101–120 [Online]. Available at https://doi-org.ezproxy3.lib.le.ac.uk/10.1007/s10694-011-0245-6

Kuligowski, E. (2016) 'Burning down the silos: integrating new perspectives from the social sciences into human behaviour in fire research', *Fire and materials*, vol. 41, no. 5, pp. 389–411 [Online]. Available at https://doi.org/10.1002/fam.2392

LACORS (2008) *Housing – Fire Safety: Guidance on fire safety provisions for certain types of existing housing* [Online]. Available at https://www.cieh.org/media/1244/guidance-on-fire-safety-provisions-for-certain-types-of-existing-housing.pdf

Lindell, M. (2013) 'Disaster Studies', *Current Sociology Review*, vol. 61, no. 5-6, pp. 797–825 [Online]. Available at https://journals-sagepub-com.ezproxy4.lib.le.ac.uk/doi/abs/10.1177/0011392113484456

Liu, T. and Jiao, H. (2017) 'How does information affect fire risk reduction behaviors? Mediating effects of cognitive processes and subjective knowledge', *Natural Hazards*, vol. 90, no. 3, pp. 1461–1483 [Online]. Available at https://link-springer-com.ezproxy4.lib.le.ac.uk/article/10.1007/s11069-017-3111-0

Local Government Association (2018) *Fire Vision 2024* [Online]. Available at https://www.local.gov.uk/sites/default/files/documents/10.20%20-%20Fire%20Vision%202024_4.pdf

London Fire Brigade (2016) *Fire Survival Guidance (Supervisor)*; *(*submitted as evidence to Grenfell inquiry*)* [Online]. Available at https://assets.grenfelltowerinquiry.org.uk/documents/Fire%20Survival%20Guidance%20%28Supervisor%29%20-%20Providing%20support%20and%20assistance%20to%20CROs%20handling%20Fire%20Survival%20Guidance%20%28FSG%29%20calls%20LFB00003541_0.pdf

Matellini, D. B., Wall, A.D., Jenkninson, I. D., Wang, J. and Pritchard, R. (2013) 'Modelling dwelling fire development and occupancy escape using Bayesian network', *Reliability Engineering & System Safety,* vol. 114, pp. 75–91 [Online]. Available at https://doi-org.ezproxy4.lib.le.ac.uk/10.1016/j.ress.2013.01.001

Mytton, J., Goodenough, T. and Novak, C. (2017) 'Children and young people's behaviour in accidental dwelling fires: A systematic review of the qualitative literature', *Safety Science* vol. 96, pp. 143–149 [Online]. Available at https://doi-org.ezproxy4.lib.le.ac.uk/10.1016/j.ssci.2017.03.019

National Association of Fire Equipment Distributors (2010) *The effectiveness of Portable Fire Extinguishers: An Overview 1976-2010* [Online]. Available at http://www.nafed.org/uploads/1/1/6/7/116763213/nafed_2010_effectivenessofpo.pdf

National Operational Guidance (n.d.) *Hazard - Failure to handle emergency calls and mobilise resources in a timely manner* [Online]. Available at https://www.ukfrs.com/training-specification/search/failure-handle-emergency-calls-and-mobilise-resources-timely-manner

NESTA and Alliance for Useful Evidence (2016) *Using Research Evidence: A practice guide* [Online]. Available at Using-Research-Evidence-for-Success-A-Practice-Guide-v6-web.pdf (alliance4usefulevidence.org)

New Local Government Network (2015) *Fireworks: A collaborative way forward for the fire and rescue service* [Online]. Available at https://www.basw.co.uk/resources/fire-works-collaborative-way-forward-fire-and-rescue-service

Nickerson, R. S. (1998) 'Confirmation Bias: A Ubiquitous Phenomenon in Many Guises', *Review of General Psychology*, vol. 2, no. 2, pp. 175–220 [Online]. Available at https://doi.org/10.1037%2F1089-2680.2.2.175

Pidgeon, N., Hood, C., Jones, D., Turner, B. and Gibson, R. (1992) 'Risk Perception', in The Royal Society Report, *Risk: Analysis, Perception and Management*, London, Royal Society.

Poole, B. R. (2012) *Ordinary People and Effective Operation of Fire Extinguishers*, Worcester Polytechnic Institute [Online]. Available at Student Work | Ordinary People and Effective Operation of Fire Extinguishers | ID: t148fh606 | Digital WPI

Rodriguez, H., Trainor, J. and Quarantelli, E.L. (2006) 'Rising to the Challenges of a Catastrophe: The Emergent and Prosocial Behavior Following Hurricane Katrina', *ANNALS of the American Academy of Political and Social Science,* vol. 604, pp. 82–101 available at: https://www-jstor-org.ezproxy4.lib.le.ac.uk/stable/25097782

Schmidt, S. and Galea, E.R. (2013) *Behaviour – security – culture: Human behaviour in emergencies and disasters: A cross-cultural investigation,* Lengerich, Pabst Science Publishers.

Scottish Fire and Rescue Service (2020) *Fire and Rescue Incident Statistics* [Online]. Available at https://www.firescotland.gov.uk/about-us/fire-and-rescue-statistics.aspx

Spinardi, G., Bisby, L. and Torero, J. (2016) 'A Review of Sociological Issues in Fire Safety Regulation', *Fire Technology,* vol. 52, no. 5 [Online]. Available at https://doi.org/10.1007/s10694-016-0615-1

The Regulatory Reform (Fire Safety) Order 2005, [Online]. Available at https://www.legislation.gov.uk/uksi/2005/1541/contents/made

Thompson, O., Galea, E.R. and Hulse, L. (2018) 'A review of the literature on human behaviour in dwelling fires', *Safety science*, vol. 109, pp. 303–312 [Online]. Available at https://doi-org.ezproxy4.lib.le.ac.uk/10.1016/j.ssci.2018.06.016

Thompson, O.F. and Wales, D. (2015) 'A qualitative study of experiences, actions and motivations, during accidental dwelling fires', *Fire and Materials*, vol. 39, no. 4, pp. 453–465 [Online]. Available at https://doi.org/10.1002/fam.2248

Thompson, O.F., Hulse L., Wales, D. and Galea, E.R. (2013) 'Get Out, Stay Out versus occupier independence: the results of an 18 month study of human behaviour in accidental dwelling fires in Kent', Conference Proceedings: Volume 2: Interflam 2013, London, Interscience Communications

United Nations Office for Disaster Risk Reduction (2020) *Sendai framework: Understanding Risk* [Online]. Available at https://www.undrr.org/building-risk-knowledge/understanding-risk

United Nations Office for Disaster Risk Reduction (n.d.) *Understanding Risk* [Online]. Available at https://www.undrr.org/building-risk-knowledge/understanding-risk

Ursano, R., Fullerton, C. and Terhakopian, A. (2008) 'Disasters and Health: Distress, Disorders, and Disaster Behaviors in Communities, Neighborhoods, and Nations', *Social Research*, vol. 75, no. 3, pp. 1015–1028,1035 [Online]. Available at https://www-jstor-org.ezproxy4.lib.le.ac.uk/stable/40972101?seq=1#metadata_info_tab_contents

Veeramany, A., Weckman, E. J. and Pandey, M. D. (2014) 'A Semi-Markov Fire Growth Model', *Fire Technology*, vol. 50, pp. 437–454 [Online]. Available at https://doi-org.ezproxy4.lib.le.ac.uk/10.1007/s10694-012-0304-7

Wales, D. (2020) Unrecognised: *The public role as first responders to dwelling fires*, Unpublished MSc dissertation.

Wales, D. and Stiles, K. (2019) *Saving Lives Is Not Enough* [Online]. Available at https://tinyurl.com/SLINE2019

Wales, D.G., Thompson, O.F., Hulse, L.M. and Galea, E.R. (2015) 'From data to difference – considering the application of a large-scale database of human behaviour in accidental dwelling fires', *6th International Symposium: Human Behaviour in Fire 2015: Symposium Proceedings*. London, England, Interscience Communications, pp. 465–476.

Walker, R. G. (2017) *Practical Assessment of the Dependence of Fire Service Intervention Times on Life Safety*, PhD thesis (partial) [Online]. Available at http://clok.uclan.ac.uk/20721/1/20721%20Walker%20Richard%20Final%20e-Thesis%20%28Master%20Copy%29.pdf

Wood, P.G. (1972), '*The Behaviour of People in Fires'*, Fire Research Note 953. Boreham Wood, Building Research Establishment.

Xiong, L., Bruck, D. and Ball, M. (2015) 'Comparative investigation of 'survival' and fatality factors in accidental residential fires', *Fire Safety Journal,* vol. 73, pp. 37–47 [Online]. Available at https://doi-org.ezproxy4.lib.le.ac.uk/10.1016/j.firesaf.2015.02.003

Xiong, L., Bruck, D. and Ball, M. (2014) 'Utilization of the Haddon Matrix to Organize Factors of Survived Accidental Residential Fires: Frequencies for Human, Agent, and Environment-related Variables', *Fire Safety Science*, vol. 11, pp. 1049–1062 [Online]. Available at http://www.iafss.org/publications/fss/11/1049/view/fss_11-1049.pdf

Thanks also to Community Safety Statistics /Welsh Government for Welsh FRS data.

About the author

David Wales CCXP MSc FRSA

David is the founder of SharedAim Ltd., a company established to help organisations deliver excellent customer experience and enhance performance. It specialises in using a human first approach that recognises the dynamic and complex nature of people's lives. Uniquely, this allows organisations to take an outside-in view and have a realistic understanding of how they fit into their customers world.

Prior to this, David had a distinguished career in the Fire and Rescue Service, where he instigated and led an award-winning national study of human behaviour in fires. His insights provided an entirely new perspective and changed thinking and practice in the sector, in the UK and internationally. As a result, he was appointed as the first customer experience manager in the FRS, where he was also recognised for his innovation.

In 2019, his co-authored report 'Saving Lives Is Not Enough' (https://tinyurl.com/SLINE2019) was published, bringing a survivor and evidence-based perspective to challenge current pre-hospital burn care arrangements.

David completed a MSc in risk crisis and disaster management at the University of Leicester. His dissertation was titled 'Unrecognised: The public role as first responders to dwelling fires'.

He retains an interest in supporting the emergency sector and is an advisor to several international crisis and disaster organisations. He has held a variety of voluntary roles, including the international research lead for the National Fire Chiefs Council and the evidence champion (for the FRS) with the Alliance for Useful Evidence.

An award-winning presenter, best-selling author, awards judge and recognised customer experience influencer, David has worked extensively across multiple sectors. Taking a human-centred approach, David advocates the need to re-imagine and transform services in partnership with citizens and communities.

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Tab 4

Other USBC Non-Consensus Proposals

EC-C1301.1.1(2)-21

Proponents: DHCD Staff (sbco@dhcd.virginia.gov)

2018 Virginia Construction Code

Revise as follows:

~~**[E]**~~ **1301.1.1 Criteria.** Buildings shall be designed and constructed in accordance with the *International Energy Conservation Code.*
Exception. Buildings with occupancy classifications of Factory Group F, Storage Group S or Utility and Miscellaneous Group U.

Reason Statement: This proposal is based on legislation (Full text provided below) directing the Board of Housing and Community Development to consider to provide an exemption from any requirements in the energy efficiency standards in the current USBC and subsequent amendments for use groups and occupancy classifications F, S and U. This proposal is a replica of EC-C1301.1.1 which is being considered for revisions by the proponent based on workgroup feedback.
In the event that proposal EC-C1301.1.1 is NOT amended, this proposal will be withdrawn.

CHAPTER 407
An Act to direct the Board of Housing and Community Development to consider, during the next code development cycle, certain revisions to the Uniform Statewide Building Code regarding energy efficiency requirements for certain use and occupancy classifications.

[H 1289]Approved April 11, 2022
Be it enacted by the General Assembly of Virginia:

1. *§ 1. That the Board of Housing and Community Development is directed to consider, during the next code development cycle, revising the Uniform Statewide Building Code (§ 36-97 et seq. of the Code of Virginia) to provide an exemption from any requirements in the energy efficiency standards established pursuant to 13VAC5-63-264 of the Virginia Uniform Statewide Building Code and the 2018 Virginia Energy Conservation Code, and any subsequent amendments to the Virginia Uniform Statewide Building Code and the 2018 Virginia Energy Conservation Code, for the following use and occupancy classifications pursuant to Chapter 3 of the 2018 Virginia Construction Code: (i) Section 306, Factory Group F; (ii) Section 311, Storage Group S; and (iii) Section 312, Utility and Miscellaneous Group U.*

Cost Impact: The code change proposal will decrease the cost of construction
This proposal will decrease the cost of construction.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency
This code change does not have an effect on the resiliency of buildings in terms of withstanding disasters (copied from EC-C1301.1.1).

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: EC-C1301.1.1(2)-21

Discussion by William Penniman
Jun 10, 2022 14:34 UTC

The Board should reject any proposal to exempt Groups F, S and U from energy efficiency standards.

In the 2022 legislative session, at the behest of an industry group, the General Assembly approved HB1289 directing the Board to "consider" whether to exempt three groups of commercial buildings from the building code's energy efficiency standards.

In this proceeding, **the industry proponent of the legislation withdrew their proposal (EC-C1301.1.1-21) to exempt the three categories of buildings from energy efficiency standards.** (Instead, it has submitted a separate proposal (EC-Appendix CB-21) to rollback certain efficiency standards.)

In the absence of an industry proposal for an exemption, the DHCD Staff is presenting this proposal EC-C1301.1.1(2)-21 solely so that the requirement to "consider" is fulfilled. The Staff does not endorse an exemption and presents no arguments or data in support of the proposal.

The proposed exemption of 3 broad categories of commercial buildings (F, S and U) from the code's energy conservation standards should be rejected. The proposal is supported neither by the law nor by relevant evidence about need, costs, savings or impacts on the public.

1. The proposal is not supported by Virginia law. The proposal relies on HB1289, which directs the Board

> "to consider during the next code development cycle, revising the Uniform Statewide Building Code…to provide an exemption from any requirements in the energy efficiency standards established pursuant to 13VAC5-63-264 of the Virginia Uniform Statewide Building code and the 2018 Virginia Energy Conservation Code, and the subsequent amendments to the Virginia Uniform Statewide Building code and the 2018 Virginia Energy Conservation Code, for the following use and occupancy classifications pursuant to Chapter 3 of the 2018 Virginia Construction Code: (i) Section 306, Factory Group F; (ii) section 311, Storage Group S; and (iii) Section 312, Utility and Miscellaneous Group U."

There are several problems with this proposal for an exemption.

HB1289 is merely procedural. It directs the Board to *consider* a proposal for exemptions, but (unlike H2227 enacted in 2021) HB1289 did not alter the legal standards applicable to Virginia's building codes, nor did it create any kind of presumption in favor of granting an exemption. If the General Assembly had wanted to see an exemption for three broad categories of buildings *without review under applicable laws*, it would have simply ordered an exemption or would have modified applicable legal standards. Since it did not do so, its direction "to consider" is bound by otherwise applicable law, which does not authorize a broad rollback to standards below the latest IECC.

Virginia law governing building codes still requires implementation of code provisions that "protect the health, safety and welfare of the residents of the Commonwealth," so that buildings are "constructed, rehabilitated and maintained consistent with recognized standards of health, safety, energy conservation and water conservation." Consideration can be given to reducing the costs of compliance, only to the extent "consistent with" applicable national codes for energy conservation. Further, as a result of H2227 enacted in 2021, the building code is expected to be "at least stringent as" the latest IECC, with anything weaker having to be justified based on whether the energy cost savings and other benefits to occupants and the public "over time" are less than the incremental cost of complying with the energy conservation code. Pollution reduction benefits are among the benefits to be considered.

The applicable legal standards are clearly not met by any evidence or analysis in support of this proposal for sweeping exemptions. Exempting any category of building from the building code without application of established law governing to a convincing body of evidence would be *per se* arbitrary, harmful to the public and unlawful.

Furthermore, HB1289 directs consideration of granting an "exemption from any requirements," it does not suggest that a sweeping exemption should be considered for "all" requirements. Even specific exemptions or modifications would have to be justified by application of the generally-applicable building code laws to evidence and analysis about savings and benefits. None has been provided.

2. No credible evidence has been presented to support a total exemption from efficiency standards.

There is no evidence to support granting an exemption from any part of the otherwise applicable energy efficiency standards. The Staff's supporting statement simply indicates that, under HB1289, the Board is supposed to "consider" an exemption. Staff does not recommend adoption or present any evidence to support such an exemption. And, as noted, those who sought the legislation have withdrawn their request for an exemption.

Considerable detailed evidence would be needed for each category of building, but has not been supplied. The types of buildings are very different from each other. Section 306 Factory Group F identifies over 50 types of factories; Section 311 Storage Group S lists over 60 types of storage facilities; and Section 312 Utility and Miscellaneous Group U identifies over a dozen categories. Some of the facilities store products (*e.g.*, food) that are temperature sensitive and require a great deal of energy (lessened only by energy efficiency) to achieve temperature goals. Some have employees whose comfort must be maintained. Other buildings involve manufacturing and other operations, which have still different energy and energy-efficiency profiles. Yet the proposal provides no analysis or evidence concerning the many types of buildings or their energy footprints, available technologies, employee and customer needs, compliance costs, energy cost savings, pollution impacts or other potentially relevant factors.

No cost data are presented either for construction cost avoidance or for increased energy consumption and costs for future occupants. Warehouse buildings can be huge. Some will have millions of cubic feet of space that would be heated and/or cooled. Eliminating or weaking energy efficiency would cause great operational expense, much resulting air pollution and increased burdens on utilities that would spill over to other customers.

Virginia's builders have successfully implemented the latest energy conservation standards for these types of buildings for many years. The code provides varying pathways to achieve compliance, including ASHRAE standards as an alternative to the IECC. The code already provides some exemptions to low-energy buildings. No explanation with supporting data explains why all of those standards are now inappropriate.

There is no evidence concerning the lost energy and cost savings or lost public benefits that would result from eliminating or even weakening the code standards applicable to these types of buildings. In reality, residents of the Commonwealth would be affected by exempting these three large categories of buildings from all energy conservation requirements. There would be increased air and climate pollution from higher energy consumption (a specifically relevant factor identified in H2227), and higher demands on utilities which would affect all customers' rates and bills. Large increases in commercial demands could compound resiliency problems for utilities and other customers.

Ironically, the proposal is being presented at a time when the warehouse business has been booming in Virginia, as documented by Virginia Business.com See, for example, "**Need for speed: Developers race to build warehouses amid site shortage,"** https://www.virginiabusiness.com/article/need-for-speed/ (Dec. 31, 2021) ("Geoff Poston [of Hampton Roads] likens the current market for building, buying and leasing warehouses and distribution centers to the mid-1800s California Gold Rush: Everybody wants in." The problem is land, not demand or ability to construct.); **"Making it rain: Increased e-commerce fuels wave of distribution centers,"** https://www.virginiabusiness.com/article/making-it-rain/ (April 29, 2021) ("For Hanover County Economic Development Director Linwood Thomas, things couldn't get much better. 'It's really been a perfect storm,' Thomas says. That storm — the good type — is a deluge of distribution centers and warehouses that have opened recently or are currently in the pipeline for the county of about 108,000 residents, located about 20 miles north of Richmond.… Over the past two years or so, Hanover has added about 1.5 million square feet of new space and about 80% of that has been leased. 'Then, we've got another almost 4 million square feet proposed in the next 24 months. These are tangible products that will put us over 5.5 million square feet of new space, which is huge,' says Thomas, noting that the new space will represent a nearly 40% increase over the county's existing stock of 13.8 million square feet of industrial/warehouse space."); **"Industrial boom: Virginia continues to see more warehouses and distribution centers**,"   https://www.virginiabusiness.com/article/industrial-boom/ (July 27, 2018)("While Hampton and Southwest Virginia area also benefiting, …. Richmond's industrial warehouse market is currently undergoing a "golden age" in the distribution sector, according to a recent report from CBRE.")

Building code standards have been promulgated, over many years, under the auspices of national code organizations, including the ICC and ASHRAE. Those code provisions drew upon the hard work, expertise and negotiations of hundreds of industry and efficiency experts, architects, engineers, trade associations, environmental experts, government bodies and public review processes. Nothing in the IECC or ASHRAE standards were arbitrarily arrived at.   As evidenced by the existing code's low-energy building exemptions and performance alternatives (e.g., use of ASHRAE standards), building usage patterns and designs were considered by the IECC and ASHRAE when they drew up the standards. No evidence explains why those standards are flawed or how the public would benefit from removing them.

Although they may not have specifically reviewed all categories of buildings (including these), it is significant that DOE/PNNL have consistently found that ASHRAE and IECC standards save money for building users through energy savings compared to initial construction costs.
https://www.energycodes.gov/sites/default/files/2021-07/Cost-effectiveness_of_ASHRAE_Standard_90-1-2019-Virginia.pdf

Energy efficiency should be increased not cut back. Energy efficiency is the first line of defense against the energy production and combustion that raise occupancy costs and drive climate change. The harms from climate change are here now and growing in Virginia, the U.S. and the world. Rising heat sickens and kills people and other living things. Rising seas are flooding Virginia's coast and could rise 2 feet by 2050. Human-driven warming harms agriculture, disrupts supply chains, feeds mass-migration and hunger, and destroys resources (e.g., lumber) needed for the economy. The harm from climate pollution will last centuries. Granting special exemptions to a particular group of businesses is not justifiable when it will only exacerbate those harms to current and future generations.

Building energy efficiency also promotes resiliency by preserving comfort longer during power outages; lowers occupants operating costs; and reduces costly demands on utility systems.

Despite short-term appeals to some builders of reducing their construction costs, adopting the proposal would increase the risk that the buildings would become obsolete more quickly as energy operating costs go up for occupants. Lower rents and vacancies could follow just as they have for older office buildings in many areas.

For the reasons summarized above, the proposal should be rejected.

Attachments: https://va.cdpaccess.com/proposal/1162/discuss/150/file/download/736/comments%20on%201301.1.1%282%29-21%20Staff%20broad%20exemption%20proposal.docx

EC-C1301.1.1(2) – Staff Summary

Proponent: DHCD Staff

Brief Description:

The proposal is based on legislation directing the Board of Housing and Community Development to consider providing an exemption from any requirements in the energy efficiency standards in the current USBC and subsequent amendments for use groups and occupancy classifications, F, S and U. This proposal is similar to EC-Appendix EB, but is a full exemption from IECC for these classifications.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The Sub-Workgroup members in attendance at the May 19, 2022, meeting voted to not support the proposal.

Energy Sub-Workgroup members in attendance during the May 19, 2022 meeting:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
    - Comments from similar proposal (EC-Appendix EB): Believed this is better than the wider exception (he was referring to a previous proposal with similar outcome, which was withdrawn in favor of this proposal). Occupancy classifications are broad, covering buildings that are multi-purpose use. He's a "no" right now, and would still like to work on it because it's not specific enough. Also, it only brings the code up to the 2006 IECC standards, which is not enough.
- Chelsea Harnish: Virginia Energy Efficiency Council
    - Comments from similar proposal (EC-Appendix EB): Agreed with Eric. Particularly, utility and miscellaneous occupancies are too broad.
- K.C. Bleile: Viridiant
- William (Bill) Penniman: Sierra Club – Virginia chapter
    - Comments from similar proposal (EC-Appendix EB): Was in opposition, but agreed to continue to work with the proponent in a hope to narrow the scope.

Energy Sub-Workgroup members not in attendance during the May 19, 2022 meeting:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Brett Vassey (Virginia Manufacturers Association); Jack Avis (Avis Construction); Matt Benka (Virginia Contractor Procurement Alliance and MDB Strategies)

- Matt Benka (Virginia Contractor Procurement Alliance and MDB Strategies)
    - Supports this proposal to see it move forward to the BHCD for their consideration.

Opposition:

- Eric Lacey (RECA)
    - Is opposed to this proposal, which creates very broad exceptions for buildings.
- William Penniman (Sierra Club – Virginia Chapter)
    - Also opposes this proposal. It doesn't make sense. There is no energy efficiency or cost savings.
- Chelsea Harnish (VAEEC)
- Ben Rabe (NBI)
- Paula Eubank (FEMA)

DHCD Staff Notes: Staff created this proposal, which is identical to a proposal that was withdrawn, due to legislation (language provided below) requiring the BHCD to consider energy requirement exemptions for buildings with occupancy classifications of Groups F, S and U. There is still a similar proposal, EC-Appendix CB, for consideration. Only one of these proposals should be approved if the Board chooses to do so, to avoid conflicts.

CHAPTER 407

An Act to direct the Board of Housing and Community Development to consider, during the next code development cycle, certain revisions to the Uniform Statewide Building Code regarding energy efficiency requirements for certain use and occupancy classifications.

[H 1289]Approved April 11, 2022

Be it enacted by the General Assembly of Virginia:

1. *§ 1. That the Board of Housing and Community Development is directed to consider, during the next code development cycle, revising the Uniform Statewide Building Code (§ 36-97 et seq. of the Code of Virginia) to provide an exemption from any requirements in the energy efficiency standards established pursuant to 13VAC5-63-264 of the Virginia Uniform Statewide Building Code and the 2018 Virginia Energy Conservation Code, and any subsequent amendments to the Virginia Uniform Statewide Building Code and the 2018 Virginia Energy Conservation Code, for the following use and occupancy classifications pursuant to Chapter 3 of the 2018 Virginia Construction Code: (i) Section 306, Factory Group F; (ii) Section 311, Storage Group S; and (iii) Section 312, Utility and Miscellaneous Group U.*

Meeting summaries and proposal related information: Tab 10 - Page 79; Tab 11 - Page 43.

EC-Appendix CB-21

Proponents: Matthew Benka; John Avis (avisj@avisconstruction.com)

2021 International Energy Conservation Code

Add new text as follows:

C402.1.6 Groups F, S, and U. Appendix CB may be used as an alternative to the *building thermal envelope* provisions of this code for Groups F, S, and U.

APPENDIX CB
BUILDING ENVELOPE REQUIREMENTS

CB101
Scope

CB101.1 General. These provisions shall be permitted as an alternative to building thermal envelope requirements for building areas containing uses that are classified as Group F, S or U.

CB102
Building Envelope Requirements

CB102.1 Insulation and fenestration criteria. The building thermal envelope shall meet the requirements of Tables CB102.2(1) and CB102.3 based on the climate zone specified in Chapter 3[CE]. Buildings with a vertical fenestration area or skylight area that exceeds that allowed in Table CB102.3 shall comply with the building envelope provisions of ASHRAE/IESNA 90.1.

CB102.2 Specific insulation requirements. Opaque assemblies shall comply with Table CB102.2(1).

CB102.2.1 Roof assembly. The minimum thermal resistance (R-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table CB102.2(1), based on construction materials used in the roof assembly.

Exception: Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 .4 mm) or less and where the area weighted U-factor is equivalent to the same assembly with the R-value specified in Table CB102.2(1).

Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation.

CB102.2.2 Classification of walls. Walls associated with the building envelope shall be classified in accordance with Section CB102.2.2.1 or CB102.2.2.2.

CB102.2.2.1 Above-grade walls. Above-grade walls are those walls covered by Section CB102.2.3 on the exterior of the building and completely above grade or walls that are more than 15 percent above grade.

CB102.2.2.2 Below-grade walls. Below-grade walls covered by Section CB102.2.4 are basement or first-story walls associated with the exterior of the building that are at least 85 percent below grade.

CB102.2.2.3 Above-grade walls. The minimum thermal resistance (R-value) of the insulating material(s) installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table CB102.2(1), based on framing type and construction materials used in the wall assembly. The R-value of integral insulation installed in concrete masonry units (CMU) shall not be used in determining compliance with Table CB102.2(1). "Mass walls" shall include walls weighing at least (1) 35 pounds per square foot (170 kg/m2) of wall surface area or (2) 25 pounds per square foot (120 kg/m2) of wall surface area if the material weight is not more than 120 pounds per cubic foot (1,900 kg\m3).

CB102.2.4 Below-grade walls. The minimum thermal resistance (R-value) of the insulating material installed in, or continuously on, the below-grade walls shall be as specified in Table CB102.2(1) and shall extend to a depth of 10 feet I (3048 mm) below the outside finish ground level, or to the level of the floor, whichever is less.

CB102.2.5 Floors over outdoor air or unconditioned space. The minimum thermal resistance (R-value) of the insulating material installed either between the floor framing or continuously on the floor assembly shall be as specified in Table CB102.2(1), based on construction materials used in the floor assembly.

"Mass floors" shall include floors weighing at least (1) 35 pounds per square foot (170 kg/m2) of floor surface area or (2) 25 pounds per square foot (120 kg/m2) of floor surface area if the material weight is not more than 12 pounds per cubic foot (1,900 kg/m3).

CB102.2.6 Slabs on grade. The minimum thermal resistance (R-value) of the insulation around the perimeter of unheated or heated slab-on-grade floors shall be as specified in Table CB102.2(1). The insulation shall be placed on the outside of the foundation or on the inside of a foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance as shown in the table or to the top of the footing, whichever is less, or downward to at least the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table.

CB102.2.7 Opaque doors. Opaque doors (doors having less than 50 percent glass area) shall meet the applicable requirements for doors as specified in Table CB102.2(1) and be considered as part of the gross area of above-grade walls that are part of the building envelope.

~~**Revise as follows:**~~ **Add new text as follows:**

TABLE ~~C402.1.3~~ CB102.2(1) OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE[a] METHOD

CLIMATE ZONE	3	4 EXCEPT MARINE	5 AND MARINE 4
Roofs			
Insulation entirely above roof deck	R-15ci	R-15ci	R-15ci
Metal buildings (with R-5 thermal blocks[a])[b]	R-19	R-19	R-19
Attic and other	R-30	R-30	R-30
Walls, above grade			
Mass	R-5.7ci[c, e]	R-5.7ci[c]	R-7.6ci
Metal building[b]	R-13	R-13	R-13 + R-13
Metal framed	R-13	R-13	R-13 + R-3.8ci
Wood framed and other	R-13	R-13	R-13
Walls, below grade			
Below-grade wall[d]	NR	NR	NR
Floors			
Mass	R-5ci	R-10ci	R-10ci
Joist/framing	R-19	R-19	R-19
Slab-on-grade floors			
Unheated slabs	NR	NR	NR
Heated slabs	R-7.5 for 12″ below	R-7.5 for 12″ below	R-7.5 for 24″ below
Opaque Doors			
Swinging	U - 0.70	U - 0.70	U - 0.70
Roll-up or sliding	U - 1.45	U - 1.45	U - 1.45

2

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m2, 1 pound per cubic foot = 16 kg/m3.

ci = Continuous Insulation, NR = No Requirement

a. Thermal blocks are a minimum R-5 of rigid insulation which extends 1-inch beyond the width of the purlin on each side, perpendicular to the purlin.
b. Assembly description can be found in Table CB102.2(2).
c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-f2 °F.
d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for perimeter insulation according to the heated slab-on-grade construction.
e. Insulation is not required for mass walls in Climate Zone 3A located below the "Warm-Humid" line, and in Zone 3B

Add new text as follows:

TABLE CB102.2(2) METAL BUILDING ASSEMBLY DESCRIPTIONS

ROOFS	DESCRIPTIONS	REFERENCE
R-19 + R-10	Filled cavity roof. Thermal blocks are a minimum, R-5 of rigid insulation, which extends 1 in. beyond the width of the purlin on each side, perpendicular to the purlin.	ASHRAE/IESNA 90.1 Table A2.3
R-19	Standing seam with single insulation layer. Thermal blocks are a minimum R-5 of rigid insulation, which extends 1 in. beyond the width of the purlin on each side, perpendicular to the purlin. This construction R-19 insulation batts draped perpendicularly over the purlins. Thermal blocks are then placed above the purlin/batt, and the roof deck is secured to the purlins.	ASHRAE/IESNA 90.1 Table A2.3
Walls		
R-13	Single insulation layer The first layer of R-13 insulation batts is installed constinuously perpendicular to the girts and is compressed as the metal skin is attached to the girts.	ASHRAE/IESNA 90.1 Table A3.2
R-13 + R-13	Double insulation layer The first layer of R-13 insulation batts is installed continuously perpendicular to the girts and is compressed as the metal skin is attached to the girts.	ASHRAE/IESNA 90.1 Table A3.2

For SI: 1inch = 25.4 mm.

CB102.3 Fenestration. Fenestration shall comply with Table CB102.3.

CB102.3.1 Maximum area. The vertical fenestration area (not including opaque doors) shall not exceed the percentage of the gross wall area specified in Table CB102.3. The skylight area shall not exceed the percentage of the gross roof area specified in Table CB102.3.

CB102.3.2 Maximum U-factor and SHGC. For vertical fenestration, the maximum U-factor and solar heat gain coefficient (SHGC) shall be as specified in Table CB102.3, based on the window projection factor. For skylights, the maximum U-factor and solar heat gain coefficient (SHGC) shall be as specified in Table CB102.3.

The window projection factor shall be determined in accordance with Equation CB-1.

PF = A/B (Equation CB-1)

where:

PF = Projection factor (decimal).

A = Distance measured horizontally from the furthest continuous extremity of any overhang, eave, or permanently attached shading device to the vertical surface of the glazing.

B = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave, or permanently attached shading device.

Where different windows or glass doors have different PF values, they shall each be evaluated separately, or an area-weighted PF value shall be calculated and used for all windows and glass doors.

CB102.4
Air leakage

CB102.4.1 Window and door assemblies. The air leakage of window and sliding or swinging door assemblies that are part of the building envelope shall be determined in accordance with AAMA/WDMA/CSA 101/I.S.2/A440, or I NFRC 400 by an accredited, independent laboratory, and labeled and certified by the manufacturer and shall not exceed the values in Section 402.4.2.

Exception: Site-constructed windows and doors that arc weatherstripped or sealed in accordance with Section CB102.4.3.

CB102.4.2 Curtain wall, storefront glazing and commercial entrance doors. Curtain wall, storefront glazing and commercial glazed swinging entrance doors and revolving doors shall be tested for air leakage at 1.57 pounds per square foot (psf) (75 Pa) in accordance with ASTM E 283. For curtain walls and storefront glazing, the maximum air leakage rate shall be 0.3 cubic foot per minute per square foot (cfm/ft2) (5.5 m3/h x m2) of fenestration area. For commercial glazed swinging entrance doors and revolving doors, the maximum air leakage shall be 1.00 cfm/ft2 (18.3 m3/h x m2) of door area when tested in accordance with ASTM E 283.

CB102.4.3 Sealing of the building envelope. Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.

CB102.4.4 Outdoor air intakes and exhaust openings. Stair and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be equipped with not less than a Class I motorized, leakage-rated damper with a maximum leakage rate of 4 cfm per square foot (6.8 L/s – C m2) at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance 1.0 inch with AMCA 500D.

Exception: Gravity (nonmotorized) dampers are permitted to be used in buildings less than three stories in height above grade.

CB102.4.5 Loading dock weather seals. Cargo doors and loading dock doors shall be equipped with weather seals to restrict infiltration when vehicles are parked in the doorway.

CB102.4.6 Vestibules. A door that separates conditioned space from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time.

Exceptions:

1. Buildings in Climate Zones I and 2 as indicated in Figure C301.1 and Table C301.1.

2. Doors not intended to be used as a building entrance door, such as doors to mechanical or electrical equipment rooms.

3. Doors opening directly from a sleeping unit or dwelling unit.

4. Doors that open directly from a space less than 3,000 square feet (298 m2) in area.

5. Revolving doors.

6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

~~**Revise as follows:**~~ **Add new text as follows:**

TABLE CB102.3 BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

CLIMATE ZONE			**3**	**4 EXCEPT MARINE**	**5 AND MARINE 4**			
Vertical fenestration (40% maximum of above-grade wall)								
***U*-factor**								
Framing materials othe rthan metal with or without metal reinforcement or cladding								
U-factor			0.65	0.40	0.35			
Metal framing with or without thermal break								
Curtain Wall/Storefront U-factor			0.60	0.50	0.45			
Entrance Door U-factor			.90	.85	.80			
All Other U-factor[a]			.65	.55	.55			
SHGC-All Fram Types								
SHGC: PF < 0.25			.25	.40	.40			
SHGC: 0.25 ≤ PF < 0.5			.33	NR	NR			
SHGC ≥ 0.5			0.40	NR	NR			
Skylights (3% maximum)								
Glass								
U-Factor			0.90	0.60	0.60			
SHGC			0.40	0.40	0.40			
Plastic								
U-Factor			1.30	1.30	1.30			
SHGC			0.35	0.62	0.62			

NR = No Requirement, PF = Projection Factor (See Section CB102.3.2.

a. All others includes operable windows, fixed windows and non-entrance doors.

Add new text as follows:

CB102.4. 7 Recessed luminaires. When installed in the building envelope, recessed luminaires shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.

2. Type IC or non-IC rated, installed inside a sealed box constructed from a minimum 0.5-inch-thick (12.7 mm) gypsum wallboard or constructed from a preformed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose, while maintaining required clearances of not less than 0.5 inch (12.7 mm) from combustible material and not less than 3 inches (76 mm) from insulation material.

3. Type IC rated, in accordance with ASTM E 283 admitting no more than 2.0 cubic feet per minute (cfm) (0.944 L/s) of air movement from the conditioned space to the ceiling cavity. The luminaire shall be tested at 1.57 psf (75 Pa) pressure difference and shall be labeled.

CB102.5 Moisture control. All framed walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a permeance rating of 1 perm (5.7 x 10-11 kg/Pa· s · m2) or less, when tested in accordance with the dessicant method using Procedure A of ASTM E 96. The vapor retarder shall be installed on the warm-in-winter side of the insulation.

Exceptions:

1. Buildings located in Climate Zones 1 through 3 as indicated in Figure C301.1 and Table C301.1.

2. In construction where moisture or its freezing will not damage the materials.

3. Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are provided.

Reason Statement: In consideration of discussion at the April 14 Energy General Workgroup Meeting, this proposal is offered as a potential alternative to EC-C1301.1.1-21 (ID 997). The proposed appendix is a companion to EC-C401.2-21 (ID 1163) and represents the building envelope requirements of the 2006 IECC.

The current energy code requirements are over burdensome for Factory Group F, Storage Group S, and Utility and

Miscellaneous Group U. These use groups do not traditionally use a lot of energy as they are not heated or cooled to normal heating and cooling

temperatures and or they create their own heat, etc. The change would eliminate unneeded and extra cost to the building owner. Additional

insulation, roofing materials, and wall panel materials are being required in excess for buildings that will not fully utilize them.

Many storage facilities are vacant most of the time and a lot of manufacturing and utility buildings will have the drive through doors open during

production.

The General Assembly of Virginia enacted the following legislation in 2022.

HB 1289 Uniform Statewide Building Code; exemption for certain use and occupancy classifications.

1. § 1. That the Board of Housing and Community Development is directed to consider, during the next code development cycle, revising the

Uniform Statewide Building Code (§ 36-97 et seq. of the Code of Virginia) to provide an exemption from any requirements in the energy efficiency

standards established pursuant to 13VAC5-63-264 of the Virginia Uniform Statewide Building Code and the 2018 Virginia Energy Conservation Code,

and any subsequent amendments to the Virginia Uniform Statewide Building Code and the 2018 Virginia Energy Conservation Code, for the following

use and occupancy classifications pursuant to Chapter 3 of the 2018 Virginia Construction Code: (i) Section 306, Factory Group F; (ii) Section 311,

Storage Group S; and (iii) Section 312, Utility and Miscellaneous Group U.

Cost Impact: The code change proposal will decrease the cost of construction
The recent update to the *International Energy Conservation Code* causes undue hardship on building owners, developers, and contractors while they do not reap the full benefits of the standards.

For example,

1. A 7,200 SF building, with limited heating to be used for vehicle storage. This current energy code and building code would require a standing seam roof system and (R19/R11) insulation in the roof and (R25) insulation in the walls. When priced with a fasten down roof system and just R19 in the roof and R13 walls, the material and labor price goes down by $5.97/SF. That equates to a cost of $42,984. That is enough to keep this project from being built.

2. A 100,000SF warehouse project used for storage of materials with heat maintained at 60 degrees or less and no cooling. The current building code and energy code would require a standing seam roof system and (R19/R11) insulation in the roof (R25) and insulation in the walls. Maintaining the standing seam roof system but changing the insulation to 6” in roof and 4” in walls results in a $311,247 deduct just for material. With labor, material, and equipment the cost savings approach $5.00/SF or $500,000.

The systems required to meet the current energy code are complicated and time consuming. These systems have other drawbacks such a liner system that cover up the purlins and girts affecting other trades such as plumbing, HVAC, electrical, and sprinkler. (The added cost to the electrical and mechanical trades are in addition to the cost shown in the examples above.) The trims on overhead doors and window on the new required systems are deep. These trims make the wall accessories look recessed and some would say less attractive. The current energy code makes some architectural features more difficult to design and build around. For example, just adding a masonry wainscot becomes a challenge.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency
This code change does not have an effect on the resiliency of buildings in terms of withstanding disasters.

Attached Files

- **APPENDIX CB (underlined).pdf**
  https://va.cdpaccess.com/proposal/1196/1650/files/download/689/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐Approved
☐Approved with Modifications
☐Carryover
☐Disapproved
☐None

Public Comments for: EC-Appendix CB-21

Discussion by William Penniman
Jun 7, 2022 22:17 UTC

Appendix CB should be rejected. This proposal would move 3 broad categories of commercial buildings (F, S and U) back to the 2006 level of code standards. The proposal has not been adequately supported by either applicable law or any evidence of need, costs, benefits or harms to building occupants or the public. *As described in Part 1 of the comments below*, support rests entirely on incomplete descriptions of two potential warehouses, and no information on the scores of other types of buildings for which building standards would be rolled back. *As discussed in Part 2*, the proposal is inconsistent with applicable Virginia law. Far from being "consistent with" or "at least as stringent" as the latest IECC, the proposal would move Virginia's code backwards by more than a decade to the 2006 code standards. By moving more than a decade backward from the latest national building code standards, the proposal would waste energy, raise occupancy costs, harm employees and harm the "health, safety and welfare" of the residents of Virginia both now and in the long run.

1. <u>The Proponent has not provided credible support for its proposed rollback of code standards</u>.

The supporting statement is brief and conclusory without providing any reasonable basis for rolling back conservation standards for any type of building.

In support of cutting back standards for dozens of types of buildings within the 3 broad categories Groups F, S and U, the proposal only offers two examples of warehouses accompanied by few generalized statements that ***some*** of the buildings in F are "not heated or cooled to normal heating and cooling temperatures" or are "vacant" some of the time or might have "open doors" part of the time.

The proposal ignores Virginia's successful implementation of higher conservation standards for more than a decade, and it does not address lost energy and cost savings from its proposal or lost public benefits from greater energy efficiency and pollution reductions, all of which are relevant to the Board's determinations.

In fact, the warehouse business has been booming in Virginia, as documented by Virginia Business.com See, for example, "**Need for speed: Developers race to build warehouses amid site shortage,"** https://www.virginiabusiness.com/article/need-for-speed/ (Dec. 31, 2021) ("Geoff Poston [of Hampton Roads] likens the current market for building, buying and leasing warehouses and distribution centers to the mid-1800s California Gold Rush: Everybody wants in." The problem is land, not demand or ability to construct.); **"<u>Making it rain</u>: Increased e-commerce fuels wave of distribution centers,"** https://www.virginiabusiness.com/article/making-it-rain/ (April 29, 2021) ("For Hanover County Economic Development Director Linwood Thomas, things couldn't get much better. 'It's really been a perfect storm,' Thomas says. That storm — the good type — is a deluge of distribution centers and warehouses that have opened recently or are currently in the pipeline for the county of about 108,000 residents, located about 20 miles north of Richmond.… Over the past two years or so, Hanover has added about 1.5 million square feet of new space and about 80% of that has been leased. 'Then, we've got another almost 4 million square feet proposed in the next 24 months. These are tangible products that will put us over 5.5 million square feet of new space, which is huge,' says Thomas, noting that the new space will represent a nearly 40% increase over the county's existing stock of 13.8 million square feet of industrial/warehouse space."); **"Industrial boom: Virginia**

continues to see more warehouses and distribution centers," https://www.virginiabusiness.com/article/industrial-boom/ (July 27, 2018)("While Hampton and Southwest Virginia area also benefiting, …. Richmond's industrial warehouse market is currently undergoing a "golden age" in the distribution sector, according to a recent report from CBRE.")

The proposal also omits key information about the huge volume of air to be heated and cooled in the two illustrations of warehouses: 2.5 million cubic feet for the 100,000 Sf warehouse, and 144,000 cubic feet for the 7500 SF warehouse. Nor does it describe the correspondingly huge energy requirements, which would go up if efficiency standards are rolled back.

Two warehouse illustrations are not enough to exempt three broad categories of buildings. Section 306 Factory Group F identifies over 50 types of factories; Section 311 Storage Group S lists over 60 types of storage facilities; and Section 312 Utility and Miscellaneous Group U identifies over a dozen categories. Some of the facilities store products (*e.g.*, food) that are temperature sensitive and require a great deal of energy (lessened only by energy efficiency) to achieve temperature goals. Other buildings involve manufacturing and other operations, which have still different energy and energy-efficiency profiles. Yet the proposal provides no analysis at all of any other types of buildings or their energy footprints, available technologies, employee and customer needs, compliance costs, energy cost savings, pollution reductions or other factors.

The proposal's supporting statement does not begin to justify rolling back energy efficiency standards for three broad categories of buildings, which were promulgated, over many years, under the auspices of national code organizations, including the ICC and ASHRAE. Those code provisions drew upon the hard work, expertise and negotiations of hundreds of industry and efficiency experts, architects, engineers, trade associations, environmental experts, government bodies and public review processes. Nothing in the IECC or ASHRAE standards were arbitrarily arrived at. As evidenced by the existing code's low-energy building exemptions and performance alternatives (e.g., use of ASHRAE standards), building usage patterns and designs were considered by the IECC and ASHRAE when they drew up the standards.

Although they may not have specifically reviewed all categories of buildings (including these), it is significant that DOE/PNNL have consistently found that ASHRAE and IECC standards save money for building users through energy savings compared to initial construction costs. https://www.energycodes.gov/sites/default/files/2021-07/Cost-effectiveness_of_ASHRAE_Standard_90-1-2019-Virginia.pdf

The illustrations do not address or quantify the operating cost or pollution savings from higher efficiency standards either for the two hypothetical buildings or the larger groups of buildings.

The proponent implicitly assume that the two buildings' initial heating and cooling needs and practices will never change. The supporting statement does not consider the impacts of future increases in energy usage, which are likely to occur as climate change drives up ambient temperatures.

Nor is there any discussion whatsoever of how the public – the residents of the Commonwealth – would be affected by exempting these three large categories of buildings from all energy conservation requirements. There is no discussion, for example, of pollution impacts (a specifically relevant factor identified in H2227), or climate impacts, or impacts on resiliency if excess energy demands result from the proposal, or impacts on utility rates to all customers from removing all conservation requirements which might temper demand for high priced energy resources.

Despite short-term appeals to builders of reducing construction costs, adopting the proposal would increase the risk that the buildings would become obsolete more quickly as energy operating costs go up for occupants. Lower rents and vacancies could follow just as they have for older office buildings in many areas.

2. The proposal is not supported by Virginia law. In Appendix CB, the proponent proposes to rollback standards primarily for building envelopes to the level of the 2006 standards. For this, the proponent relies on HB1289, which directs the Board

> "to consider during the next code development cycle, revising the Uniform Statewide Building Code…to provide an exemption from any requirements in the energy efficiency standards established pursuant to 13VAC5-63-264 of the Virginia Uniform Statewide Building code and the 2018 Virginia Energy Conservation Code, and the subsequent amendments to the Virginia Uniform Statewide Building code and the 2018 Virginia Energy Conservation Code, for the following use and occupancy classifications pursuant to Chapter 3 of the 2018 Virginia Construction Code: (i) Section 306, Factory Group F; (ii) section 311, Storage Group S; and (iii) Section 312, Utility and Miscellaneous Group U."

The proponent misconstrues HB1289 and its larger context. HB1289 is merely procedural. It directs the Board to *consider* a proposal for exemptions, but, unlike H2227 enacted in 2021, HB1289 did not alter the legal standards applicable to approval of building codes, nor did it create any kind of presumption in favor of granting an exemption.

Virginia law governing building codes still requires implementation of code provisions that "protect the health, safety and welfare of the residents of the Commonwealth," that are "constructed, rehabilitated and maintained consistent with recognized standards of health, safety, energy conservation and water conservation." Further, the starting point is that the code should be "at least stringent as" the latest IECC, with anything less having to be justified based on proof that benefits to occupants and the public over time exceed the initial cost of construction. Those standards are clearly not met by this proposal for sweeping exemptions and the proponent's very limited supporting statements, as discussed below.

If the General Assembly had wanted to see an exemption for three broad categories of buildings *without review under applicable laws*, it would have simply ordered an exemption or would have modified applicable legal standards. Since it did not do so, its direction “to consider” is bound by otherwise applicable law, which does not authorize a broad rollback to standards below the latest IECC.

HB1289 also directs that consideration of such a proposal be undertaken “during the next code development cycle.” Since this code development cycle was already underway when the law was enacted, it does not refer to this cycle.

For the reasons summarized above, the proposal should be rejected.

Proposal # 1196

EC-Appendix CB– Staff Summary

Proponent: Mathew Benka; John Avis.

Brief Description:

The proposal allows Groups F (Factory), S (Storage) and U (Utility and Misc.) to use provisions from an appendix that are less stringent than the 2021 IECC for building envelope requirements.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The sub-workgroup members discussed this proposal over the course of several meetings without reaching a conclusion. Key comments from the May 19th meeting are as follows:

- Eric Lacey (RECA)
    - Believed this is better than the wider exception (he was referring to a previous proposal with similar outcome, which was withdrawn in favor of this proposal). Occupancy classifications are broad, covering buildings that are multi-purpose use. He's a "no" right now, and would still like to work on it because it's not specific enough. Also, it only brings the code up to the 2006 IECC standards, which is not enough.
- Chelsea Harnish: Virginia Energy Efficiency Council
    - Agreed with Eric. Particularly, utility and miscellaneous occupancies are too broad.
- William Penniman (Sierra Club – Virginia Chapter)
    - Was in opposition, but agreed to continue to work with the proponent.

Energy Sub-Workgroup members in attendance on May 19th:

- Andrew Clark: Homebuilders Association of Virginia (HBAV)
- Chelsea Harnish: Virginia Energy Efficiency Council
- Eric Lacey: Responsible Energy Codes Alliance (RECA)
- K.C. Bleile: Viridiant
- William (Bill) Penniman: Sierra Club – Virginia chapter

Energy Sub-Workgroup members not in attendance on May 19th:

- Andy McKinley: American Institute of Architects (AIA), Virginia
- Bettina Bergoo: Virginia Department of Energy
- Brian Clark: Habitat for Humanity
- Corey Caney: International Association of Electrical Inspectors (IAEI), Virginia
- Ellis McKinney: Virginia Plumbing and Mechanical Inspectors Association (VPMIA)
- Jeff Mang: Polyisocyanurate Insulation Manufacturers Association
- Jim Canter: Virginia Building and Code Officials Association (VBCOA)
- Maggie Kelley Riggins: Southeast Energy Efficiency Alliance
- Steve Shapiro: Apartment & Office Building Association (AOBA), Virginia Apartment Management Association (VAMA)

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Brett Vassey (Virginia Manufacturers Association)

- Brett Vassey (Virginia Manufacturers Association)
  - Is in support of this proposal. This provides more options and flexibility in factory spaces and allows Virginia to be more competitive. There is also some economic development flexibility.
- Andrew Klein (Self Storage Association)
  - Is in support of this proposal. The options Eric spoke to (see below) are not good ones, as they have minimum insulation requirements.

Opposition:

Names: Eric Lacey (RECA); Chelsea Harnish (VAEEC); and, William Penniman (Sierra Club – Virginia Chapter).

- Eric Lacey (RECA)
  - Is opposed to this proposal. There are alternatives in the code already that should address many of the concerns being raised. There are two other scenarios allowed in the IECC for low energy buildings and for buildings that aren't conditioned. ASHRAE 90.1 also has an exception to Section 5.1.2.3 for semi-heated spaces, which can be used. He thinks this code change is unnecessary. North Carolina is the only state that has made exemptions of this type.
- Chelsea Harnish (VAEEC)
  - Opposed for all of the reasons stated by Eric Lacey. We do appreciate the proponents meeting with us and would be happy to continue the conversation.
- William Penniman (Sierra Club – Virginia Chapter)
  - Is in opposition to this proposal. Agrees with Eric and thinks it will bring the code back 3 decades for these building types. He doesn't think it would help economic development and it would hurt individuals working in the buildings.
- Ben Rabe (New Buildings Institute)
  - Opposed for all of the reasons stated by Eric Lacey and William Penniman.

DHCD Staff Notes:

- Andrew Clark (HBAV) did not specifically support nor opposed the proposal but argued that just because North Carolina is the only state that has made this exception it does not necessarily mean it is a bad thing.
- Staff created a proposal, EC-C1301.1.1(2), based on the proponent's original proposal language, due to legislation requiring the BHCD to consider energy requirement exemptions for buildings with occupancy classifications of Groups F, S and U. Only one of these proposals should be approved if the Board chooses to do so.

Meeting summaries and proposal related information: Tab 10 - Page 79; Tab 11 - Page 37; Tab 11 - Page 43.

APPENDIX CB
BUILDING ENVELOPE REQUIREMENTS
GROUP F, S AND U BUILDING AREAS

SECTION CB101
SCOPE

CB101.1 General.

These provisions shall be permitted as an alternative to building thermal envelope requirements for building areas containing uses that are classified as Group F, S or U.

SECTION CB102
BUILDING ENVELOPE REQUIREMENTS

CB102.1 General.

CB102.1.1 Insulation and fenestration criteria.
The *building thermal envelope* shall meet the requirements of Tables CB102.2(1) and CB102.3 based on the climate zone specified in Chapter 3[CE]. Buildings with a vertical fenestration area or skylight area that exceeds that allowed in Table CB102.3 shall comply with the building envelope provisions of ASHRAE/IESNA 90.1.

CB102.2 Specific insulation requirements.
Opaque assemblies shall comply with Table CB102.2(1).

CB102.2.1 Roof assembly.

The minimum thermal resistance (R-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table CB102.2(1), based on construction materials used in the roof assembly.

Exception: Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 .4 mm) or less and where the area weighted U-factor is equivalent to the same assembly with the R-value specified in Table CB102.2(1).

Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation.

CB102.2.2 Classification of walls.

Walls associated with the building envelope shall be classified in accordance with Section CB102.2.2.1 or CB102.2.2.2.

CB102.2.2.1 Above-grade walls.

Above-grade walls are those walls covered by Section CB102.2.3 on the exterior of the building and completely above grade or walls that are more than 15 percent above grade.

CB102.2.2.2 Below-grade walls.

Below-grade walls covered by Section CB102.2.4 are basement or first-story walls associated with the exterior of the building that are at least 85 percent below grade.

CB102.2.3 Above-grade walls.

The minimum thermal resis-tance (R-value) of the insulating material(s) installed in the wall cavity between the framing members and continuously on the walls shall be as specified in Table CB102.2(1), based on framing type and construction materials used in the wall assembly. The R-value of integral insulation installed in concrete masonry units (CMU) shall not be used in determining compliance with Table CB102.2(1). "Mass walls" shall include walls weighing at least (1) 35 pounds per square foot (170 kg/m^2) of wall surface area or (2) 25 pounds per square foot (120 kg/m^2) of wall surface area if the material weight is not more than 120 pounds per cubic foot (1,900 kg\m^3).

CB102.2.4 Below-grade walls.

The minimum thermal resis-tance (R-value) of the insulating material installed in, or continuously on, the below-grade walls shall be as specified in Table CB102.2(1) and shall extend to a depth of 10 feet I (3048 mm) below the outside finish ground level, or to the level of the floor, whichever is less.

CB102.2.5 Floors over outdoor air or unconditioned space.

The minimum thermal resistance (R-value) of the insulating material installed either between the floor framing or con-tinuously on the floor assembly shall be as specified in Table CB102.2(1), based on construction materials used in the floor assembly.

"Mass floors" shall include floors weighing at least (1) 35 pounds per square foot (170 kg/m^2) of floor surface area or (2) 25 pounds per square foot (120 kg/m^2) of floor surface area if the material weight is not more than 12 pounds per cubic foot (1,900 kg/m^3).

CB102.2.6 Slabs on grade.

The minimum thermal resistance (R-value) of the insulation around the perimeter of unheated or heated slab-on-grade floors shall be as specified in Table CB102.2(1). The insulation shall be placed on the outside of the foundation or on the inside of a foundation wall. The insulation shall extend downward from the top of the slab for a minimum distance as shown in the table or to the top of the footing, whichever is less, or downward to at least the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table.

CB102.2.7 Opaque doors.

Opaque doors (doors having less than 50 percent glass area) shall meet the applicable requirements for doors as specified in Table CB102.2(1) and be considered as part of the gross area of above-grade walls that are part of the building envelope.

TABLE CB102.2(1)
BUILDING ENVELOPE REQUIREMENTS – OPAQUE ASSEMBLIES

CLIMATE ZONE	1	2	3	4 except Marine	5 and Marine4	6	7	8
Roofs								
Insulation entirely above deck	R-15 ci	R-15 ci	R-15 ci	R-15 ci	R-20 ci	R-20 ci	R-25 ci	R-25 ci
Metal buildings (with R-5 thermal blocks[a])[b]	R-19 + R-10	R-19	R-19	R-19	R-19	R-19	R-19 + R-10	R-19 + R-10
Attic and other	R-30	R-30	R-30	R-30	R-30	R-30	R-38	R-38
Walls, Above Grade								
Mass	NR	NR	R-5.7 ci[c, e]	R-5.7 ci[c]	R-7.6 ci	R-9.5 ci	R-11.4 ci	R-13.3 ci
Metal building[b]	R-13	R-13	R-13	R-13	R-13 + R-13	R-13 + R-13	R-13 + R-13	R-13 + R-13
Metal framed	R-13	R-13	R-13	R-13	R-13 + R-3.8 ci	R-13 + R-3.8 ci	R-13 + R-7.5 ci	R -ß + R-7.5 ci
Wood framed and other	R-13	R-13	R-13	R-13	R-13	R-13	R-13	R-13 + R-7.5 ci
Walls, Below Grade								
Below grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5 ci	R-7.5 ci
Floors								
Mass	NR	R-5 ci	R-5 ci	R-10 ci	R-10 ci	R-10 ci	R-15 ci	R-15 ci
Joist/Framing	NR	R-19	R-19	R-19	R-19	R-30	R-30	R-30
Slab-on-Grade Floors								
Unheated slabs	NR	NR	NR	NR	NR	NR	NR	R-10 for 24 in. below
Heated slabs	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-7.5 for 24 in. below	R-10 for 36 in. below	R-10 for 36 in. below	R-10 for 48 in. below
Opaque Doors								
Swinging	U – 0.70	U – 0.70	U – 0.70	U – 0.70	U – 0.70	U – 0.70	U – 0.70	U – 0.50
Roll-up or sliding	U – 1.45	U – 1.45	U – 1.45	U – 1.45	U – 1.45	U – 0.50	U – 0.50	U – 0.50

For SI: 1 inch = 25.4 mm.

ci – Continuous Insulation

NR – No Requirement

a. Thermal blocks are a minimum R-5 of rigid insulation, which extends 1-inch beyond the width of the purlin on each side, perpendicular to the purlin.

b. Assembly descriptions can be found in Table CB102.2(2).

c. R-5.7 ci may be substituted with concrete block walls complying with ASTM C 90, ungrouted or partially grouted at 32 in. or less on center vertically and 48 in. or less on center horizontally, with ungrouted cores filled with material having a maximum thermal conductivity of 0.44 Btu-in./h-f² F.

d. When heated slabs are placed below grade, below grade walls must meet the exterior insulation requirements for perimeter insulation according to the heated slab-on-grade construction.

e. Insulation is not required for mass walls in Climate Zone 3A located below the "Warm-Humid" line, and in Zone 3B.

TABLE CB102.2(2)
METAL BUILDING ASSEMBLY DESCRIPTIONS

ROOFS	DESCRIPTION	REFERENCE
R-19 + R-10	Filled cavity roof. Thermal blocks are a minimum, R-5 of rigid insulation, which extends 1 in. beyond the width of the purlin on each side, perpendicular to the purlin. This construction is R-10 insulation batts draped perpendicularly over the purlins, with enough looseness to allow R-19 batt to be laid above it, parallel to the purlins. Thermal blocks are then placed above the purlin/batt, and the roof deck is secured to the purlins. In the metal building industry, this is known as the "sag and bag" insulation system.	ASHRAE/IESNA 90.1 Table A2.3
R-19	Standing seam with single insulation layer. Thermal blocks are a minimum R-5 of rigid insulation, which extends 1 in. beyond the width of the purlin on each side, perpendicular to the purlin. This construction R-19 insulation batts draped perpendicularly over the purlins. Thermal blocks are then placed above the purlin/batt, and the roof deck is secured to the purlins.	ASHRAE/IESNA 90.1 Table A2.3
Walls		
R-13	Single insulation layer The first layer of R-13 insulation batts is installed continuously perpendicular to the girts and is compressed as the metal skin is attached to the girts.	ASHRAE/IESNA 90.1 Table A3.2
R-13 + R-13	Double insulation layer The first layer of R-13 insulation batts is installed continuously perpendicular to the girts, and is compressed as the metal skin is attached to the girts. The second layer of R-13 insulation batts is installed within the framing cavity.	ASHRAE/IESNA 90.1 Table A3.2

For SI: 1 inch = 25.4 mm.

CB102.3 Fenestration.

Fenestration shall comply with Table CB102.3.

CB102.3.1 Maximum area.

The vertical fenestration area (not including opaque doors) shall not exceed the percentage of the gross wall area specified in Table CB102.3. The skylight area shall not exceed the percentage of the gross roof area specified in Table CB102.3.

CB102.3.2 Maximum U-factor and SHGC.

For vertical fen-estration, the maximum U-factor and solar heat gain coeffi-cient (SHGC) shall be as specified in Table CB102.3, based on the window projection factor. For skylights, the maximum U-factor and solar heat gain coefficient (SHGC) shall be as specified in Table CB102.3.

The window projection factor shall be determined in accordance with Equation CB-1.

$PF = A/B$ **(Equation CB-1)**

where:

PF = Projection factor (decimal).

A = Distance measured horizontally from the furthest continuous extremity of any overhang, eave, or per-manently attached shading device to the vertical sur-face of the glazing.

B = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave, or per-manently attached shading device.

Where different windows or glass doors have different PF values, they shall each be evaluated separately, or an area-weighted PF value shall be calculated and used for all windows and glass doors.

CB102.4 Air leakage.

CB102.4.1 Window and door assemblies.

The air leakage of window and sliding or swinging door assemblies that are part of the building envelope shall be determined in accordance with AAMA/WDMA/CSA 101/I.S.2/A440, or I NFRC 400 by an accredited, independent laboratory, and labeled and certified by the manufacturer and shall not exceed the values in Section 402.4.2.

> **Exception:** Site-constructed windows and doors that arc weatherstripped or sealed in accordance with Section CB102.4.3.

CB102.4.2 Curtain wall, storefront glazing and commercial entrance doors.

Curtain wall, storefront glazing and commercial glazed swinging entrance doors and revolving doors shall be tested for air leakage at 1.57 pounds per square foot (psf) (75 Pa) in accordance with ASTM E 283. For curtain walls and storefront glazing, the maximum air leakage rate shall be 0.3 cubic foot per minute per square foot (cfm/ft^2) (5.5 m^3/h x m^2) of fenestration area. For commercial glazed swinging entrance doors and revolving doors, the maximum air leakage shall be 1.00 cfm/ft^2 (18.3 m^3/h x m^2) of door area when tested in accordance with ASTM E 283.

CB102.4.3 Sealing of the building envelope.

Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.

CB102.4.4 Outdoor air intakes and exhaust openings.

Stair and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be equipped with not less than a Class I motorized, leakage-rated damper with a maximum leakage rate of 4 cfm per square foot (6.8 L/s – C m^2) at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance 1.0 inch with AMCA 500D.

> **Exception:** Gravity (nonmotorized) dampers are permitted to be used in buildings less than three stories in height above grade.

TABLE CB102.3
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

CLIMATE ZONE	1	2	3	4 except Marine	5 and Marine 4	6	7	8
Vertical Fenestration (40% maximum of above-grade wall)								
***U*-Factor**								
Framing materials other than metal with or without metal reinforcement or cladding								
U-Factor	1.20	0.75	0.65	0.40	0.35	0.35	0.35	0.35
Metal framing with or without thermal break								
Curtain Wall/Storefront *U*-Factor	1.20	0.70	0.60	0.50	0.45	0.45	0.45	0.45
Entrance Door *U*-Factor	1.20	1.10	0.90	0.85	0.80	0.80	0.80	0.80
All Other *U*-Factor[a]	1.20	0.75	0.65	0.55	0.55	0.55	0.50	0.50
SHGC-All Frame Types								
SHGC: PF < 0.25	0.25	0.25	0.25	0.40	0.40	0.40	NR	NR
SHGC: 0.25 ≤ PF < 0.5	0.33	0.33	0.33	NR	NR	NR	NR	NR
SHGC: PF ≥ 0.5	0.40	0.40	0.40	NR	NR	NR	NR	NR
Skylights (3% maximum)								
Glass								
U-Factor	1.60	1.05	0.90	0.60	0.60	0.60	0.60	0.60
SHGC	0.40	0.40	0.40	0.40	0.40	0.40	NR	NR
Plastic								
U-Factor	1.90	1.90	1.30	1.30	1.30	0.90	0.90	0.60
SHGC	0.35	0.35	0.35	0.62	0.62	0.62	NR	NR

NR = No requirement.

PF = Projection factor (See Section CB102.3.2)

a. All others includes operable windows, fixed windows and non-entrance doors.

CB102.4.5 Loading dock weather seals.

Cargo doors and loading dock doors shall be equipped with weather seals to restrict infiltration when vehicles are parked in the doorway.

CB102.4.6 Vestibules.

A door that separates conditioned space from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time.

Exceptions:

1. Buildings in Climate Zones I and 2 as indicated in Figure C301.1 and Table C301.1.
2. Doors not intended to be used as a building entrance door, such as doors to mechanical or electrical equipment rooms.

3. Doors opening directly from a sleeping unit or dwelling unit.

4. Doors that open directly from a space less than 3,000 square feet (298 m^2) in area.

5. Revolving doors.

6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

CB102.4. 7 Recessed luminaires. When installed in the building envelope, recessed luminaires shall meet one of the following requirements:

1. Type IC rated, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity and sealed or gasketed to prevent air leakage into the unconditioned space.

2. Type IC or non-IC rated, installed inside a sealed box constructed from a minimum 0.5-inch-thick (12.7 mm) gypsum wallboard or constructed from a pre-formed polymeric vapor barrier, or other air-tight assembly manufactured for this purpose, while maintaining required clearances of not less than 0.5 inch (12.7 mm) from combustible material and not less than 3 inches (76 mm) from insulation material.

3. Type IC rated, in accordance with ASTM E 283 admitting no more than 2.0 cubic feet per minute (cfm) (0.944 L/s) of air movement from the conditioned space to the ceiling cavity. The luminaire shall be tested at 1.57 psf (75 Pa) pressure difference and shall be labeled.

CB102.5 Moisture control.

All framed walls, floors and ceilings not ventilated to allow moisture to escape shall be provided with an approved vapor retarder having a permeance rating of 1 perm (5.7×10^{-11} kg/Pa· s · m^2) or less, when tested in accordance with the dessicant method using Procedure A of ASTM E 96. The vapor retarder shall be installed on the warm-in-winter side of the insulation.

Exceptions:

1. Buildings located in Climate Zones 1 through 3 as indicated in Figure C301.1 and Table C301.1.

2. In construction where moisture or its freezing will not damage the materials.

3. Where other approved means to avoid condensation in unventilated framed wall, floor, roof and ceiling cavities are provided.

B903.2.3-21

Proponents: David Beahm

2018 Virginia Construction Code

Revise as follows:

[F] 903.2.3 Group E. An *automatic sprinkler system* shall be provided for Group E occupancies as follows:

1. Throughout all Group E *fire areas* greater than 20,000 square feet (1858 m^2) in area.
2. The Group E fire area is located on a floor other than a level of exit discharge serving such occupancies.

   Exceptions: In buildings where every classroom has not fewer than one exterior exit door at ground level, an *automatic sprinkler system* is not required in any area below the lowest level of exit discharge serving that area.

3. ~~The Group E fire area has an occupant load of 300 or more.~~

Reason Statement: During the 2018 ICC code change a change was put into place and it was not reviewed for consistency with current Virginia changes and now during the code update training it was questioned about its possible inconsistency. Virginia has consistently modified the model code square footage related to Educational Use and Occupancy with regards to requiring sprinklers from model code 12,000 to Virginia's 20,000. The change that was made during the 2018 model code process was to additionally add the maximum occupant load number of 300. While this is actually consistent with how Virginia looks at religious worship A-3 occupant loads with exemption 2 of 903.2.1.3. Most would say that this may actually be creating consistency even though within A-3 it keeps the maximum square footage at 12,000. There are many differences between the two with regards to uses of the space in that many churches only have a main sanctuary and many of those have fixed seats that create limitations to the amount of occupants. Now let's look at a small private school (which is what this change really effects) that acquires a large space that stays under the 20,000 square feet. Most public schools would not have a space this small and if they did the same allowances would be allowed. If a school were to have a just a full-size basketball court that could be used for many other purposes, the normal size is 84' by 50' which is 4,200 square feet. This space would then have an occupant load set at 280 for the least allowable calculation (15 net), which would then only allow for 20 additional occupants. Now it could be argued that you could justify that the space would not be used concurrently with the remainder of the area, but that isn't a guarantee. Also, if you used the calculation that would more than likely be used is for concentrated chairs/not fixed (7 net) instead of tables and chairs the occupant load would be 600. While this may be looked at a larger potential for fatalities due to the use of education and not the religious worship, I would argue it may be less. I don't know of any religious worship location that performs fire drills or that is inspected on a yearly basis as a requirement as schools are and have fire drills.

Cost Impact: The code change proposal will decrease the cost of construction
This will remove the requirement for the structure to be sprinklered if the occupant load is greater than 300, but still under the 20,000 square foot requirement that currently exists.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications

☐Carryover
☐Disapproved
☐None

Public Comments for: B903.2.3-21

This proposal doesn't have any public comments.

Proposal # 1194

B903.2.3-21 – Staff Summary

Proponent: David Beahm

Brief Description:

The proposal deletes the 300 occupant load criteria as one of the thresholds requiring fire sprinklers in group E fire areas.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: David Beahm

- David Beahm stated, in response to the opposing comment below, that he is hoping to maintain the niche for private schools. He also highlighted, as part of earlier statements, that there was a proposed change in previous code change cycles to drop the existing 20k square feet threshold to 12k, but the private schools were opposed to it.

Opposition:

Names: Andrew Milliken, representing self

- Andrew Milliken, representing self, indicated that there could be a gymnasium, 20k square feet in area, without sprinklers. The occupant load of 300 is standard and should remain.

DHCD Staff Notes:

One of the long standing triggers for automatic sprinkler systems in group E occupancies is the size of the fire area. Before the 2009 IBC edition, the fire area threshold was 20,000 square feet. In the 2009 IBC this was reduced to 12,000 square feet. Virginia amended the 2009 IBC to maintain the 20,000 square feet threshold. This amendment is still in place today.

The 2018 IBC added an additional trigger for sprinkler requirement – when the group E fire area has an occupant load of 300 or more. Given this 2018 IBC change, in most cases, the existing Virginia amendment allowing for (non-sprinklered) group E fire areas up to 20,000 square feet would become obsolete, and buildings with fire areas much smaller would have to be provided with sprinklers given the occupant load trigger.

Proposal B903.2.3-21 appears to seek to maintain the applicability of existing Virginia amendment which allows non-sprinklered group E occupancies with fire areas of up to 20,000 square feet.

Meeting summaries and proposal related information: Tab 10 - Page 62;

B1006.3.4-21

Proponents: Lyle Solla-Yates (lyle.sollayates@gmail.com)

2021 International Building Code

Revise as follows:

1006.3.4 Single exits. A single *exit* or access to a single *exit* shall be permitted from any *story* or occupied roof where one of the following conditions exists:

1. The *occupant load*, number of *dwelling units* and exit access travel distance do not exceed the values in Table 1006.3.4(1) or 1006.3.4(2).
2. Rooms, areas and spaces complying with Section 1006.2.1 with *exits* that discharge directly to the exterior at the *level of exit discharge*, are permitted to have one *exit* or access to a single *exit*.
3. Parking garages where vehicles are mechanically parked shall be permitted to have one *exit* or access to a single *exit*.
4. Group R-3 and R-4 occupancies shall be permitted to have one *exit* or access to a single *exit*.
5. Individual single-story or multistory *dwelling units* shall be permitted to have a single *exit* or access to a single *exit* from the *dwelling unit* provided that both of the following criteria are met:

    5.1. The *dwelling unit* complies with Section 1006.2.1 as a space with one *means of egress*.

    5.2. Either the exit from the *dwelling unit* discharges directly to the exterior at the *level of exit discharge*, or the *exit access* outside the *dwelling unit's* entrance door provides access to not less than two *approved* independent *exits*.

6. Not more than 5 stories of Group R-2 occupancy are permitted to be served by a single exit under the following conditions:

    6.1. The building shall be of not less than one hour fire-resistive construction and shall also be equipped throughout with an automatic sprinkler system in accordance with subsection 903.3.1.1. Residential-type sprinklers shall be used in all habitable spaces in each dwelling unit.

    6.2 An exterior stairway or interior exit stairway shall be provided. The interior exit stairway, including any related exit passageway, shall be pressurized in accordance with subsection 909.20. Doors in the stairway shall swing into the interior exit stairway regardless of the occupant load served, provided that doors from the interior exit stairway to the building exterior are permitted to swing in the direction of exit travel.

    6.3 A corridor shall separate each dwelling unit entry/exit door from the door to an interior exit stairway, including any related exit passageway, on each floor. Dwelling unit doors shall not open directly into an interior exit stairway. Dwelling unit doors are permitted to open directly into an exterior stairway.

    6.4 There shall be no more than 20 feet (6096 mm) of travel to the exit stairway from the entry/exit door of any dwelling unit.

    6.5 Travel distance measured in accordance with section 1017 shall not exceed 125 feet (38100 mm).

    6.6 Elevators shall be pressurized in accordance with section 909.21 or shall open into elevator lobbies that comply with section 713.14. Where approved by the building official, natural ventilation is permitted to be substituted for pressurization where the ventilation would prevent the accumulation of smoke and gases.

    6.7 Other occupancies are permitted in the same building provided they comply with all the requirements of this code. Other occupancies shall not communicate with the Group R occupancy portion of the building or with the single-exit stairway. Exception: parking garages and occupied roofs accessory to the Group R occupancy are permitted to communicate with the exit stairway.

    6.8 The exit serving the Group R occupancy shall not discharge through any other occupancy, including an accessory parking garage.

    6.9 There shall be no openings within 10 feet (3048 mm) of unprotected openings into the stairway other than required exit doors having a one-hour fire-resistance rating.

Reason Statement: Experience in Seattle and New York City has shown that this kind of development with a limited floorplan can be allowed safely, as well as in other countries. This allows more compact missing middle residential development that was historically common in Virginia but has not been permitted for many years. Reviewers note that there is still a need for reliable aerial access, sprinklers, and alarms.

For more on this see the attached articles "The Single-Staircase Radicals Have a Good Point" by writer Henry Grabar in Slate posted here https://slate.com/business/2021/12/staircases-floor-plan-twitter-housing-apartments.html and "The Case for More Single Stair Buildings in the US" by architect Michael Eliason in Treehugger posted here https://www.treehugger.com/single-stair-buildings-united-states-5197036

Cost Impact: The code change proposal will decrease the cost of construction
Reducing the number of staircases required for smaller missing middle residential structures will reduce cost per square foot and make more sites and configurations feasible.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

Attached Files

- **The Single-Staircase Radicals Have a Good Point Grabar.pdf**
  https://va.cdpaccess.com/proposal/944/1676/files/download/525/
- **singlestaireliason.pdf**
  https://va.cdpaccess.com/proposal/944/1676/files/download/521/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: B1006.3.4-21

Discussion by Florin Moldovan
Jun 13, 2022 17:24 UTC

See attached floor modification discussed at the GSWG meeting on 06/07/2022.
Attachments: https://va.cdpaccess.com/proposal/944/discuss/173/file/download/780/B1006.3.4-21+Floor+Modification.pdf

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B1006.3.4-21 – Staff Summary

Proponent: Lyle Solla-Yates

Brief Description:

The proposal allows up to 5 stories of Group R-2 occupancy to be served by a single exit.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Andrew Clark, Home Builders Association of Virginia (HBAV); Rory Stolzenberg, Charlottesville Planning Commission; and Dannie (last name and/or organization represented not indicated).

- Andrew Clark, HBAV, expressed support for the proposal as it reduces building costs (in contrast with many other proposals which increase costs). In response to some opposing comments, he suggested that perhaps this should be limited to where there's ISO-1 fire service.
  He hears everyone's suggestion to wait for the review of such a proposal at the national level (see opposing comments below), but if we are going to wait for the national level, we will be waiting for a long time as there does not appear to be any progress at the national level in trying to lower the cost of housing. Every year there are more proposals to pile on cost with the justification that it is just a little bit more. He suggested that a Study Group be put together next code development cycle to focus specifically on trying to increase the middle housing supply into the market. This is the chief concern for local governments, industry, state policy makers, but he does not see a lot of progress in the building codes to account for that. He hopes that next cycle we can dedicate as much time to focus on housing affordability and lowering housing cost as we do for fire sprinklers, energy code proposals and resiliency. He supports the idea of a workgroup at the national level as suggested by others, but indicated that maybe we should be leading the way, as he hears so often on energy code proposals, instead of waiting for ICC to do something about it.
- Rory Stolzenberg, Charlottesville Planning Commission, stated that an incremental approach would be good. Instead of 5-story, it could start with 4-story buildings. It could also have limits like not allowing exterior stairs, etc.
- Dannie expressed that he is strongly in favor of the proposal.

Opposition:

Names: Steve Shapiro, representing self; Allison Cook, Arlington County; Dan Willham, Fairfax County; David Beahm, Warren County; Andrew Milliken, representing self.

- Steve Shapiro, representing self, as a former building official for 34 years thinks this is bigger than just Virginia and should be proposed and debated at the national level. The code in Seattle, which this proposal is based on, has about 14 limitations and this proposal does not. For as long as he has been in the codes profession, single exit buildings have been fairly limited due to the inherent dangers of only having one stairwell. This is dangerous and he is totally opposed to it.

- Allison Cook, Arlington County, noted that one exit is unsafe; and agreed that the changes should be debated at the national level. She understands that there is a housing problem but she does not think this is the way to address it were for a lower cost of housing we end up with a lower degree of safety.
- Dan Willham, Fairfax County, pointed out that the Seattle code has many limitations and exceptions which this proposal does not include, not that he would support it if it did. For example, the number of units on each floor and the size of the floorplans, as well as the limitation of no more than two single exit buildings per lot. He also thinks this should be debated at the national level.
- David Beahm, Warren County, agreed with the other commenters that the changes should be submitted and vetted at the national level. He also stated that this is the first time he saw the floor modification and has not had a chance to review it.
- Andrew Milliken:
    - Speaking in behalf of the Virginia Fire Services Board, Codes and Standards Committee: they oppose the original version of the proposal and did not have a chance to review the floor modification which was shared today by the proponent.
    - Representing self, expressed opposition to the proposal and touched on a few aspects of the proposal that he sees problematic: exterior stairways have no ventilation; interior stairway pressure is discussed by the proposal, but there is no requirement to use an interior stairway; and, there's a lot of different landscape in Virginia, unlike in Seattle and New York City.

DHCD Staff Notes:

The proposal was originally discussed at the General Stakeholders Workgroup (GSWG) meeting on April 12, 2022. The proponent requested for the proposal to be carried over to the July GSWG meeting so that he can meet with stakeholders in the meantime and explore potential areas of agreement. DHCD staff offered to attend said meetings to provide assistance, as applicable, but the staff was not invited to the meetings and conversations that took place outside of the code development process facilitated by DHCD. The comments noted in the "GENERAL STAKEHOLDERS WORKGROUP INFORMATION" section above are based on the floor modification submitted by the proponent at the July GSWG meeting.

Meeting summaries and proposal related information: Tab 10 - Page 27; Tab 10 - Page 63.

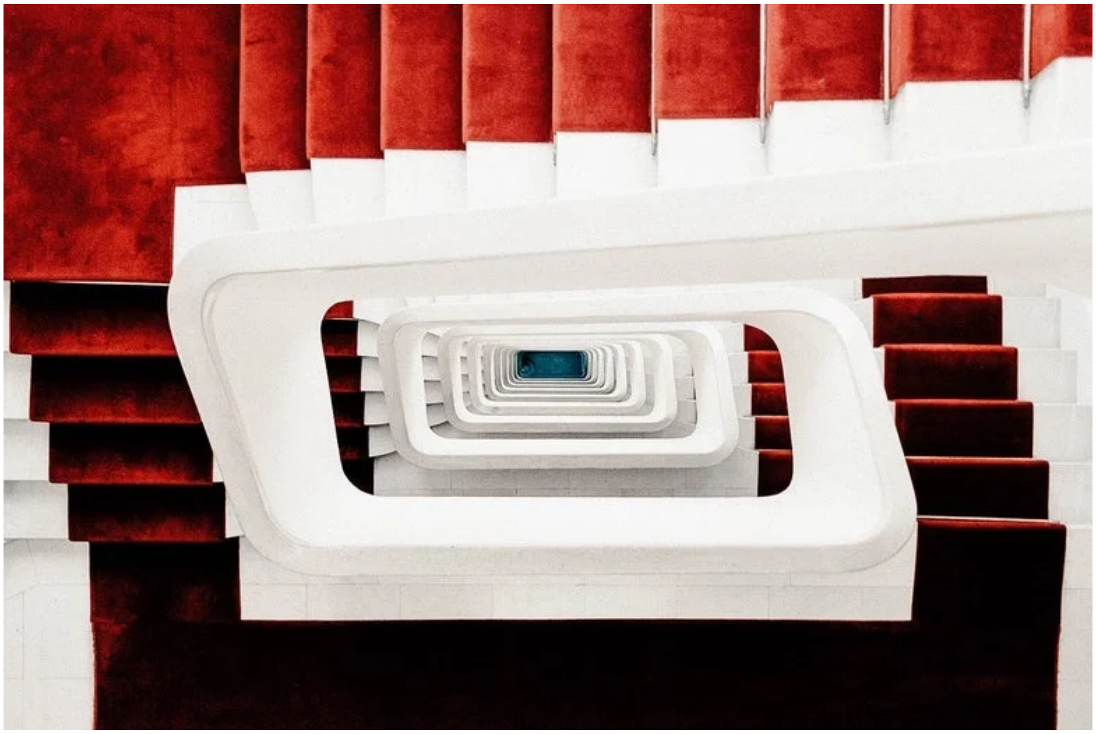
METROPOLIS

The Single-Staircase Radicals Have a Good Point

A surprising theory of what's wrong with North American apartment buildings.

BY HENRY GRABAR

DEC 23, 2021 • 10:29 AM



Now that's a staircase. Thomas Serer on Unsplash

The Seattle-based architect Michael Eliason has a number of complaints about the way America makes its apartment buildings. The components are inferior, he says: The best sliding doors and windows are made elsewhere. The designs rarely accommodate larger families. And there are too many staircases.

Too many what now? Eliason is the founder of Larch Lab and the lead evangelist of a small group of architects and developers intrigued by the possibilities of making multifamily buildings with only one stairway. And conversely, fed up with the North American standards that require most apartments to be accessible by two of them.

Mandating two stairways, Eliason says, produces smaller, more unpleasant, more expensive apartments in larger buildings full of wasted space. He likes to contrast the boxy North American multifamily building with nimbler designs from South Korea, China, Sweden, Italy, or Germany. In those countries, apartments in midrise buildings may be served by a single stair, often encircling or adjacent to the elevator. Online, Eliason is a founding father of what he's called Floor Plan Twitter, where he shares these foreign, single-stair blueprints with a gusto usually reserved for imports like wine or sports cars.

wohnBAUMoffensive
@holz_bau

looking at floor plate efficiencies of 3 different vertical egress typologies...

left: 6-unit single loaded corridor. 83,5% floor plate efficiency

middle: 12-unit double loaded corridor. 87% floor plate efficiency

right: 6-unit point access block. 93,5% floor plate efficiency

9:04 PM · Dec 21, 2021

Read the full conversation on Twitter

295 Reply Copy link to Tweet

Read 14 replies

Of all of Eliason's beefs with U.S. building practices, which he has outlined for the environmental news site Treehugger, this one is both the most tangible—you don't need to be an architect to understand the difference between two staircases and one—and the most opaque. It's one staircase, Michael. What could it cost?

The answer, Eliason and the single-staircase brigade insist, can be measured in terms of light, air, space, and money.

Most American apartment buildings over four stories are required to include two means of egress from every apartment. In Canada, the height limit of a single-stair building is just two stories. The purported reason for such rules is fire safety, though there's no evidence that Americans and Canadians are any safer from structure fires than our neighbors around the world, where one-staircase construction is permitted even in buildings eight, 10, or 20 stories high.

That second staircase is a drag. When we spoke last week, Eliason showed me a presentation he gives to drive home the building culture that is shaped by the two-stair system. It featured a still from the movie *The Shining*, of Danny riding his tricycle down the long, carpeted hallway of the Overlook Hotel. If you've been in an American apartment building of the past half-century or so, you probably recognize this airless environment, which architects call a "double-loaded corridor" because it has doors on both sides. Nobody likes these hallways. The double-loaded corridor, the architect Frank Zimmerman writes, is a "case study in anti-human engineering."

Eliason observes that when you require every apartment to connect to two staircases, you all but ensure those units are built around one long double-loaded corridor, to give all residents access to both stairways. You tilt the scales in favor of larger floor plates in bigger buildings, because developers need to find room for two stairways, and connect them—and then compensate for the unsellable interior space consumed by the corridor.

The designs that result, Eliason argues, are more likely than not to offer smaller, cookie-cutter units constrained by their position along the long hallway. Apartments must look either north or south. Sunlight or shade. Sunrise or sunset. Busy street or quiet back yard. And no one, save perhaps a lucky occupant of a corner unit, gets a cross-breeze.

The Bandeira Building, a 20-story apartment complex in São Paulo, has one staircase and three units on each floor, each with windows on two sides. Una Arquitetos, via Divisare

Cut out one of those staircases, and you can cut out the corridor, too. Narrower sites are suddenly in play. Construction costs go down. The ratio of "rentable" space in a building goes up, which makes development cheaper. That in turn can translate into lower rents or more flexible designs. Two or three units a floor is suddenly more economical, which makes the stairway a more intimate, closely shared space. Family-size units. Units where the living room faces south to the sun and the street and the bedrooms face north to the quiet shade. "In the architecture world it's hammered in from the beginning that we need two exits from every space," Eliason said. "But in most other countries, that second means of egress is the fire brigade."

Another Floor Plan Twitter fan is Conrad Speckert, an architecture student at McGill University who takes that required second staircase personally. “I grew up in a three-storey, single egress apartment building where we knew our neighbours well, the stair landings were generous and naturally lit, and everyone got pretty crazy with their Christmas decorations,” he writes on the website for his master’s degree project, Second Egress. “My childhood home in Switzerland reminds me that stairs should be about more than just circulation and fire safety, and that there is a sensuality to them too—the tactile sensation of a winding guardrail, the slip-resistance of the treads, the wash of light from a skylight or the breeze from an operable window.” (The classic European single-stair also produces a mean movie fight-scene.)

But such buildings have been illegal in Canada since 1941, when the country adopted stricter building regulations. For Speckert, the Second Egress website is the first step toward petitioning for a change to the Canadian building code. He has collected the maximum heights of single-stair buildings in various countries and assembled a “Manual of Illegal Floor Plans” from more permissive regimes, showing what might be possible.

In North America, staircases are usually required to be closed off from the corridor, which makes them into isolated and unpleasant spaces. They’re also designed that way. But they don’t need to be. “There’s an intuition that once a building is more than two stories of height, you use the elevator,” Speckert told me. “But when you have a building with one stair that opens directly to the landing, you have the opportunity to design that stair. To not make it concrete with an aluminum guardrail. Now you’re sharing circulation with neighbors, you may know them.”

The 14-story Stone Garden building in Beirut, which has one staircase and one or two units on each floor. Lina Ghotmeh Architecture, via Divisare

But the biggest problem with two staircases, the single-stair brigade agrees, is affordability: A second staircase makes it harder to build small-footprint, midrise, multifamily rental buildings. It is one of the many obstacles (zoning, parking, height limits, etc.) we have thrown up over the past century to block the "missing middle" housing that defined early 20th century cities, and now constitutes some of their most beloved and expensive real estate.

The specter of big structure fires—like the fire at London's Grenfell Tower, the single-stair housing project whose defective façade panels caught fire in 2017, killing 71 people—is what reformers like Eliason and Speckert are up against. But building fires are much less common than they were when single-stair rules were codified, to the extent that most city dwellers roll their eyes at office fire drills and curse their hyperactive apartment smoke alarms. Data from the World Fire Statistics Centre show Canada, for example, has little to show for its two-story limit.

Bobby Fijan, a developer in Philadelphia, is another guy who likes a single stair. Fijan calls himself the Bill James of floor plans, a reference to the baseball analyst whose keen statistical-appraisal technique helped changed the way players and skills were valued in the sport. "I'm not sure the effect it would have on a 250-unit building by Mill Creek," he said, citing a large apartment developer. "But it would be particularly meaningful on urban infill"—the one-off apartment projects taken on by developers in already dense neighborhoods.

"I'm having to do increasingly convoluted 'stacked townhouse' arrangements instead of small-flat buildings," said the developer Payton Chung. He's putting the top floors of a small building inside one multistory apartment, rather than making them separate apartments, to avoid triggering that second-stair requirement. The International Building Code (which, like the World Series, is really an American institution) doesn't care if you have six or 60 units on a floor—you still need your two staircases.

One place that's closer to the global standard? Eliason's hometown of Seattle. The city has approved single stairs in buildings up to six stories. It's all right with the Seattle Fire Department. Could it work in your city, too?

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Sustainability for All.

News • Home & Design

The Case for More Single Stair Buildings in the US

Citing the Grenfell Tower tragedy isn't enough to nix this idea.

By Michael Eliason

Published August 10, 2021 06:36PM EDT

Little Buildings in Aspern Seestadt.
Lloyd Alter

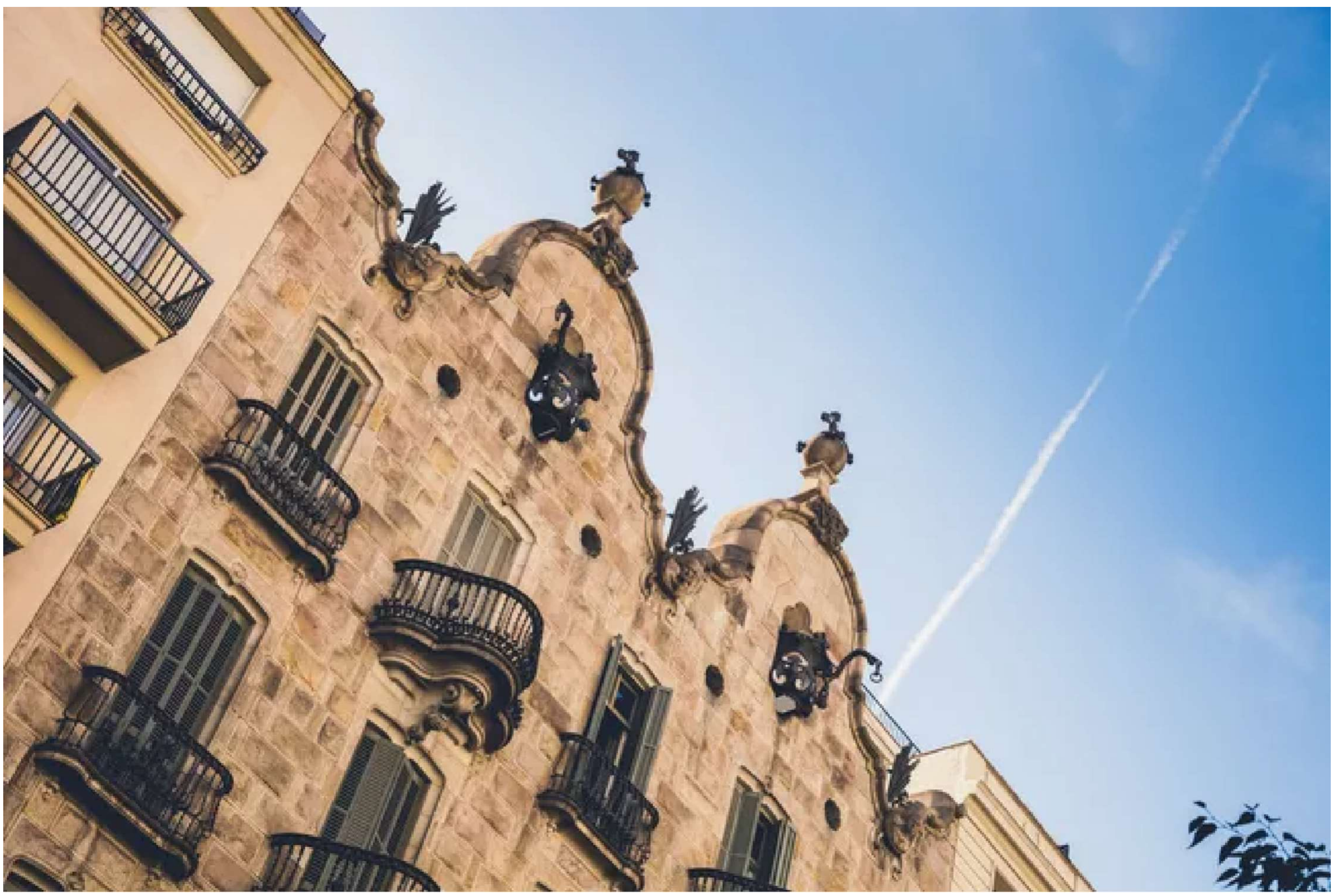
While covering America's broken architecture and construction industries recently, I made a passing remark on how single stair buildings should be legal. This resulted in several comments and discussions across a spectrum of media. It is a topic I weighed in on regularly for several years, but I had never seen this much consternation regarding it.

Simply put: Single stair buildings can be a good thing.

designed to compartmentalize fires that occurred, but as the recent trial has laid bare, it was poorly managed and badly renovated, with an incredible number of faulty decisions leading up to the fire.

Acknowledging this tragedy is important because I am not advocating that construction should be a free-for-all — in fact, far from it. Building regulations are necessary for establishing minimum standards, safety, and accessibility. Often they are data-driven, but there are also cultural elements based on historic practices found in building regulations.

In the United States, building and energy regulations are written by a private entity rather than government agencies, as found in Europe, Canada, and most other countries. It should be noted single stair multifamily buildings are incredibly common in Europe and most don't have fire sprinklers either. That goes for both existing, historic, and new construction. The tallest single stair building I've seen outside of the United Kingdom, in comparison, is only 10 floors.



Casa Calvet.
Leo Patrizi/ Getty Images

massive influx of workers migrating to cities, before the advent of the elevator and when people got around primarily by foot. In these urban centers, building parcels were generally narrow and family-owned – and they were expanded on over time. Due to the narrowness, there was largely only room for one stairwell.

Most of the construction wasn't wood framed like in the United States, but rather solid construction — generally brick or stone, and eventually concrete. Floors and roofs/inhabited attics were built with wood beams and floors. Thus, many buildings were of the sort where vertical elements were relatively fire-resistant, but the horizontal elements were not.

There was no professional fire brigade until the 19th century. With little to no fire regulations, cities throughout Europe had massive fires. Some, like Passau, Germany, had multiple fire events that destroyed the city several times over.

Construction detailing and the onset of concrete floors generally changed the equation on this, allowing for compartmentalization to slow or contain fires. Mass Timber today can be designed to operate in a similar manner.

To this date, the single stair configuration has endured. But double-loaded corridor buildings — buildings with units on either side of a central hallway — have been less common. I don't know the exact reasons for this, but I believe a large part is cultural. Double loaded corridors prevent units from getting lights from multiple sides, and they don't allow cross ventilation, which is a growing issue on a warming planet. (Yes, even for multifamily passivhaus projects.)

Double loaded corridors generally have dark hallways, and result in less usable space per floor than a single stair configuration, especially if your building code allows units to enter directly off the stairwell, as they do in Germany, Austria, and France. There are also structural tradeoffs with a double-loaded corridor, particularly for a building that is cellular or repetitive in design like a hotel, dormitory, or efficiency units. Single stair buildings generally have more flexibility in their floor plan configurations.

A double loaded corridor

Long corridor with lots of units in Kent, Ohio.
Lloyd Alter

Another issue with large double-loaded corridor buildings is there are more people using the same elevators, halls, and entries. There are more people entering this sort of building than would in a single-stair configuration, due to limits on the number of units per floor. There are certainly social implications for this worth evaluating, whether one is more personal or impersonal. Post-pandemic, does it make sense to design buildings where many residents are using the same public spaces or does it make sense to partition buildings into smaller pods?

Open Stair in Munich

Single open stair in Munich.
Lloyd Alter

So, what does this single stair configuration look like in Germany or Austria? Well, for starters, it should also be noted there generally is not a requirement for sprinklers. There are regulations on fire-rated stairwells, walls, and floors. There are limits on the number of units per floor for each stair – four for Germany; eight for Austria. There are maximum travel distances to the stairwell (115 feet).

There are limits on the building height as well: In Germany, the floor must be a maximum of 72 feet above grade — generally seven or eight stories. Interestingly, 72 feet is the max wall height for most of the Berlin Altstadt, which was set at the max height of ladder rescue, as well as street width in case of collapse. There are allowances to go a little higher with more stringent requirements on exit doors and egress, as well as the availability of rescue apparatuses that can reach this high. This is where it gets interesting.

Austrian architecture firm Querkraft Architekten designed an incredible 8-floor passivhaus multifamily building with a single stair configuration serving up to eight units per floor, in the heart of Vienna, Austria. Note the exterior (thermally broken!) concrete balconies. What is the function of balconies? The function of balconies is to access urban life, the outdoors directly from one's unit. However, most importantly, it is the second means of egress.

Yes, you read that correctly. Like the United States and Canada, German and Austrian building regulations require two means of egress. The difference is that, in part due to one, they have monstrous fire apparatuses that can do bucket rescues on tall buildings such as this rescue in Karlsruhe at 131 feet up.

Cute little fire truck in Copenhagen

CC BY 2.0. Seen in Copenhagen: cute little fire engines/ Lloyd Alter

In Germany, there are also very specific regulations on fire planning — where buildings are located, separation between buildings or courtyards, the heights/widths to get around or through a building to a courtyard, as well as where apparatuses go to make these rescues. When I was working there, a fair amount of my time was spent planning for stuff like this, studying *schleppkurven* (turning radii) and apparatus layouts. Perhaps it is also a function of smaller, more nimble fire apparatuses in Europe. Possible also, is their fire departments spend more time dealing with fires, rather than medical emergencies, as in the United States.

Single Stair in Munich

Single Open Stair in Munich.
Lloyd Alter

Germany also allows for multiple single-stair configurations to be used in the same building, as in the lovely walden48 baugruppe by scharabi + raupach architekten, a massive mass timber multifamily development that is effectively broken up into 3 separate buildings, separated by firewalls. Similarly, the Dennewitz Einz baugruppe — one big development, 3 separate buildings, designed in collaboration by 3 separate architecture firms. These units get light on multiple sides, cross-ventilation, and a good variety in the unit mix. Those additional measures for additional height that I mentioned are how a 10-floor, mass timber multifamily building with a single stair, like the Skaio in Heilbronn, Germany, by Berlin-based architecture firm Kaden + Lager, can be built.

Another personal favorite is this 9-unit, 7-floor social housing project by FRES architectes in Paris – a stunning project that would be infeasible if a second stairwell were required. As well as this 6-floor plus mezzanine and roof deck multifamily building by Lola Domènech and Lussi + Partner in the heart of Barcelona.

Mexico and Japan also have 10-story, single exit buildings. Despite this abundance of buildings with single stair configurations and little to no active fire suppression, these buildings are quite safe due to compartmentalization and building regulations. Many also have wonderful, daylit, open stairwells for active usage by residents.

Fema fire deaths

FEMA

Per this FEMA report, France, Germany, and Austria all have much lower fire death rates than the United States, where multiple stairs and active fire suppression are required for most multifamily buildings. Despite what we have been led to believe over the years, single stair multifamily buildings are legal even in some U.S. jurisdictions. The International Building Code allows for up to four floors, but with stringent regulations including a max of four units per floor, and requirements for sprinklers. Seattle allows up to six floors plus a mezzanine with a single stair configuration.

Small buildings in Munich

Small Buildings with Single Stairs in Munich.
Lloyd Alter

also accessible, as buildings in both continents require elevators on projects like this and many in Germany are barrier-free or adaptable.

Most importantly, they are legal. Maybe we should follow suit.

Fussgaengerzone (pedestrian zone) in Landshut, Germany

Treehugger Voices

America's Architecture and Construction Industry Is Broken

intelligent City section

Treehugger Voices

Intelligent City Builds Prefab, Passive, Mass Timber Housing With Robots

Sustainability for All.

Fussgaengerzone (pedestrian zone) in Landshut, Germany

Treehugger Voices

26 Climate Actions Cities Should Adopt at COP26 for Climate Change Resilience

1 De haro

Treehugger Voices

San Francisco's First Cross-Laminated Timber Building Is Complete

7 MCH apartment renovation by Studio Bravo interior

Home & Design

Clever Small Apartment Renovation Features a Lantern-Like Bathroom

Large Projects

Treehugger Voices

Which Building Should Win the UK Passivhaus Trust Large Project Award?

Solis in the Evening

Treehugger Voices

No, Passive House Doesn't Have to Cost a Lot More

Sustainability for All.

huts on the wall

Home & Design

This Apartment Building in Vienna Is a Highrise of Huts

Interior of Theater

Home & Design

Sara Kulturhus by White Arkitekter Is a Wooden Wonder

Stairway to Nowhere

Treehugger Voices

In Praise of Stairs

Three Generation House by BETA interior

Home & Design

Family's Modern, Adaptable

Sustainability for All.

Il Cubotto micro-apartment renovation by thecaterpilar interior

Home & Design

Architect Converts Historic Micro-Apartment Into a Modern Live-Work Space

Through The Looking Glass House by Ben Callery Architects kitchen

Home & Design

Heritage Renovation Gets Lit Up With a Clever Glass Floor

A Moulting Flat small apartment renovation by Husos Architects living room

Home & Design

Musician's Dramatic Small Apartment Renovated With Reclaimed Materials

Interior of Passivhaus

Home & Design

You'd Never Guess This NYC Townhouse Is a Passivhaus

Sustainability for All.

432 Park Avenue from the top of Rockefeller Center

Treehugger Voices

Residents of 432 Park Avenue Find Posh New York Towers Can Be Too Tall and Too Thin

2021 International Building Code

Revise as follows:

1006.3.4 Single exits.

A single exit or access to a single exit shall be permitted from any story or occupied roof where one of the following conditions exists:

1. The occupant load, number of dwelling units and exit access travel distance do not exceed the values in Table 1006.3.4(1) or 1006.3.4(2).

2. Rooms, areas and spaces complying with Section 1006.2.1 with exits that discharge directly to the exterior at the level of exit discharge, are permitted to have one exit or access to a single exit.

3. Parking garages where vehicles are mechanically parked shall be permitted to have one exit or access to a single exit.

4. Group R-3 and R-4 occupancies shall be permitted to have one exit or access to a single exit.

5. Individual single-story or multistory dwelling units shall be permitted to have a single exit or access to a single exit from the dwelling unit provided that both of the following criteria are met:

> 5.1. The dwelling unit complies with Section 1006.2.1 as a space with one means of egress.
>
> 5.2. Either the exit from the dwelling unit discharges directly to the exterior at the level of exit discharge, or the exit access outside the dwelling unit's entrance door provides access to not less than two approved independent exits.

6. Not more than 5 stories of Group R-2 occupancy are permitted to be served by a single exit under the following conditions:

> 6.1. The building shall be of not less than one hour fire-resistive construction and shall also be equipped throughout with an automatic sprinkler system in accordance with subsection 903.3.1.1. Residential-type sprinklers shall be used in all habitable spaces in each dwelling unit.
>
> 6.2. An exterior stairway or interior exit stairway shall be provided. The interior exit stairway, including any related exit passageway, shall be pressurized in accordance with subsection 909.20. Doors in the stairway shall swing into the interior exit stairway regardless of the occupant load served, provided that doors from the interior exit stairway to the building exterior are permitted to swing in the direction of exit travel.
>
> 6.3. A corridor shall separate each dwelling unit entry/exit door from the door to an interior exit stairway, including any related exit passageway, on each floor. Dwelling unit doors shall not open directly into an interior exit stairway. Dwelling unit doors are permitted to open directly into an exterior stairway.
>
> 6.4. There shall be no more than 20 feet (6096 mm) of travel to the exit stairway from the entry/exit door of any dwelling unit.
>
> 6.5. Travel distance measured in accordance with section 1017 shall not exceed 125 feet (38100 mm).
>
> 6.6. Elevators shall be pressurized in accordance with section 909.21 or shall open into elevator lobbies that comply with section 713.14. Where approved by the building official, natural

ventilation is permitted to be substituted for pressurization where the ventilation would prevent the accumulation of smoke or toxic gases.

6.7. Other occupancies are permitted in the same building provided they comply with all the requirements of this code. Other occupancies shall not communicate with the Group R occupancy portion of the building or with the single-exit stairway. Exception: parking garages and occupied roofs accessory to the Group R occupancy are permitted to communicate with the exit stairway.

6.8. The exit serving the Group R occupancy shall not discharge through any other occupancy, including an accessory parking garage.

6.9. There shall be no openings within 10 feet (3048 mm) of unprotected openings into the stairway other than required exit doors having a one-hour fire-resistance rating.

B1010.2.8-21

Proponents: DHCD Staff on behalf of the following stakeholders represented at the Active Shooter and Hostile Threat Events in Public Buildings Study Group: Virginia Building & Code Officials Association, Virginia Fire Prevention Association, Nightlock

2018 Virginia Construction Code

Revise as follows:

Section 108.1 When applications are required. Application for a permit shall be made to the *building official* and a permit shall be obtained prior to the commencement of any of the following activities, except that applications for emergency *construction*, alterations or *equipment* replacement shall be submitted by the end of the first *working day* that follows the day such work commences. In addition, the *building official* may authorize work to commence pending the receipt of an application or the issuance of a permit.

1. *Construction* or demolition of a *building* or *structure.* Installations or alterations involving (i) the removal or addition of any wall, partition or portion thereof, (ii) any structural component, (iii) the repair or replacement of any required component of a fire or smoke rated assembly, (iv) the alteration of any required means of egress system, including the addition or removal of *emergency supplemental hardware*, (v) water supply and distribution system, sanitary drainage system or vent system, (vi) electric wiring, (vii) fire protection system, mechanical systems, or fuel supply systems, or (viii) any *equipment* regulated by the USBC.
2. For *change of occupancy*, application for a permit shall be made when a new certificate of occupancy is required by the VEBC.
3. Movement of a *lot line* that increases the hazard to or decreases the level of safety of an existing *building* or *structure* in comparison to the *building* code under which such *building* or *structure* was constructed.
4. Removal or disturbing of any asbestos containing materials during the *construction* or demolition of a *building* or *structure*, including additions.

110.1.1 Consultation and notification. Prior to approval or removal of *emergency supplemental hardware*, the building code official shall consult with the local fire code official, or state fire code official if no local fire code official exists, and head of the local law-enforcement agency. The local fire code official; the state fire code official; and the local fire, EMS, and law-enforcement first responders shall be notified by the building code official of such approval or removal, after approval or removal of such *emergency supplemental hardware* ~~by the building code official.~~ .

SECTION 202 DEFINITIONS. "Public Building" - a structure or building that is owned, leased, or otherwise occupied by a municipality or the state and used for any municipal or public purposes by the municipality or the state.

~~1010.1.4.4~~ 1010.2.8 ~~Locking arrangements in educational occupancies~~ Emergency Supplemental Hardware. In Group E occupancies, except Group E day care facilities, ~~and~~ Group B educational occupancies and public buildings, *exit access doors* from classrooms, offices, and other occupied rooms, except for exit doors and doors across corridors, shall be permitted to be provided with *emergency supplemental hardware* where all of the following conditions are met:

1. The door shall be capable of being opened from outside the room with a key, proprietary device provided by the manufacturer, or other *approved* means.
2. The door shall be openable from within the room in accordance with Section 1010.1.9, except *emergency supplemental hardware* is not required to comply with Chapter 11.

   Note: School officials and building owners should consult with their legal counsel regarding provisions of the Americans with Disabilities Act of 1990 (42 USC § 12101 et seq.) and any other applicable requirements.
3. Installation of *emergency supplemental hardware* on fire door assemblies must comply with Section 716.2. Modifications shall not be made to listed *panic hardware*, fire door *hardware*, or door closures.
4. The *emergency supplemental hardware* shall not be capable of being used on other doors not intended to be used and shall have at least one component that requires modification to, or is permanently affixed to, the surrounding wall, floor, door, or frame assembly *construction* for it to properly function.
5. Employees shall engage in lockdown training procedures on how to deploy and remove the *emergency supplemental hardware*, and its use shall be incorporated in the *approved* lockdown plan complying with the SFPC.
6. The *emergency supplemental hardware* and its components shall be maintained in accordance with the SFPC.
7. *Approved emergency supplemental hardware* shall be of consistent type throughout a building.

   Exception: The *building official* may approve alternate types of *emergency supplemental hardware* in accordance with Section 110.1 when a consistent device cannot be installed.

1103.2.15 Emergency supplemental hardware. In Group E occupancies, except Group E day care facilities, ~~and~~ Group B educational occupancies, and public buildings, when *emergency supplemental hardware* is deployed during an active shooter or hostile threat event and provided in accordance with Section ~~1010.1.4.4.~~ 1010.2.8, is not required to comply with this chapter.

2018 Virginia Statewide Fire Prevention Code

Revise as follows:

1031.11 Emergency supplemental hardware. *Emergency supplemental hardware* shall be installed in accordance with the *applicable building code* and shall be *maintained* in accordance with this code , the conditions of its approval and the manufacturer's instructions. The *fire code official* shall be authorized to revoke the use and storage of *emergency supplemental hardware* within a *building* for due cause based on failure to comply with requirements in this code or the *applicable building code*. Revocations shall be rescinded upon achieving compliance with this code and the *applicable building code*.

Reason Statement: The proposal intends to comply with the SB 333 and HB 670 by expanding on the existing provisions for ESH. The gist of the proposal is the addition of "public buildings" to the list of uses/occupancies already allowed to be provided with ESH. The proposal was generated as a result of discussions during the Active Shooter and Hostile Threats in Public Buildings - Study Group, convened pursuant to the aforementioned bills. For more information on the Study Group activities and discussions, please see attached Study Group Report.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
The proposal intends to **allow** the installation of ESH in public buildings, it does not **mandate** such. Should the building owner(s) decide to install ESH, the proposal could reduce or increase the cost of construction, depending upon the type of locking devices selected.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency
While the proposal does not increase the resiliency of buildings, arguments could be made that the resiliency of building occupants could be increased against active shooter or hostile threats events. Conversely, it could also be claimed that the resiliency of occupants could be reduced by enabling assailants to lock occupants in a given room and prevent first responders from entering.

Attached Files

- **20220407 Active Sh. and Hostile Threats in Pub.pdf**
  https://va.cdpaccess.com/proposal/1012/1448/files/download/629/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: B1010.2.8-21

This proposal doesn't have any public comments.

B1010.2.8-21– Staff Summary

Proponent: DHCD Staff on behalf of the following stakeholders represented at the Active Shooter and Hostile Threat Events in Public Buildings Study Group: Virginia Building & Code Officials Association, Virginia Fire Prevention Association, and Nightlock.

Brief Description:

The proposal provides a compliance path for the installation of emergency supplemental hardware within public buildings and defines "public buildings" within the context of the Uniform Statewide Building Code and the Statewide Fire Prevention Code.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

The proposal was drafted and submitted by DHCD staff on behalf of several members of the Active Shooter and Hostile Threat Events in Public Buildings Study Group, as a result of discussions over several Study Group meetings.

The following Study Group members expressed support for the proposal:

- Jimmy Moss: Virginia Building & Code Officials Association (VBCOA)
- Ernie Little: Virginia Fire Prevention Association (VFPA)
- Jack Taylor: Nightlock

The following Study Group members expressed opposition to the proposal:

- Kurt Roeper: Door and Hardware Institute
- Mark Dreyer: Virginia Department of General Services - Division of Engineering
- Rob Comet: American Institute of Architects – Virginia Chapter

The following Study Group members did not voice an opinion:

- Billy Hux: Virginia Department of Fire Programs/State Fire Marshal's Office
- Patrick Green: Virginia State Police
- Frederick Presley: Stafford County
- Jim Crozier: Local Government – County
- James Garrett: Local Law Enforcement – City
- Chris Kuyper: Local Law Enforcement – County
- Teri Morgan: Accessibility
- Chris Barry: Virginia Fire Chiefs Association

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Jimmy Moss, VBCOA, a member of the Active Shooter and Hostile Threats in Public Buildings Study Group; Andrew Milliken, representing the Virginia Fire Services Board (VFSB) – Code and Standards Committee.

- Jimmy Moss indicated that he participated in the Study Group where there was thorough discussion around the emergency supplemental hardware. He acknowledged that there was some opposition to the whole idea of allowing emergency supplemental hardware but noted that if we are to be moving in the direction of allowing these types of devices, this is the way to do it. He feels that the proposal gives good guidance and direction to the code officials to follow when dealing with these devices.
- Andrew Milliken, representing the VFSB – Codes and Standards Committee, stated that they discussed the proposal and the VFSB – Codes and Standards Committee supports the proposal.

Opposition:

Names: Andrew Milliken, representing self.

- Andrew Milliken, representing self, noted that the proposal goes beyond the scope of the model code and although there was some good feedback for and against the proposal, he thinks it is appropriate for additional discussions to take place at the Board (of Housing and Community Development) level.

DHCD Staff Notes:

During the 2020 General Assembly Session, SB 333 and HB 670 directed DHCD to convene stakeholders to develop USBC and SFPC proposals with the goal of assisting in the provision of safety and security measures for the Commonwealth's public buildings for active shooter or hostile threats while maintaining compliance with basic ADA accessibility requirements.

Please see the attached Active Shooter and Hostile Threats in Public Buildings Study Group Report for additional information.

The proposal, which was developed as a result of discussions during said Study Group, was on the Agenda for the General Stakeholders Workgroup (GSWG) meetings on April 12, 2022 and June 7, 2022. At the April meeting a minor concern was raised with some of the existing code language; no opposition to the changes suggested by the proposal was noted. The proposal was carried over so that the Study Group members have an opportunity to review any potential alternative language. After the meeting, the opposing party decided to submit a separate and distinct proposal to address the concerns with the existing code language. As such, the proposal was not brought back for further discussions by the Study Group, but was included in the Agenda for the June 7th GSWG meeting. The support and opposition summary included in the "GENERAL STAKEHOLDERS WORKGROUP INFORMATION" section above, reflects comments made during the June GSWG meeting.

Meeting summaries and proposal related information: Tab 10 - Page 29; Tab 10 - Page 63; Tab 12: Active Shooter Study Group Report.

RB326-21

Proponents: Jason Laws (lawsj@chesterfield.gov)

2018 Virgina Residential Code

Revise as follows:

[RB] ATTIC, HABITABLE. A finished or unfinished ~~area, not considered a story, complying with all of the following requirements:~~ habitable space within an attic

1. ~~The occupiable floor area is at least 70 square feet (17 m^2), in accordance with Section R304,~~
2. ~~The occupiable floor area has a ceiling height in accordance with Section R305, and~~
3. ~~The occupiable space is enclosed by the roof assembly above, knee walls (if applicable) on the sides and the floor-ceiling assembly below.~~

~~Habitable attics greater than two-thirds of the area of the story below or over 400 square feet (37.16 m^2) shall not be permitted in dwellings or townhouses that are three stories above grade plane in height..~~

2021 International Residential Code

SECTION R326
HABITABLE ATTICS

R326.1 General. Habitable attics shall comply with Sections R326.2 and R326.3.

R326.2 Minimum dimensions. A habitable attic shall have a floor area in accordance with Section R304 and a ceiling height in accordance with Section R305.

Revise as follows:

R326.3 Story above grade plane. A habitable attic shall be considered a story above grade plane.
Exceptions: A habitable attic shall not be considered to be a story above grade plane provided that the habitable attic meets all the following:

1. The aggregate area of the habitable attic is ~~either of the following:~~

~~1.1. Not~~ not greater than ~~one-third~~ two-thirds of the floor area of the story ~~below.~~

~~1.2. Not greater than one-half of the floor area of the story below where the habitable attic is located within a dwelling unit equipped with a fire sprinkler system in accordance with Section P2904.~~ below or a maximum of 400 square feet.

2. The occupiable space is enclosed by the roof assembly above, knee walls, if applicable, on the sides and the floor-ceiling assembly below.

~~3.~~
~~The floor of the habitable attic does not extend beyond the exterior walls of the story below.~~

~~4.~~
~~Where a habitable attic is located above a third story, the dwelling unit or townhouse unit shall be equipped with a fire sprinkler system in accordance with Section P2904.~~

R326.4 Means of egress. The means of egress for habitable attics shall comply with the applicable provisions of Section R311.

Reason Statement: To remove the requirements of a habitable attic out of the definition and into the body of the code.
The intent of this change is to use the definition that is currently being used in the 2021 IRC and to adapt the code sections from the 2021 IRC to meet the current Virginia requirements. So this proposal should result in no change to how habitable attics are enforced in Virginia.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
no change in how habitable attics are enforced

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- ☐ Approved
- ☐ Approved with Modifications
- ☐ Carryover
- ☐ Disapproved
- ☐ None

Public Comments for: RB326-21

This proposal doesn't have any public comments.

Proposal # 1152

RB326-21 – Staff Summary

Proponent: Jason Laws, VBCOA

Brief Description:

The proposal seeks to remove the habitable attic technical provisions from the definition of Habitable Attic and place the requirements in the body of the code, with the intent of maintaining the existing Virginia technical amendments.

STUDY GROUP OR SUB-WORKGROUP INFORMATION.

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: William Penniman, Sierra Club – Virginia Chapter; David Beahm, representing self; Andrew Clark, Home Builders Association of Virginia (HBAV)

- William Penniman Sierra Club – Virginia Chapter, stated that he supports this proposal.
- Andrew Clark, HBAV, and David Beahm, representing self, wanted to get on the record as supporting the proposal.

Opposition:

Names: Jeff Shapiro, representing self; Dan Willham, Fairfax County; Paula Eubank, Federal Emergency Management Agency (FEMA);

- Jeff Shapiro, representing self, stated that this proposal creates a loophole for a 4th story in the residential code by removing the requirements for a P2904 sprinkler system for those buildings with a habitable attic located above a 3rd story.
- Dan Willham, Fairfax County, and Paula Eubank, FEMA, wanted to get on the record as opposing the proposal.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 98.

PM103.2-21

Proponents: Ronald Clements (clementsro@chesterfield.gov)

2018 Virginia Maintenance Code

Delete without substitution:

~~**STRUCTURE UNFIT FOR HUMAN OCCUPANCY.** An existing *structure* determined by the *code official* to be dangerous to the health, safety and welfare of the *occupants* of the *structure* or the public because (i) of the degree to which the *structure* is in disrepair or lacks maintenance, ventilation, illumination, sanitary or heating facilities or other essential equipment, or (ii) the required plumbing and sanitary facilities are inoperable.~~

Revise as follows:

UNSAFE STRUCTURE. An existing *structure* ~~(i)~~ determined by the *code official* to be dangerous to the health, safety and welfare of the *occupants* of the *structure* or the public ~~, (ii) that contains *unsafe equipment,* or (iii) that~~ because of, but not limited to, any of the following conditions:
1. The structure contains *unsafe equipment;*
2. The structure is so damaged, decayed, dilapidated, structurally unsafe or of such faulty construction or unstable foundation that partial or complete collapse is likely;
3. The *structure* is unsecured or open ;
4. The degree to which the structure is in disrepair or lacks maintenance, ventilation, illumination, sanitary or heating facilities or other essential equipment;
5. The required plumbing and sanitary facilities are inoperable.
~~shall be deemed to be an *unsafe structure.* likely. A vacant existing *structure*~~

103.2 Maintenance requirements. Buildings, *structures* and systems shall be *maintained* and kept in good repair in accordance with the requirements of this code and when applicable in accordance with the USBC under which such building or structure was constructed. No provision of this code shall require alterations to be made to an existing building or *structure* or to equipment unless conditions are present which meet the definition of an *unsafe structure* ~~or a *structure unfit for human occupancy.*~~ .

105.2 Notices, reports and orders. Upon findings by the *code official* that violations of this code exist, the *code official* shall issue a correction notice or notice of violation to the *owner, tenant* or the person responsible for the maintenance of the *structure; or,* a notice of *unsafe structure* in accordance with Section 106 when a *building* or *structure* is determined by the *code official* to be an *unsafe structure.* Work done to correct violations of this code subject to the permit, inspection and approval provisions of the VCC shall not be construed as authorization to extend the time limits established for compliance with this code. When the *owner* is not the responsible party to whom the notice of violation or correction notice is issued, a copy of the notice shall also be delivered to the *owner.*

105.4 Notice of violation. If the *code official* determines there are violations of this code a written notice of violation may be issued to the *owner, tenant* or the person responsible for the maintenance or use of the building or *structure* in lieu of a correction notice as provided for in Section 105.3. In addition, the *code official* shall issue a notice of violation for any uncorrected violation remaining from a correction notice established in Section 105.3. The *code official* shall provide the section numbers for any code provisions cited in the notice of violation to the *owner, tenant* or the person responsible for the maintenance or use of the building or *structure.* The notice shall require correction of the violation within a reasonable time. The *owner, tenant* or person to whom the notice of violation has been issued shall be responsible for contacting the *code official* within the timeframe established for any reinspections to assure the violations have been corrected. The *code official* will be responsible for making such inspection and verifying the violations have been corrected. In addition, the notice of violation shall indicate the right of appeal by referencing the appeals section of this code.

Exceptions:

1. ~~Notices issued and legal proceedings or emergency actions taken under Section 106 for *unsafe structures, unsafe equipment, or structures unfit for human occupancy.*~~
2. Notices issued for failing to maintain buildings and structures as required by Section 103.2, as evidenced by multiple or repeated violations on the same property are not required to include a compliance deadline for correcting defects.

105.6 Further action when violation not corrected. If the responsible party has not complied with the notice of violation or notice of *unsafe structure*, the code official may request the legal counsel of the locality to institute the appropriate legal proceedings to restrain, correct or abate the violation or to require the removal or termination of the use of the building or *structure* involved. In cases where the locality or legal counsel so authorizes, the code official may issue or obtain a summons or warrant.

105.6.1 Further action for corrected violations. Compliance with a notice of violation or notice of unsafe structure notwithstanding, the *code official* may request legal proceedings be instituted for prosecution when a responsible party is served with three or more separate notices of violation or notice of unsafe structure for the same property within any 5 consecutive years. Legal proceedings shall not be instituted under this section for violation notices issued pursuant to the initial inspection of the property. Legal proceedings for violations that have been abated in residential rental *dwelling units* within a multifamily apartment development may only be instituted for such violations that affect safe, decent, or sanitary living conditions.

Exception: Legal proceedings shall not be instituted for violations that have been abated on owner-occupied single family dwellings.

SECTION 106
UNSAFE ~~STRUCTURES OR STRUCTURES UNFIT FOR HUMAN OCCUPANCY~~ STRUCTURES

106.1 General. This section shall apply to existing *structures* which are classified as unsafe ~~or unfit for human occupancyoccupancy .~~ . All conditions causing such *structures* to be classified as ~~unsafe or unfit for human occupancy~~ unsafe shall be remedied or as an alternative to correcting such conditions, the *structure* may be vacated and secured against public entry or razed and removed. Vacant and secured *structures* shall still be subject to other applicable requirements of this code. Notwithstanding the above, when the *code official* determines that an *unsafe structure* ~~or a *structure unfit for human occupancy* constitutes~~ constitutes such a hazard that it should be ~~razed or removed~~ demolished, then the *code official* shall be permitted to order the demolition of such *structures* in accordance with applicable requirements of this code.

Note: *Structures* which become unsafe during construction are regulated under the VCC.

Delete without substitution:

~~**106.2 Inspection of unsafe or unfit structures.** The *code official* shall inspect any *structure* reported or discovered as unsafe or unfit for human habitation and shall prepare a report to be filed in the records of the local enforcing agency and a copy issued to the *owner*. The report shall include the use of the *structure* and a description of the nature and extent of any conditions found.~~

Revise as follows:

106.3 Notice of unsafe ~~structure or structure unfit for human occupancy~~ structure . When a *structure* is determined ~~to be unsafe or unfit for human occupancy~~ by the *code official* to be an *unsafe structure,* a written notice of *unsafe structure* ~~or *structure unfit for human occupancy*~~shall be issued by personal service to the *owner,* the owner's agent or the person in control of such ~~*structure.*~~*structure.* If the notice is unable to be issued by personal service, then the notice shall be sent by registered or certified mail to the last know address of the responsible party and a copy of the notice shall be posted in a conspicuous place on the *premises.* The notice shall specify the section numbers for any code provisions cited, the corrections necessary to comply with this code, or if the *structure* is required to be demolished, the notice shall specify the time period within which the demolition must ~~occur. Requirements in Section 105.2 for notices of violation are also applicable to notices issued under this section to the extent that any such requirements are not in conflict with the requirements of this section.~~ occur. The notice of *unsafe structure* shall indicate the right of appeal by referencing the appeals section of this code. The person to whom the notice has been issued shall be responsible for contacting the *code official* within the timeframe established for any re-inspections to assure the violations have been corrected. The *code official* will be responsible for making such inspection and verifying the violations have been corrected.

Note: Whenever possible, the notice should also be given to any *tenants* of the affected *structure.*

~~**106.3.1**~~ **106.4 Vacating unsafe structure.** ~~If the~~ The code official ~~determines there~~ is ~~actual and immediate danger to the *occupants* or public, or when life is endangered by the *occupancy* of an *unsafe structure,* the *code official* shall be~~ authorized to order ~~the~~ occupants to ~~immediately~~ vacate the unsafe ~~structure. When~~ structure of prohibit occupancy of the unsafe structure. When an *unsafe structure* is ordered to be vacated or prohibited from occupancy, the *code official* shall ~~post a notice with the following wording at each entrance: "THIS STRUCTURE IS UNSAFE AND ITS OCCUPANCY (OR USE) IS PROHIBITED BY THE CODE OFFICIAL." After posting, *occupancy* or use of the *unsafe structure* shall be prohibited except when authorized to enter to conduct inspections, make required repairs or as necessary to demolish the *structure.*~~ include the order in the notice of unsafe structure, or issue a separate order.

Delete without substitution:

~~**106.4 Posting of notice.** If the notice is unable to be issued by personal service as required by Section 106.3, then the notice shall be sent by registered or certified mail to the last known address of the responsible party and a copy of the notice shall be posted in a conspicuous place on the *premises.*~~

Revise as follows:

106.5 Posting of placard. ~~In the case of a *structure* unfit for human habitation, at the time the notice is issued, a placard~~ An *unsafe structure* that has been issued an order to vacate or prohibited from occupancy shall be posted with the following wording ~~shall be posted~~ at ~~the~~ each entrance to the *structure:* "THIS STRUCTURE IS ~~UNFIT FOR HABITATION~~ UNSAFE AND ITS USE OR OCCUPANCY HAS BEEN PROHIBITED BY THE CODE OFFICIAL." ~~In the case of an *unsafe structure,* if the notice is not complied with, a placard with the above wording shall be posted at the entrance to the *structure.*~~ After a *structure* is placarded, entering the *structure* shall be prohibited except as authorized by the *code official* to make inspections, to perform required repairs or to demolish the *structure.* In addition, the placard shall not be removed until the *structure* is determined by the *code official* to be safe to occupy, nor shall the placard be defaced.

106.6 Revocation of certificate of occupancy. If a notice of *unsafe structure* ~~or *structure* unfit for human habitation is~~ is not complied with within the time period stipulated on the notice, the *code official* shall be permitted to request the local building department to revoke the certificate of occupancy issued under the VCC.

106.7 Vacant and open structures. When an *unsafe structure* ~~or a *structure* unfit for human habitation~~ is open for public entry ~~at the time a placard~~

~~is issued under Section 106.5~~, the *code official* shall be permitted to authorize the necessary work to make such *structure* secure against public entry whether or not legal action to compel compliance has been instituted.

106.8 Emergency repairs and demolition. To the extent permitted by the locality, the *code official* may authorize emergency repairs to *unsafe* ~~*structures*~~ *structures* ~~or *structures* unfit for human habitation~~ when it is determined that there is an imminent danger of any portion of the *unsafe structure* ~~or *structure* unfit for human habitation~~ collapsing or falling and when life is endangered. Emergency repairs may also be authorized where there is a code violation resulting in the immediate serious and imminent threat to the life and safety of the *occupants.* The *code official* shall be permitted to authorize the necessary work to make the *structure* temporarily safe whether or not legal action to compel compliance has been instituted. In addition, whenever an *owner* of an *unsafe structure* ~~or *structure* unfit for human habitation~~ fails to comply with a notice to demolish issued under Section 106.3 in the time period stipulated, the *code official* shall be permitted to cause the structure to be demolished. In accordance with §§ 15.2-906 and 15.2-1115 of the Code of Virginia, the legal counsel of the locality may be requested to institute appropriate action against the property *owner* to recover the costs associated with any such emergency repairs or demolition and every such charge that remains unpaid shall constitute a lien against the property on which the emergency repairs or demolition were made and shall be enforceable in the same manner as provided in Articles 3 (§ 58.1-3940 et seq.) and 4 (§ 58.1-3965 et seq.) of Chapter 39 of Title 58.1 of the Code of Virginia.

Note: *Code officials* and local governing bodies should be aware that other statutes and court decisions may impact on matters relating to demolition, in particular whether newspaper publication is required if the *owner* cannot be located and whether the demolition order must be delayed until the *owner* has been given the opportunity for a hearing. In addition, *historic building* demolition may be prevented by authority granted to local historic review boards in accordance with § 15.2-2306 of the Code of Virginia unless determined necessary by the *code official.*

106.9 Closing of streets. When necessary for public safety, the *code official* shall be permitted to order the temporary closing of sidewalks, streets, public ways or *premises* adjacent to unsafe ~~or unfit~~ *structures* and prohibit the use of such spaces.

Reason Statement: The overall intent of this code change is to simplify the unsafe building provisions of the VMC and get rid of the two version of "unsafe", unsafe structure and structure unfit for human occupancy, and combine them into one definition and process.
Unsafe Structure and Structure Unfit for Human Occupancy definitions- The two definitions are a distinction without a difference. Both definitions are defining structures that are "determined by the code official to be dangerous to the health, safety, and welfare of the occupants of the structure or the public." That is the base definition in both definitions. They are the same. Technically, unfit for human occupancy is a subset of unsafe structure. If you declare a building unfit for human occupancy, since it is then by definition dangerous to the health, safety, and welfare of the occupants of the structure or the public, it is also by definition an unsafe structure. Where they differ is in what constitutes the quoted phrase in each definition. Why does it matter? Dangerous is dangerous. To correct this both definitions have been combined into the definition of Unsafe structure, and Structure Unfit for Human occupancy has been deleted. The new list in the unsafe structure definition is a combination of both lists from both definitions. With the deletion of the Unfit for Human Occupancy definition, the term has been deleted throughout the code sections.

The Virginia Maintenance Code has included structures unfit for human habitation (or occupancy) within the Unsafe Building (later Unsafe Structure) section as a descriptor of unsafe buildings/structures until the 2003 edition of the USBC when the title of the section was changed to Unsafe Structures or Structures unfit for Human Habitation and some minor distinctions in the section were created. Even in the current 2018 code the two are somewhat blurred together in section 106 and the terms unfit for human habitation and unfit for human occupancy are still used haphazardly and interchangeably. The difference in code application between the two definition is subtle and hard to justify, as detailed below:

"Structure Unfit for Human occupancy" verses "unsafe structures"

106.1 - No difference in code application

106.2 - No difference in code application

106.3 - No difference in code application

106.3.1 - Grants code official authority to vacate an unsafe structure if there is an immediate danger, or life is endangered, which is always the case if a building meets the definition of unsafe structure. Vacating a structure unfit for human habitation (occupancy) is addressed in section 106.5 with a very slight difference in it is based on posting the placard.

106.4 - No difference in code application

106.5 - Refers to structure unfit for human habitation, if you assume that unfit for human habitation is a synonym for unfit for human occupancy (which is defined) then the difference between unfit for human occupancy and unsafe structure is that if it is unfit you must post the placard, if it is unsafe, you post the placard if the notice is not complied with.

106.6 - No difference in code application

106.7 - No difference in code application

106.8 - No difference in code application

106.9 - No difference in code application

As detailed in the above list the only difference in code application is in 106.3.1 and 106.5. 106.3.1 grants authority to vacate and unsafe structure and 106.5 implies based on placarding an unfit structure that entering the unfit structure is prohibited. Effectively what is the difference? The difference is subtle to negligible. Clearly not enough to justify separate definitions and subtle differences in code provisions that make little sense. The other difference is the requirement to immediately placard if unfit verses placard if notice is not complied with for unsafe. Why the difference?

Lastly there has been some confusion regarding application of the USBC (VCC) section 104.1 provision in the second paragraph of the section. In VCC section 104 it states that following: upon a finding by the local building department, following a complaint by a tenant of a residential dwelling unit that is the subject of such complaint, that there may be a violation of the unsafe structures provisions of part III of the USBC, also known as the VMC, the local building department shall enforce such provisions. The confusion is that some localities have interpreted this to mean that this provision only applies to "unsafe structures" and not "structures unfit for human occupancy." The first error in this interpretation is that all unfit structures are also, by definition unsafe. Further investigation into the legislative and code development history shows that the legislative intent was to enforce all unsafe provisions on tenant occupied property, including structures unfit for human occupancy. Please see the attached documentation (Files attached to this code change in cdpVA) that chronicles the legislative actions that created this requirement and the associated code provisions that were in effect when each bill was enacted. It is clear that the legislature intended for all unsafe and unfit conditions to be addressed in what is now VCC section 104.1. When the legislation was passed to create the requirement that is now in VCC 104.1, unfit for human habitation was a descriptor of unsafe buildings (the terms at the time) in the Unsafe Buildings section of USBC Volume 2. So clearly the legislative intent was to apply the requirement to enforce unsafe and unfit building provisions for both conditions, not just unsafe buildings. The next bill that was passed, which affected the unsafe building provisions was HB2109. Originally in HB2109 the law referenced a specific section number in USBC volume two. At the time HB 2344, which addressed search warrants and inspection, was presented the section number in the code for unsafe building had changed so the bill included a cleanup of the statute to remove the USBC section number (which is subject to change) and just refer to the section title "unsafe structure". It was not until the 2003 edition of the USBC, without any additional changes to the statute, that structures unfit for human habitation was pulled into the section title and treated as a separate companion term to unsafe structure. Clearly unfit for human habitation was not broken out by the General Assembly to limit application of VCC section 104.1 as is the assumption used for the incorrect interpretation.

I asked DHCD staff for their opinion on this matter and Jeff Brown informed me that the question had previously been raised to DHCD staff and he provided me the following email regarding application of VCC 104.1 to structures unfit for human occupancy. I also asked if DHCD had a documented reason statement or any other documentation that described the intent of the code change that added unfit for human habitation to the title of the unsafe structures section in the 2003 USBC and Jeff informed me that DHCD did not have any such documentation.

---------- Forwarded message ---------

From: Brown, Jeffrey <jeff.brown@dhcd.virginia.gov>

Date: Fri, Jul 12, 2019 at 2:15 PM

Subject: Re: FW: USBC 104.1, complaints by tenants of residential dwelling units

To: REDACTED

Cc: Potts Richard ilv62300 <richard.potts@dhcd.virginia.gov>, King, Thomas <thomas.king@dhcd.virginia.gov>, Harper Roger hqb65995 <skip.harper@dhcd.virginia.gov>, Cindy Davis <cindy.davis@dhcd.virginia.gov>

Hi REDACTED,

The requirement in VCC 104.1 comes from state law. See § 36-105(C)(2) of the Code of Virginia:

2. Complaints by tenants. However, upon a finding by the local building department, following a complaint by a tenant of a residential dwelling unit that is the subject of such complaint, that there may be a violation of the unsafe structures provisions of the Building Code, the local building department shall enforce such provisions.

My first thought was that since the VMC (and the state law where the language comes from) is specific to "unsafe structures", it wouldn't apply to "unfit structures"....then I did some historical research and went back to the 1996 USBC (link below):

https://www.dhcd.virginia.gov/sites/default/files/Docx/building-codes-regulations/archive-codes/1996/1996-virginia-uniform-statewide-building-code.pdf

See Section 105.1.1 of Part I (USBC) and then see Section 129.1 of Part II (VMC). It appears that when the state law was passed, the unsafe/unfit provisions were not so separate/distinct. Also at the time the original law was passed, the law said "section 105" and not "unsafe provisions", so it would have been clear at that time that it applied to both unsafe and unfit. In 2001 (while the 1996 USBC was in effect) the language was amended to say "the unsafe provisions", but again, at that time a structure unfit for human habitation was an unsafe structure. Here is a link to the bill from

2001:

http://lis.virginia.gov/cgi-bin/legp604.exe?011+sum+HB2344

HB2344 was really related to warrants and it looks like they were just trying to clean up the reference to the unsafe section so that it wasn't tied to a specific USBC section number. I don't think the intent was to limit it any further, because again at that time, there was no clear distinction between unsafe/unfit.

Over the years, changes have been made to the VMC to make them distinct, but it appears to me that when the law was passed, it would have applied to what we now call unfit structures as well. If the requirement was only in the VMC, I would say it definitely only applies to unsafe and not unfit. Since it is a law, just because we monkeyed around with the unsafe provisions and created a separate definition and notice requirements for unfit structures, I am not sure it should make the law not apply to unfit structures now.

As a side note....In my opinion, if a BO in a locality that does not enforce the VMC, gets a complaint from a tenant of a rental dwelling unit and they allege the dwelling is unsafe, the BO has an obligation to inspect and prepare a report per section 106.2. That decision can then be appealed by the tenant if they are aggrieved.

Those are my thoughts, but I've copied some others to chime in if they have differing opinions...

Sincerely,

JEFF BROWN, MCP

Director of State Building Codes Office

Section specific change reason statements:

103.2- Removed reference to *structure unfit for human occupancy*.

105.2- Since an unsafe structure is a violation requiring notice, and this is a general section on notices, reports and orders, the unsafe structure notice is proposed to be added to the list of notices detailed in this section.

105.4 Exception #1 deletion- Exception #1 does not provide a definable exception. It does not specify what it is exempting. The proposed amendments to section 106 address the provisions addressed in this section relatable to unsafe structures so that Section 106 will stand on its own.

105.6 and 105.6.1- Since an unsafe structure is a violation and a notice of unsafe structures is equivalent to a notice of violation, the unsafe structure notice is proposed to be added to this section. This is further supported by the current reference in section 106.3 that the requirements of Section 105.2 for notices of violation are also applicable.

106 (Title)- Removed reference to *structure unfit for human occupancy*.

106.1- Removed reference to *structure unfit for human occupancy*. The terminology “razed or removed” was replaced with the term “demolished” for consistency because the term demolished is used in other sections within Section 106.

106.2- This section is proposed for deletion. Inspections are addressed in section 104.5.3. Taken literally, which is the intent of code language, this section assumes someone other that the code official can discover an unsafe/unfit structure and then based on that discovery the code official is compelled to inspect and prepare a report on the conditions, not determine if it is unsafe or unfit for occupancy. Someone other than the code official cannot determine if a structure is unsafe or unfit for human occupancy; therefore, the validity of this section is questionable.

106.3- Removed references to *structure unfit for human occupancy.* This section relies on a very interpretive reference back to 105.2 "to the extent that such reference does not conflict with this requirement." I also question if the referenced section number is complete or correct as other section of 105 should be applicable. To clean this up and make it clear the reference to 105.2 has been replaced by bringing the necessary requirements from 105 over to 106.3 that includes: the right of appeal, responsibility of the person issued the notice, the timeframe to correct, the responsibility of the code official to reinspect. Additionally, since this section addresses service, and section 106.4 also addresses service, the provisions of section 106.4 that addresses when the notice is unable to be served by personal service are proposed to be relocated in this section so that all of the service options are available in the one section.

106.3.1, 106.4- With the service provision in 106.4 proposed to be relocated to 106.3 and the fact that vacating an unsafe structure is a stand-alone provision, 106.3.1 is proposed to be renumbered 106.4. Additionally, the statement about actual and immediate danger is proposed to be removed because the other qualifier is “or when life is endangered by occupancy”. Since the definition of Unsafe structure is “dangerous to the health safety and welfare of the occupants” any declaration of unsafe structure is going to establish the structure is dangerous or endangers life. All of the phrasings of dangerous are synonymous. The phrase “prohibit occupancy” was added as that language is used on the required placard in current sections 106.3.1 and 106.5. The requirement to post the placard is proposed for deletion and the placard requirement in 106.5 will remain and be used; there is no need to have two separate slightly different placard wording requirements. Lastly, the last sentence is proposed to clearly state that an order to vacate an unsafe structure shall be included in the notice or issued in a separate notice.

106.5- Removed references to *structure unfit for human occupancy* and added the reference to unsafe structures. The section already applied to unsafe structures where the notice of unsafe structures had not been complied with (even though the placard refers to "Structure unfit for human habitation"). This proposed change removes the reference to unfit and moves the requirement to placard from 106.4 (prior 106.3.1) to this section. Basically this is a consolidation of current sections 106.3.1 and 106.5.

106.6- Removed references to *structure unfit for human occupancy*.

106.7- Removed references to *structure unfit for human occupancy*. The at the time a placard is issued qualifier to authorize securing the property against entry is proposed to be deleted because in most vacant building cases the initial securing of the building gets defeated by vandals or squatters and has to be re-installed.

106.8- Removed references to *structure unfit for human occupancy.*

106.9- Removed references to *structure unfit for human occupancy.*

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This is an editorial code change and has no impact on construction cost.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency
This is an editorial code change and has no impact on resiliency.

Attached Files

- **Usafe.Unfit code change documentation part 2.pdf**
  https://va.cdpaccess.com/proposal/1128/1531/files/download/666/
- **Usafe.Unfit code change documentation part 1.pdf**
  https://va.cdpaccess.com/proposal/1128/1531/files/download/665/

Workgroup Recommendation

2021 Workgroups Workgroup Action: Non-Consensus

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐Approved
☐Approved with Modifications
☐Carryover
☐Disapproved
☐None

Public Comments for: PM103.2-21

This proposal doesn't have any public comments.

PM103.2-21 – Staff Summary

Proponent: Ronald Clements

Brief Description:

The proposal seeks to simplify the unsafe building provisions of the VMC and get rid of the two versions of “unsafe”: unsafe structure and structure unfit for human occupancy. This proposal combines these two phrases into a single term (“Unsafe Structure”) with a single definition and a single process. Multiple sections in Chapter 1 were modified to accommodate this change, most of which are simple updates to the terminology used.

STUDY GROUP OR SUB-WORKGROUP INFORMATION

N/A

GENERAL STAKEHOLDERS WORKGROUP INFORMATION

Support:

Names: Steve Shapiro, AOBA and VAMA

- Steve Shapiro, representing AOBA and VAMA spoke in support of the proposal and stated that he does not think the two terms (“unsafe” and “unfit for human occupancy”) are needed.

Opposition:

Names: David Beahm, representing self; Christina Jackson, representing self

- David Beahm, representing himself, stated that there are some instances in which building components, such as inoperable plumbing, may render a structure unfit for human occupancy but does not make the structure an unsafe structure. He also stated that he would prefer language that says the structure is an imminent danger to safety.
- Christina Jackson, representing herself, testified that removing the phrase “unfit for human occupancy” may raise questions in different jurisdictions. The example she gave was a situation in which a placard is posted and residents are allowed to enter the premises and remove their personal items.

DHCD Staff Notes: N/A

Meeting summaries and proposal related information: Tab 10 - Page 86.

(1)

HB 2109 1995

LD5595204

Original Bill

HOUSE BILL NO. 2109

Offered January 23, 1995

A BILL to amend and reenact § 36-105 of the Code of Virginia, relating to the Uniform Statewide Building Code; enforcement.

Patrons—Mims, Almand and Miller; Senators: Calhoun and Waddell

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Referred to Committee on General Laws

Be it enacted by the General Assembly of Virginia:

1. That § 36-105 of the Code of Virginia is amended and reenacted as follows:

§ 36-105. Enforcement of Code; appeals from decisions of local department; inspection of buildings.

Enforcement of the Building Code shall be the responsibility of the local building department. There shall be established within each local building department a local board of Building Code appeals whose composition, duties and responsibilities shall be prescribed in the Building Code. Appeals from the local building department concerning application of the Building Code or refusal to grant a modification to the provisions of the Building Code covering the manner of construction or materials to be used in the erection, alteration or repair of a building or structure shall first lie to the local board of Building Code appeals. No appeal to the State Building Code Technical Review Board shall lie prior to a final determination by the local board of Building Code appeals. Whenever a county or a municipality does not have such a building department or board of Building Code appeals, the local governing body shall enter into an agreement with the local governing body of another county or municipality or with some other agency, or a state agency approved by the Department for such enforcement and appeals resulting therefrom. For the purposes of this section, towns with a population of less than 3,500 may elect to administer and enforce the Building Code; however, where the town does not elect to administer and enforce the Building Code, the county in which the town is situated shall administer and enforce the Building Code for the town. In the event such town is situated in two or more counties, those counties shall administer and enforce the Building Code for that portion of the town which is situated within their respective boundaries. Fees may be levied by the local governing body in order to defray the cost of such enforcement and appeals.

Any building or structure may be inspected at any time before completion, and shall not be deemed in compliance until approved by the inspecting authority. Where the construction cost is less than $1,000, however, the inspection may, in the discretion of the inspecting authority, be waived. The building official shall coordinate all reports of inspections for compliance with the Building Code, with inspections of fire and health officials delegated such authority, prior to issuance of an occupancy permit. The local governing body may also inspect and enforce the Building Code for existing buildings and structures, whether occupied or not, including such regulations for elevators. Such inspection and enforcement shall be carried out by an agency or department designated by the local governing body.

The local governing body, however, shall enforce the Building Code for existing buildings and structures (i) to the extent such enforcement relates to the plumbing, electrical, heating, fire prevention, and structural integrity of such buildings and structures and (ii) upon a finding by the local governing body that a serious threat to health and safety exists following a complaint by a tenant of a residential rental unit which is the subject of the complaint.

The local governing body may, upon an affirmative finding of the need to protect the public health, safety and welfare, require the issuance of certificates of compliance with current building regulations for existing residential buildings located in conservation and rehabilitation districts designated by the local governing body after inspections of such buildings upon termination of the rental tenancies or when such rental property is sold. Such certificate of compliance shall be issued in accordance with the administrative provisions of the Uniform Statewide Building Code.

INTRODUCED

HB2109

Housing Commission Generated/

This is the Bill that Created the requirement in current 2018 VCC Section 104.1 to enforce unsafe/unfit provisions of the VMC for rental units.

VIRGINIA ACTS OF ASSEMBLY -- 1995 SESSION

(2)

CHAPTER 95

An Act to amend and reenact § 36-105 of the Code of Virginia, relating to the Uniform Statewide Building Code; enforcement.

HB 2109 1995 AS Approved

[H 2109]

Approved March 7, 1995

Be it enacted by the General Assembly of Virginia:
1. That § 36-105 of the Code of Virginia is amended and reenacted as follows:

§ 36-105. Enforcement of Code; appeals from decisions of local department; inspection of buildings.

Enforcement of the Building Code shall be the responsibility of the local building department. There shall be established within each local building department a local board of Building Code appeals whose composition, duties and responsibilities shall be prescribed in the Building Code. Appeals from the local building department concerning application of the Building Code or refusal to grant a modification to the provisions of the Building Code covering the manner of construction or materials to be used in the erection, alteration or repair of a building or structure shall first lie to the local board of Building Code appeals. No appeal to the State Building Code Technical Review Board shall lie prior to a final determination by the local board of Building Code appeals. Whenever a county or a municipality does not have such a building department or board of Building Code appeals, the local governing body shall enter into an agreement with the local governing body of another county or municipality or with some other agency, or a state agency approved by the Department for such enforcement and appeals resulting therefrom. For the purposes of this section, towns with a population of less than 3,500 may elect to administer and enforce the Building Code; however, where the town does not elect to administer and enforce the Building Code, the county in which the town is situated shall administer and enforce the Building Code for the town. In the event such town is situated in two or more counties, those counties shall administer and enforce the Building Code for that portion of the town which is situated within their respective boundaries. Fees may be levied by the local governing body in order to defray the cost of such enforcement and appeals.

Any building or structure may be inspected at any time before completion, and shall not be deemed in compliance until approved by the inspecting authority. Where the construction cost is less than $1,000, however, the inspection may, in the discretion of the inspecting authority, be waived. The building official shall coordinate all reports of inspections for compliance with the Building Code, with inspections of fire and health officials delegated such authority, prior to issuance of an occupancy permit.

The local governing body may also inspect and enforce the Building Code for existing buildings and structures, whether occupied or not, including such regulations for elevators. Such inspection and enforcement shall be carried out by an agency or department designated by the local governing body. *However, upon a finding by the local building department, following a complaint by a tenant of a residential rental unit which is the subject of such complaint, that there may be a violation of § 105 of Volume II of the Building Code, the local building department shall enforce § 105 of Volume II.*

The local governing body may, upon an affirmative finding of the need to protect the public health, safety and welfare, require the issuance of certificates of compliance with current building regulations for existing residential buildings located in conservation and rehabilitation districts designated by the local governing body after inspections of such buildings upon termination of the rental tenancies or when such rental property is sold. Such certificate of compliance shall be issued in accordance with the administrative provisions of the Uniform Statewide Building Code.

Housing Commission
HB 2109 1995
Final

Code in Effect 1995
when HB2109 passed

3A

government. Records may be disposed of in accordance with the provisions of the Virginia Public Records Act (§ 42.1-76 et seq. of the Code of Virginia), (a) after one year in the case of buildings under 1,000 square feet in area and one and two family dwellings of any area, and (b) after three years in the case of all other buildings.

SECTION 104.0. VIOLATIONS.

104.1. Code violations prohibited: Buildings and equipment in violation of the provisions of this code shall not be used except as approved by the code official.

104.2. Notice of violation: The code official shall serve a notice of violation on the person responsible for maintenance or use of a building in violation of the provisions of this code. Such order shall reference the code section that serves as a basis for the violation and specify a time limit for the discontinuance or abatement of the violation. Such notice of violation shall be in writing, and be served by either delivering a copy of the notice to such person by mail to the last known post office address, delivering in person or by delivering it to and leaving it in the possession of any person in charge of the premises, or by posting the notice in a conspicuous place at the entrance door or accessway if such person cannot be found on the premises.

104.3. Prosecution of violation: If the notice of violation is not complied with, the code official shall request, in writing, the legal counsel of the jurisdiction to institute the appropriate legal proceedings to restrain, correct or abate such violation; or to require the removal or termination of the use of the building in violation of the provisions of this code.

104.4. Violation penalties: Violations of this code are a misdemeanor in accordance with § 36-106 of the Code of Virginia, and upon conviction, may be punished by a fine of not more than $2,500.

104.5. Abatement of violation: Conviction of a violation of this code shall not preclude the institution of appropriate legal action to require correction or abatement of the violation or to prevent other violations or recurring violations of this code relating to maintenance and use of the building or premises.

104.6. Suspension or revocation of certificate of occupancy: The code official may suspend or revoke the certificate of occupancy for failure to correct repeated violations in apparent disregard for the provisions of the USBC.

SECTION 105.0. UNSAFE BUILDINGS.

105.1. General: This section shall apply to buildings and their equipment that fail to comply with the Building Maintenance Code through damage, deterioration, infestation, improper maintenance, or for other reasons, and thereby become unsafe, unsanitary, or deficient in adequate exit facilities, or which constitute a hazard or public nuisance, or are otherwise dangerous to human life, health or safety, or the public welfare. All such buildings or other structures declared by the code official to be a public nuisance or unfit for human habitation shall either be: made safe through compliance with this code, or be vacated and secured against public entry, or taken down and removed as determined by the code official. A vacant building, unsecured or open at door or window, may be deemed a fire hazard and unsafe within the meaning of this section.

unfit part of unsafe

Not broken out by legislature

105.2. Inspection of unsafe buildings: The code official shall examine any building reported as unsafe, and shall prepare a report to be filed in the records of the enforcing agency. In addition to a description of unsafe conditions found, the report shall include the use of the building, and nature and extent of damages, if any, caused by a collapse or failure.

105.3. Notice of unsafe buildings: If a building is found to be unsafe, the code official shall serve a notice to the owner, the owner's agent or person in control of the unsafe building. The notice shall specify the required repairs or improvements to be made to the building, or require the unsafe building, or portion of the building to be taken down and removed within a stipulated time. Such notice shall require the person notified to declare to the designated official without delay acceptance or rejection of the terms of the notice.

Note: Whenever possible, the notice of unsafe building should also be given to the tenants of the unsafe building.

105.4. Posting of unsafe building notice: If the person named in the notice of an unsafe building cannot be found, the notice shall be sent by registered or certified mail to the last known address of such person. A copy of the notice shall be posted in a conspicuous place on the premises. Such procedure shall be deemed the equivalent of personal notice.

105.5. Disregard of notice: If the person served with a notice of unsafe building refuses or neglects to comply with requirements of the notice to abate the unsafe condition, the code official may revoke the certificate of occupancy. In the case of a vacant building, including one vacated through revocation of the certificate of occupancy, the code official may cause the building to be closed through any available means.

unfit term

105.6. Authority to vacate building: When in the opinion of the code official, there is actual and immediate danger of failure or collapse of a building or any part of a building which would endanger life; or when any building or part of a building has fallen and life is endangered by occupancy of the building; or when any other hazardous condition poses an immediate and serious threat to life; or when a building or other structure is declared a public nuisance, or unfit for human habitation, the code official may order the occupants to vacate the building. The code official shall post a notice at each entrance to such building that reads: "THIS STRUCTURE IS UNSAFE OR UNFIT FOR HABITATION AND ITS USE OR OCCUPANCY HAS BEEN PROHIBITED BY THE CODE OFFICIAL". Upon the posting of the notice, no person shall enter such a building except upon authorization of the code official for one of the following purposes: (i) to make the required repairs; (ii) to take the building down and remove it; or (iii) to make inspections.

105.7. Temporary safeguards and emergency repairs: When, in the opinion of the code official, there is immediate danger of collapse or failure of a building or any part of a building which would endanger life, or when a violation of this code results in a hazard that creates an immediate, serious and imminent threat to the life and safety of the occupants, the code official shall have the necessary work done to the extent permitted by the local government to make such building or part of the building temporarily safe, whether or not legal action to force compliance has begun.

105.8. Abatement or removal: Whenever the owner of a building or structure that has been deemed to be a public nuisance pursuant to Section 105.1 fails to comply with the requirements of the notice to abate, the code official may cause the building to be razed or removed.

Note: A local governing body may, after official action pursuant to § 15.1-29.21 or 15.1-11.2 of the Code of Virginia, maintain an action to compel a responsible party to abate, raze, or remove a public nuisance. If the public nuisance presents an imminent and immediate threat to life or property, then the governing body of the county, city or town may abate, raze, or remove such public nuisance, and a county, city or town may bring an action against the responsible party to recover the necessary costs incurred for the provision of public emergency services reasonably required to abate any such public nuisance.

SECTION 106.0. APPEALS.

106.1. Local Board of Building Code Appeals (BBCA): Each jurisdiction shall have a BBCA to hear appeals as authorized herein or it shall enter into an agreement with the governing body of another county or municipality or with some other agency, or a state agency approved by the Department of Housing and Community Development, to act on appeals. The jurisdiction may have separate BBCA's provided that each BBCA complies with this section. An appeal case decided by a separate BBCA shall constitute an appeal in accordance with this section and shall be final unless appealed to the State

Bill regarding Warrants and Inspections

2001 SESSION

HB2344 2001

(4)

INTRODUCED

015256660

HOUSE BILL NO. 2344 Original

Offered January 10, 2001

Prefiled January 10, 2001

A BILL to amend the Code of Virginia by adding sections numbered 36-105.3 through 36-105.7, relating to the Virginia Uniform Statewide Building Code; and inspection warrants.

Patrons—Almand, Albo and May

Referred to Committee on General Laws

Be it enacted by the General Assembly of Virginia:

1. That the Code of Virginia is amended by adding sections numbered 36-105.3 through 36-105.7 as follows:

§ 36-105.3. Inspections of buildings, structures, properties, and premises.

In order to carry out the purposes of the Building Code, the local building maintenance code official or the duly authorized representative of such official, upon presenting appropriate credentials to the owner, operator, or agent in charge, may enter a building or structure for the purpose of conducting an inspection or reinspection during regular working hours and at other reasonable times, and in a reasonable manner, to determine if the building, structures, equipment and materials, and all pertinent conditions therein, are in compliance with the requirements, regulations, or standards set forth in the Building Code.

§ 36-105.4. Issuance of warrant.

Search warrants for inspections or reinspection of buildings, structures, and equipment subject to inspections pursuant to the Building Code shall be based upon a demonstration of probable cause and supported by an affidavit. Such inspection warrants may be issued by any judge or magistrate having authority to issue criminal warrants whose territorial jurisdiction encompasses the building, structure, property, and equipment to be inspected or entered, if the issuing judicial officer is satisfied from the affidavit that there is probable cause for the issuance of an inspection warrant. No inspection warrant shall be issued pursuant to this section except upon probable cause, supported by an affidavit, particularly describing the place, thing or property to be inspected, and the purpose of which the inspection is to be made. Probable cause shall be deemed to exist if such an inspection appears necessary to ensure compliance with (i) the Building Code for the protection of health, safety, or public welfare, or (ii) a routine general inspection program established by a locality in which rental properties are inspected on an annual basis. The supporting affidavit shall contain either a statement that consent to inspect has been sought and refused or that facts or circumstances reasonably justify the failure to seek such consent in order to enforce effectively the Building Code that authorizes such inspection. In the case of an inspection warrant based upon state law or administrative standards for selecting buildings, structures, and equipment for inspections, the affidavit shall contain factual allegations sufficient to justify an independent determination by the judge or magistrate that the inspection program is based on reasonable standards and that the standards are being applied to a particular place in a neutral and fair manner. The issuing judge or magistrate may examine the affiant under oath or affirmation to verify the accuracy of any matter in the affidavit.

§ 36-105.5. Duration of warrant.

An inspection warrant shall be effective for the time specified therein, for a period of not more than seven days, unless extended or renewed by the judicial officer who signed and issued the original warrant. The issuing judicial officer may extend or renew the inspection warrant upon application for extension or renewal setting forth the results, which have been obtained, or a reasonable explanation of the failure to obtain such results. The extension or renewal period of the warrant shall not exceed seven days. The warrant shall be executed and returned to the issuing judicial officer within the time specified in the warrant or within the extended or renewed time. The return shall list any Building Code violations identified pursuant to the warrant. After the expiration of such time, the warrant, unless executed, shall be void.

§ 36-105.6. Conduct of inspections.

No warrant shall be executed in the absence of the owner, operator, custodian, possessor, or agent of any of the foregoing of the particular building, structure, and equipment unless specifically authorized by the issuing judicial officer upon showing that such authority is reasonably necessary to effect the purposes of a statute or regulation being enforced.

§ 36-105.7. Review by courts.

A. No court of the Commonwealth shall have jurisdiction to hear a challenge to the warrant prior to

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HB2344

its return to the issuing judge or magistrate except as a defense in a contempt proceeding, unless the owner, operator, custodian, or agent of any of the foregoing of the building, structure, and equipment to be inspected makes by affidavit a substantial preliminary showing accompanied by an offer of proof that (i) a false statement, knowingly and intentionally, or with reckless disregard for the truth, was included by the affiant in his affidavit for the inspection warrant and (ii) the false statement was necessary to the finding of probable cause. The court shall conduct such expeditious in-camera review as the court may deem appropriate.

B. After the warrant has been executed and returned to the issuing judicial officer, the validity of the warrant may be reviewed either as a defense to any citation issued by the local building maintenance code official or the duly authorized representative of such official or otherwise by declaratory judgment action brought in a circuit court. In any such action, the review shall be confined to the face of the warrant and affidavits and supporting materials presented to the issuing judge unless the owner, operator, custodian, or agent of any of the foregoing whose building, structure, and equipment has been inspected makes a substantial showing by affidavit accompanied by an offer of proof that (i) a false statement, knowingly and intentionally, or with reckless disregard for the truth, was made in support of the warrant and (ii) the false statement was necessary to the finding of probable cause. The review shall only determine whether there is substantial evidence in the record supporting the decision to issue the warrant.

(6)

VIRGINIA ACTS OF ASSEMBLY -- 2001 SESSION

CHAPTER 119

An Act to amend and reenact § 36-105 of the Code of Virginia, relating to enforcement of the Uniform Statewide Building Code; inspection warrants.

HB 2344 2001 AS Approved

[H 2344]

Approved March 13, 2001

Be it enacted by the General Assembly of Virginia:

1. That § 36-105 of the Code of Virginia is amended and reenacted as follows:

§ 36-105. Enforcement of Code; appeals from decisions of local department; inspection of buildings; inspection warrants.

Enforcement of the Building Code shall be the responsibility of the local building department. There shall be established within each local building department a local board of Building Code appeals whose composition, duties and responsibilities shall be prescribed in the Building Code. Appeals from the local building department concerning application of the Building Code or refusal to grant a modification to the provisions of the Building Code covering the manner of construction or materials to be used in the erection, alteration or repair of a building or structure shall first lie to the local board of Building Code appeals. No appeal to the State Building Code Technical Review Board shall lie prior to a final determination by the local board of Building Code appeals. Whenever a county or a municipality does not have such a building department or board of Building Code appeals, the local governing body shall enter into an agreement with the local governing body of another county or municipality or with some other agency, or a state agency approved by the Department for such enforcement and appeals resulting therefrom. For the purposes of this section, towns with a population of less than 3,500 may elect to administer and enforce the Building Code; however, where the town does not elect to administer and enforce the Building Code, the county in which the town is situated shall administer and enforce the Building Code for the town. In the event such town is situated in two or more counties, those counties shall administer and enforce the Building Code for that portion of the town which is situated within their respective boundaries. Fees may be levied by the local governing body in order to defray the cost of such enforcement and appeals.

Clean up to get rid of Section Number Reference

Any building or structure may be inspected at any time before completion, and shall not be deemed in compliance until approved by the inspecting authority. Where the construction cost is less than $2,500, however, the inspection may, in the discretion of the inspecting authority, be waived. The building official shall coordinate all reports of inspections for compliance with the Building Code, with inspections of fire and health officials delegated such authority, prior to issuance of an occupancy permit.

The local governing body may also inspect, and enforce the Building Code for, existing buildings and structures, whether occupied or not. The local governing body, however, shall inspect and enforce the Building Code for elevators except for elevators in single and two-family homes and townhouses. Such inspection and enforcement shall be carried out by an agency or department designated by the local governing body. However, upon a finding by the local building department, following a complaint by a tenant of a residential rental unit ~~which~~ *that* is the subject of such complaint, that there may be a violation of ~~§ 105 of Volume II of~~ *the unsafe structures provisions of* the Building Code, the local building department shall enforce ~~§ 105 of Volume II~~ *such provisions. If the local building department receives a complaint that a violation of the Building Code exists that is an immediate and imminent threat to the health or safety of the owner or tenant of a residential dwelling unit or a nearby residential dwelling unit, and the owner or tenant of the residential dwelling unit that is the subject of the complaint has refused to allow the local building official or his agent to have access to the subject dwelling, the local building official or his agent may present sworn testimony to a court of competent jurisdiction and request that the court grant the local building official or his agent an inspection warrant to enable the building official or his agent to enter the subject dwelling for the purpose of determining whether violations of the Building Code exist. The local building official or his agent shall make a reasonable effort to obtain consent from the owner or tenant of the subject dwelling prior to seeking the issuance of an inspection warrant under this section.*

The local governing body may, upon an affirmative finding of the need to protect the public health, safety and welfare, require the issuance of certificates of compliance with current building regulations for existing residential buildings located in conservation and rehabilitation districts designated by the local governing body, or in other areas designated as blighted pursuant to § 36-49.1:1, after inspections of such buildings upon termination of the rental tenancies or when such rental property is sold. Such certificate of compliance shall be issued in accordance with the administrative provisions of the ~~Uniform Statewide~~ Building Code.

HB 2344 2001

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from application of Part II of this chapter of the USBC.

Exceptions: Industrialized buildings and manufactured homes.

Section 125.0 Use of model codes and standards.

125.1. Adoption: The following document is adopted and incorporated by reference to be an enforceable part of the USBC:

The BOCA National Property Maintenance Code/1996, Fifth Edition, hereinafter referred to as "BNPMC," published by Building Officials and Code Administrators International, Inc., 4051 W. Flossmoor Rd., Country Club Hills, IL 60478-5795, toll free number 1-800-323-1103.

125.1.1. Deletion: Delete BNPMC Chapter 1.

125.2. Administrative and enforcement amendments: All requirements of the BNPMC and the standards referenced therein that relate to fees, permits, unsafe notices, disputes, condemnation, scope of enforcement and inspections, and all other procedural, and administrative matters are deleted and replaced by the provisions of Chapter 1 (Parts I and III) of the USBC. The provisions of this part of this chapter shall be used by enforcement personnel. The purpose of this provision is to eliminate overlap, conflict and duplication by providing a single standard for administration, procedural and enforcement of this part of the USBC.

Note: The BNPMC and its referenced standards contain some areas of regulation outside of the scope of the USBC, as established by the BHCD and under state law. Where conflicts have been readily noted, changes have been made to the BNPMC its referenced standards to bring it within the scope of authority; however, in some areas, judgments will have to be made as to whether the provisions of the BNPMC and its referenced standards are applicable.

125.3. Other amendments: The USBC amendments (Part IV of this code) noted in BNBC, Chapter 34, Existing Structures, shall be made to the BNPMC and its referenced standards for use as part of this part. The USBC contains provisions adopted by the BHCD, some of which change or amend provisions of the BNPMC and its referenced standards. Where conflicts occur between such changed provisions and the unchanged provisions of the BNPMC and its referenced standards, the provisions changed by the BHCD shall govern.

Section 126.0 Enforcement.

126.1. General: Following official action by the locality, enforcement of the provisions of the USBC governing maintenance is the responsibility of the local enforcing agency.

126.2. Interagency coordination: When enforcement of any portion of this part of this chapter is assigned to an agency other than the local building department, that local enforcing agency shall coordinate its reports of inspection with the local building department.

126.3. Permits: Alterations, repairs, installations, construction or demolition shall be subject to the building permit, certificate of occupancy and other provisions of Part II of this chapter of the USBC.

126.4. Fees: Section 36-105 of the Code of Virginia provides that fees are permitted to be levied by the locality in order to defray the cost of enforcement and appeals.

Section 127.0 Local enforcing agency.

127.1. Code official: Each local enforcing agency shall have an executive official in charge, hereinafter referred to as the "building maintenance code official" or "code official."

127.1.1. Appointment: The building maintenance code official shall be appointed in a manner selected by the locality. After

Code in effect when Passed

 HB 2344 (8)

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structures and equipment to enforce this part of this chapter as authorized by § 36-105 of the Code of Virginia. The building maintenance code official and assistants shall carry proper credentials of office when inspecting structures and equipment in the performance of duties under the USBC.

128.1.2.1. Records: The code official shall approve the maintenance or use in writing or give written notice of defective maintenance or use to the owner and the person responsible for maintenance or use of a structure. Such defects shall be corrected within a reasonable time and reinspected. Records of all reports of inspections, tests, examinations, discrepancies, notices, approvals, modifications and orders issued shall be communicated promptly in writing to the owner and the person responsible for maintenance or use of a structure.

128.2. Modifications: The code official may grant modification to any provision of this part upon application by the owner or the owner's agent provided the spirit and intent of the USBC are observed and public health, welfare, and safety are assured.

128.2.1. Supporting data: The code official may also require and consider a statement from an architect, professional engineer or other competent person as to the equivalency of the proposed modification.

128.2.2. Records: The application for modification and the final decision of the code official shall be in writing and shall be recorded in the permanent records of the local enforcing agency.

128.3. Delegation of duties and powers: The code official may delegate duties and powers subject to any limitations imposed by the locality, but shall be responsible that any such powers and duties are carried out in accordance with the USBC.

128.4. Enforcing agency records: The code official shall keep records of; reports of inspections, tests, examinations, discrepancies, notices, approvals, fees collected, modifications and orders issued and such other matters as directed by the locality. Such records shall be retained in the official records or shall be disposed of in accordance with General Schedule Number Six available from the Library of Virginia.

128.5. Coordination with other agencies. The building maintenance code official shall cooperate with fire, health and other state and local agencies having related maintenance, inspection or functional design responsibilities, and shall coordinate required inspections. The building maintenance code official shall coordinate all reports of inspections for compliance with Part III of the USBC, with inspections of fire and health officials delegated such authority.

Section 129.0 Unsafe structures.

129.1. General: This section shall apply to existing structures and equipment that fail to comply with this part of the USBC through damage, deterioration, infestation, improper maintenance, or for other reasons, and thereby become unsafe, unsanitary, or deficient in adequate exit facilities, or which constitute a hazard or public nuisance, or are otherwise dangerous to human life, health or safety, or the public welfare. All such structures declared by the code official to be a public nuisance or unfit for human habitation shall either: **(i)** be made safe through compliance with this code, or **(ii)** be vacated and secured against public entry, or **(iii)** be taken down and removed as determined by the building maintenance code official. All work shall comply with the requirements of Part II of this chapter of the USBC. A vacant structure, unsecured or open, shall be deemed a fire hazard and unsafe within the meaning of this section.

129.1.1. Unsafe conditions not related to maintenance: When the code official finds a condition that constitutes a serious and dangerous hazard to life or health in an existing structure which was constructed, altered, converted, or repaired before the effective date of the initial edition of the USBC, and when such condition was not caused by faulty maintenance, or by failure to comply with the applicable state and local regulations that were in effect at the time, the building maintenance code official is permitted to order the minimum changes needed to remedy the hazardous condition. All work shall comply with the requirements of Part II of this chapter of the USBC.

129.1.2. Retrofitting: This part of the USBC does not generally provide for retrofitting of an existing structure. However, conditions may exist in older structures, because of faulty design or equipment, which constitute such serious and dangerous hazards that correction is necessary to protect life and health. It is not the intent of this section that such changes comply fully with the requirements of the current edition of the USBC (Part II). Only those changes that are needed to remedy the serious and dangerous hazards to life or health may be required by the building maintenance code official.

129.2. Inspection of unsafe structures: The code official shall examine any existing structure reported as unsafe, and shall prepare a report to be filed in the records of the local enforcing agency and a copy issued to the owner. The report shall include the use of the structure, a description of unsafe conditions found and the nature and extent of the conditions.

129.3. Notice of unsafe structures: If an existing structure is found to be unsafe, the code official shall issued a notice to the owner, the owner's agent or person in control of the unsafe existing structure. The notice shall specify the required repairs or improvements to be made to the structure, or require the unsafe structure, or portion of the structure to be taken down and removed within a stipulated time. All work shall comply with the requirements of Part II of this chapter of the USBC. Such notice shall require the person thus notified to declare immediately upon receipt to the code official acceptance or rejection of the terms of the notice.

Note: Whenever possible, the notice of unsafe structure should also be given to the tenants of the unsafe structure.

129.4. Posting of unsafe structure notice: If the person named in the notice of unsafe structure and the owner cannot be found, the notice shall be sent by registered or certified mail to the last known address of such persons. A copy of the notice shall be posted in a conspicuous place on the premises. Such procedure shall be deemed the equivalent of personal notice.

129.5. Disregard of notice: If the person issued a notice of unsafe structure or the owner refuses or fails to comply with requirements of the notice to abate the unsafe condition, the code official may revoke the certificate of occupancy. In the case of a vacant structure, including one vacated through revocation of the certificate of occupancy, the code official may cause the structure to be closed through any available means, according to authority granted by the locality.

129.6. Authority to vacate structure: When in the opinion of the code official, there is actual and immediate danger of failure or collapse of an existing structure or any part thereof which would endanger life; or when any structure or part thereof has fallen and life is endangered by occupancy of the structure; or when any other hazardous condition poses an immediate and serious threat to life; or when a structure is declared a public nuisance, or unfit for human habitation, the code official may order the occupants to vacate the structure. The code official shall post a notice at each entrance to such structure that reads: "THIS STRUCTURE IS UNSAFE OR UNFIT FOR HABITATION AND ITS USE OR OCCUPANCY HAS BEEN PROHIBITED BY THE CODE OFFICIAL." Upon the posting of the notice, no person shall enter such structure except upon authorization by the code official for one of the following purposes: **(i)** to make the required repairs, **(ii)** to take the

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inspections, tests, examinations, discrepancies, notices, approvals, fees collected, modifications and orders issued and such other matters as directed by the locality. Such records shall be retained in the official records or shall be disposed of in accordance with General Schedule Number Six available from the Library of Virginia.

129.8. Coordination with other agencies. The building maintenance official shall cooperate with fire, health and other state and local agencies having related maintenance, inspection or functional design responsibilities, and shall coordinate required inspections. The building maintenance official shall coordinate all reports of inspections for compliance with Parts I and III of the USBC, with inspections of fire and health officials delegated such authority.

SECTION 130.0. UNSAFE STRUCTURES.

130.1. General. This section shall apply to existing unsafe structures, unsafe equipment and structures unfit for human occupancy. All such structures shall either be made safe through compliance with this code or be vacated and secured against public entry, unless the building maintenance official determines that the potential for collapse requires that the unsafe structure be razed or removed in accordance with Section 130.6.4. All work shall comply with the requirements of USBC Parts I and II.

130.2. Unsafe conditions not related to maintenance. When the building maintenance official finds a condition that constitutes a serious and dangerous hazard to life or health in an existing structure which was constructed, altered, converted, or repaired before the effective date of the initial edition of the USBC, and when such condition was not caused by faulty maintenance, or by failure to comply with the applicable state and local regulations that were in effect at the time, the building maintenance official is permitted to order the minimum changes needed to remedy the hazardous condition.

130.2.1. Retrofitting. Parts I and III of the USBC do not generally provide for retrofitting of an existing structure. However, conditions may exist in older structures, because of faulty design or equipment, which constitute such serious and dangerous hazards that correction is necessary to protect life and health. It is not the intent of this section that such changes comply fully with the requirements of Parts I and II of the current edition of the USBC. Only those changes that are needed to remedy the serious and dangerous hazards to life or health may be required by the building maintenance official.

130.3. Notice of unsafe structure. If an existing structure is found to be unsafe, the building maintenance official shall issue a notice of unsafe structure to the owner, the owner's agent or person in control of the unsafe existing structure. The notice shall specify the required repairs or improvements to be made to the structure, or require the unsafe structure, or portion of the structure to be taken down and removed within a stipulated time. The notice shall be in the form prescribed in Section 105 and delivered in accordance with section 105.2.1, except the provisions of parts (i) & (ii) of section 105.2 shall not apply. Such notice shall require the person thus notified to declare immediately upon receipt, to the building maintenance official, acceptance or rejection of the terms of the notice.

Note: Whenever possible, the notice of unsafe structure should also be given to the tenants of the unsafe structure.

130.3.1. Posting of notice. If the person named in the notice of unsafe structure and the owner cannot be found, the notice shall be sent by registered or certified mail to the last known address of such persons. A copy of the notice shall be posted in a conspicuous place on the premises. Such procedure shall be deemed the equivalent of personal notice.

130.3.2. Placarding. Upon failure of the person issued the notice of unsafe structure to comply with the notice provisions within the time given, the building maintenance official shall post a placard at each entrance to such structure that reads: "THIS STRUCTURE IS UNSAFE OR UNFIT FOR HABITATION AND ITS USE OR OCCUPANCY HAS BEEN PROHIBITED BY THE BUILDING MAINTENANCE OFFICIAL."

130.3.3. Prohibited occupancy. Upon the posting of the placard, no person shall enter such structure except upon authorization by the building maintenance official for one of the following purposes: (i) to make the required repairs, (ii) to take the structure down and remove it, or (iii) to make inspections.

130.3.4. Removal of placard. The building maintenance official shall remove the placard whenever the defect or defects upon which the notice of unsafe structure were based have been eliminated. No person shall deface or remove a placard without the approval of the building maintenance official.

130.3.5. Disregard of notice. If the person issued a notice of unsafe structure or the owner refuses or fails to comply with requirements of the notice to abate the unsafe condition, the building maintenance official may revoke the certificate of occupancy.

130.4. Vacant open structures. If a structure is vacant, open and unfit for human habitation, and is not in danger of structural collapse, the building maintenance official shall post a placard at each entrance to such structure that reads: "THIS STRUCTURE IS UNSAFE OR UNFIT FOR HABITATION AND ITS USE OR OCCUPANCY HAS BEEN PROHIBITED BY THE BUILDING MAINTENANCE OFFICIAL." The building maintenance official shall issue a report of inspection in accordance with Section 115.9. Upon the failure of the owner to comply with the report of inspection the building maintenance official shall issue a notice of violation in accordance with Section 105. Upon the failure of the owner to comply with the notice of violation the building maintenance official shall have the necessary work done to the extent permitted by the locality to make such structure secure against public entry, whether or not legal action to compel compliance has been instituted.

130.5. Authority to vacate structure. When in the opinion of the building maintenance official, there is actual and immediate danger of failure or collapse of an existing structure or any part thereof which would endanger life; or when any structure or part thereof has fallen and life is endangered by occupancy of the structure; or when any other hazardous condition poses an immediate and serious threat to life; or when a structure is declared an unsafe structure, or unfit for human habitation, the building maintenance official shall order the occupants to vacate the structure and shall post a placard at each entrance to such structure that reads: "THIS STRUCTURE IS UNSAFE OR UNFIT FOR HABITATION AND ITS USE OR OCCUPANCY HAS BEEN PROHIBITED BY THE BUILDING MAINTENANCE OFFICIAL." and shall issue a notice of unsafe structure in accordance with section 130.3.

130.6. Temporary safeguards and emergency repairs. When, in the opinion of the building maintenance official, there is immediate danger of collapse or failure of an existing structure or any part thereof which would endanger life, or when a violation of Part I (13 VAC 5-62-10 et seq.) or III (13 VAC 5-62-420 et seq.) of the USBC results in a hazard that creates an immediate, serious and imminent threat to the life and safety of the occupants, the building maintenance official shall have the necessary work done to the extent permitted by the locality to make such structure or part thereof temporarily safe, whether or not legal action to compel compliance has been instituted. All work shall comply with the requirements of USBC Parts I 13 VAC 5-62-10 et seq. and II (13 VAC 5-62-70 et seq.).

130.6.1. Closing streets. When necessary for the public safety, the building maintenance official shall temporarily close structures and close, or order the authority having jurisdiction to close, sidewalks, streets, public ways and places adjacent to unsafe structures, and prohibit the same from being utilized.

130.6.2. Emergency repairs. For the purposes of this section, the building maintenance official shall, to the extent permitted by the locality, employ the necessary labor and materials to perform the required work as expeditiously as possible.

130.6.3. Costs of emergency repairs. The legal counsel of the locality may institute appropriate action against the owner to recover the necessary costs incurred in the performance of emergency work reasonably required to abate any such immediate danger.

130.6.4. Public removal. Whenever the owner of a structure fails to comply with the requirements of the notice of unsafe structure, the building maintenance official may cause the structure to be razed or removed, according to authority granted by the locality. If the unsafe structure presents an imminent and immediate threat to life or property, then the locality may abate, raze, or remove such unsafe structure, and bring an action against the responsible party to recover the necessary costs incurred for the provision of public emergency services reasonably required to abate any such unsafe structure, according to authority granted to the locality.

Note: A locality may, after official action under §§ 15.2-900, 15.2-906 or 15.2-1115 of the Code of Virginia, maintain an action to compel a responsible party to abate, raze, or remove a public nuisance.

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SECTION 131.0. IPMC AMENDMENTS.

The following changes shall be made to the model codes and standards as indicated in this article for use as part of the USBC.

1. IPMC Chapter 1 was deleted in USBC, Chapter 1, Part III, Article 1.

2. Replace term "code official" with "building maintenance official" in the entire IPMC.

3. IPMC Section 202.0. General definitions.

   Add the following definitions to read:

   Unsafe structure: An existing structure that is judged to be dangerous to the health, safety and welfare of the occupants of the structure or the public, or an existing structure that contains unsafe equipment or is so damaged, decayed, dilapidated, structurally unsafe, or of such faulty construction or unstable foundation, that partial or complete collapse is likely. A vacant existing structure, unsecured or open, shall be deemed a fire hazard and unsafe.

   Unsafe equipment: Unsafe equipment includes any boiler, heating equipment, elevator, moving stairway, electrical wiring or device, flammable liquid containers or other equipment which is in such disrepair or condition that such equipment is judged to be dangerous to the health, safety and welfare of the occupants of structures or the public.

   Structure unfit for human occupancy: An existing structure that is judged to be dangerous to the health, safety and welfare of the occupants of the structure or the public because of the degree to which the structure is in disrepair or lacks maintenance, or lacks ventilation, illumination, sanitary or heating facilities or other essential equipment, or if the required plumbing and sanitary facilities are inoperable.

4. Delete IPMC subsections 302.1, 302.4, 302.8, 302.9, and 306.

5. Change IPMC subsection 302.2 to read:

   302.2. Grading and drainage. All premises shall be graded and maintained to protect the foundation walls or slab of the structure from the accumulation and drainage of surface or stagnant water in accordance with the USBC.

6. Change IPMC subsection 302.3 to read:

   302.3. Sidewalks and driveways. All sidewalks, walkways, stairs, driveways, parking spaces and similar spaces, regulated under the USBC, shall be kept in a proper state of repair, and maintained free from hazardous conditions. Stairs shall comply with the requirements of Sections 304 and 702.

7. Change IPMC subsection 302.5 to read:

   302.5. Rodent harborage. All structures and adjacent premises shall be kept free from rodent harborage and infestation where such harborage or infestation adversely affects the structures.

8. In IPMC subsection 303.14, Insect screens, add the date "April 1" to the first bracketed DATE area and "December 1" to the second bracketed DATE area.

9. Add IPMC subsection 304.7 to read:

   304.7. Lead-based paint. Interior and exterior painted surfaces of dwellings and child care facilities, including fences and outbuildings, which contain lead levels equal to or greater than 1.0 milligram per square centimeter or in excess of 0.50 percent lead by weight shall be maintained in a condition free from peeling, chipping and flaking paint or removed or covered in an approved manner. Any surface to be covered shall first be identified by approved warning as to the lead content of such surface.

10. Change IPMC subsection 305.1 to read:

    305.1. Accumulation of rubbish or garbage. The interior of every structure shall be free from excessive accumulation of rubbish or garbage.

11. Delete IPMC subsections 305.2, 305.2.1, 305.3, 305.3.1 and 305.3.2.

12. Add IPMC subsections 505.5, 505.5.1 and 505.5.2 to read:

    505.5. Inspection and testing of backflow prevention assemblies. Inspection and testing shall comply with Sections 505.5.1 and 505.5.2.

    505.5.1. Inspections. Inspections shall be made of all backflow prevention assemblies and air gaps to determine whether they are operable.

NO legislation Submitted

12

Unfit for Human Habitation added to title

to restrain, correct or abate the violation or to require the removal or termination of the use of the building or structure involved. In cases where the locality so authorizes, the code official may issue or obtain a summons or warrant.

104.5.7 Penalties and abatement. Penalties for violations of this code shall be as set out in Section 36-106 of the Code of Virginia. The successful prosecution of a violation of the code shall not preclude the institution of appropriate legal action to require correction or abatement of a violation.

SECTION 105 UNSAFE STRUCTURES OR STRUCTURES UNFIT FOR HUMAN HABITATION

105.1 General. This section shall apply to existing buildings or structures which are classified as unsafe or unfit for human occupancy. All such structures shall be made safe through compliance with this code or shall be vacated and secured against public entry; however, such vacant and secured structures shall still be subject to other applicable requirements of this code. Notwithstanding the above, when the code official determines that an unsafe structure or a structure unfit for human occupancy constitutes such a hazard that it should be razed or removed, then the code official shall be permitted to order the demolition of such structures in accordance with applicable requirements of this code.

Note: Buildings or structures which become unsafe during construction are regulated under the Virginia Construction Code.

105.2 Inspection of unsafe or unfit structures. The code official shall inspect any structure reported as unsafe or unfit for human habitation and shall prepare a report to be filed in the records of the local enforcing agency and a copy issued to the owner. The report shall include the use of the structure and a description of the nature and extent of any conditions found.

105.3 Unsafe conditions not related to maintenance. When the code official finds a condition that constitutes a serious and dangerous hazard to life or health in a building or structure constructed prior to the initial edition of the USBC and when that condition is of a cause other than improper maintenance or failure to comply with state or local building codes which were in effect when the building or structure was constructed, then the code official shall be permitted to order those minimum changes to the design or construction of the building or structure to remedy the condition.

105.3.1 Limitation to requirements for retrofitting. In accordance with Section 103.2, this code does not generally provide for requiring the retrofitting of any building or structure. However, conditions may exist in buildings or structures constructed prior to the initial edition of the USBC because of faulty design or equipment that constitute a danger to life or health or a serious hazard. Any changes to the design or construction required by the code official under this section shall be only to remedy the serious hazard or danger to life or health and such changes shall not be required to fully comply with the requirements of the Virginia Construction Code applicable to newly constructed buildings or structures.

105.4 Notice of unsafe structure or structure unfit for human occupancy. When a building or structure is determined to be unsafe or unfit for human occupancy by the code official, a written notice of unsafe structure or structure unfit for human occupancy shall be issued in person to the owner, the owner's agent or the person in control of such structure. The notice shall specify the corrections necessary to comply with this code, or if the structure is required to be demolished, the notice shall specify the time period within which the demolition must occur. Requirements in Section 104.5.4 for notices of violation are also applicable to notices issued under this section to the extent that any such requirements are not in conflict with the requirements of this section. In addition, the notice shall contain a statement requiring the person receiving to notice to either accept or reject the terms of the notice.

Note: Whenever possible, the notice should also be given to any tenants of the affected building.

105.5 Posting of notice. If the notice is unable to be issued in person as required by Section 105.4, then the notice shall be sent by registered or certified mail to the last known address of the responsible party and a copy of the notice shall be posted in a conspicuous place on the premises.

105.6 Posting of placard. In the case of a structure unfit for human habitation, at the time the notice is issued, a placard with the following wording shall be posted at the entrance to the building: "THIS STRUCTURE IS UNFIT FOR HABITATION AND ITS USE OR OCCUPANCY HAS BEEN PROHIBITED BY THE CODE OFFICIAL." In the case of an unsafe structure, if the notice is not complied with, a placard with the above wording shall be posted at the entrance to the building. After a building is placarded, entering the building shall be prohibited except as authorized by the code official to make inspections, to perform required repairs or to

DEPARTMENT OF HOUSING AND COMMUNITY DEVELOPMENT

Base Document for the 2021 Virginia Industrialized Building Safety Regulations

09/30/2021

Summary – This document is compiled by staff of the State Building Codes Office (SBCO) of the Division of Building and Fire Regulation. Its purpose is to make those changes necessary to the 2018 IBSR to utilize the 2021 editions of the International Codes and to review the existing IBSR for any changes necessary to comport with state law. Other substantive changes to the IBSR by interest groups or by SBCO staff are handled through proposals submitted through the department's electronic code change system (cdpVA). Once the base document is approved by the Board of Housing and Community Development, any code change proposals which are approved by the Board of Housing and Community Development prior to the development of proposed regulations will be combined with the base document and brought back to the Board of Housing and Community Development as a separate "proposed regulations" document for review.

13VAC5-91-10. Definitions.

The following words and terms when used in this chapter shall have the following meanings unless the context clearly indicates otherwise.

"Administrator" means the Director of DHCD or his designee.

"Approved" as applied to a material, device, method of construction, registered building, or as otherwise used in this chapter means approved by the administrator.

"Building official" means the officer or other designated authority charged with the administration and enforcement of the USBC, or duly authorized representative.

"Closed panel construction" means a method of construction utilizing individual wall, roof, or floor components (panels) manufactured off site for installation or assembly at the construction site, where a portion of the component cannot be inspected at the building site without disassembly or damage to the component.

"Compliance assurance agency" means an architect or professional engineer registered in Virginia, or an organization, determined by DHCD to be specially qualified by reason of facilities, personnel, experience, and demonstrated reliability, to investigate, test and evaluate industrialized buildings; to list such buildings complying with standards at least equal to this chapter; to provide adequate follow-up services at the point of manufacture to ensure that production units are in full compliance; and to provide a label as evidence of compliance.

"DHCD" means the Virginia Department of Housing and Community Development.

"ICC" means the International Code Council, Inc.

"Industrialized building" means a combination of one or more closed panels, sections or modules, subject to state regulations and including the necessary electrical, plumbing, heating, ventilating, and other service systems, manufactured off-site and transported to the point of use for installation or erection, with or without other specified components, to comprise a finished building. Manufactured homes defined in § 36-85.3 of the Code of Virginia and certified under the provisions of the National Manufactured Housing Construction and Safety Standards Act (42 USC § 5401 et seq.) shall not be considered industrialized buildings for the purpose of this law.

"Label," "certification label," or "compliance assurance agency certification label" means the label required by 13VAC5-91-210.

"Model" means a specific design of an industrialized building designated by the producer of the building including production buildings with variations and options that do not affect compliance with the standards governing structural, plumbing, mechanical, or electrical systems or any other items governed by this chapter.

"Registered" means an industrialized building which displays a registration seal issued by DHCD in accordance with this chapter.

"Seal," "registration seal," or "Virginia registration seal" means the seal required by 13VAC5-91-260."SBCO" means the State Building Codes Office within DHCD.

"State Review Board" means the Virginia State Building Code Technical Review Board as established by § 36-108 of the Code of Virginia.

"This law" means the Virginia Industrialized Building Safety Law as embraced in Chapter 4 (§ 36-70 et seq.) of Title 36 of the Code of Virginia."USBC" means the Virginia Uniform Statewide Building Code (13VAC5-63).

13VAC5-91-20. Application and compliance.

A. In accordance with § 36-81 of the Code of Virginia, registered industrialized buildings shall be acceptable in all localities as meeting the requirements of the Industrialized Building Safety Law (Chapter 4 (§ 36-70 et seq.) of Title 36 of the Code of Virginia), which shall supersede the building codes and regulations of the counties, municipalities and state agencies. Local requirements affecting industrialized buildings, including zoning, utility connections, preparation of the site and maintenance of the unit shall remain in full force and effect. All building officials are authorized to and shall enforce the provisions of the Industrialized Building Safety Law (Chapter 4 (§ 36-70 et seq.) of Title 36 of the Code of Virginia) and this chapter.

B. In accordance with § 36-78 of the Code of Virginia, no person, firm or corporation shall offer for sale or rental, or sell or rent, any industrialized building subject to any provisions of this chapter unless it conforms with the applicable provisions of this chapter.

Further, any industrialized building constructed before January 1, 1972, shall remain subject to the ordinances, laws or regulations in effect at the time such industrialized building was constructed. Additionally, as a requirement of this chapter, any industrialized building bearing the label of a compliance assurance agency shall remain subject to the provisions of this chapter that were effective when such building was constructed, regardless of whether the building has been relocated.

C. In accordance with § 36-99 of the Code of Virginia and in accordance with the USBC, the installation or erection of industrialized buildings and alterations, additions, or repairs to industrialized buildings are regulated by the USBC and not this chapter. The USBC provides for administrative requirements for permits, inspections, and certificates of occupancy for such work.

D. The use of off-site manufactured intermodal freight containers, moving containers, or storage containers as building modules or components of an industrialized building must be approved by the administrator in accordance with 13VAC5-91-150.

In reviewing the use of intermodal freight containers as structural building components, the administrator will accept evaluation reports from accredited third-party evaluation services.

E. Off-site manufactured intermodal freight containers, moving containers, and storage containers placed on site temporarily or permanently for use as a storage container are not subject to this chapter.

13VAC5-91-30. Purpose.

The purpose of this chapter is to ensure safety to life, health, and property through compliance with uniform statewide construction standards for industrialized buildings.

13VAC5-91-40. Inspection and enforcement by administrator.

A. The SBCO is designated as the administrator's representative for the enforcement of this chapter and shall act as the building official for registered industrialized buildings. It shall have authority to make inspections during reasonable hours at the manufacturing facilities and at building sites where industrialized buildings are being installed. The SBCO shall have authority to issue inspection reports for correction of violations caused by the manufacturer and to take such other actions as are required to enforce this chapter.

B. The SBCO will maintain a list of approved compliance assurance agencies. Each manufacturer producing registered industrialized buildings will contract with one or more compliance assurance agencies for required evaluation, monitoring and inspection services. The contract will delineate the services to be provided by the compliance assurance agency. The compliance assurance agency will notify the SBCO within 30 days of signing a new contract or terminating an existing contract with any manufacturer.

13VAC5-91-50. Right of entry and examination by administrator.

In accordance with § 36-82 of the Code of Virginia, the administrator shall have the right, at all reasonable hours, to enter into any industrialized building upon permission of any person who has authority or shares the use, access, or control over the building, or upon request from local officials having jurisdiction, for examination as to compliance with this chapter.

13VAC5-91-60. Notice of violation from administrator.

In accordance with § 36-82 of the Code of Virginia, whenever the administrator shall find any violation of this chapter, he shall order the person responsible therefor to bring the building into compliance within a reasonable time, to be fixed in the order. In addition, as a requirement of this chapter, the administrator may request assistance from the building official for enforcement of this section. Any order issued by the administrator pursuant to this section shall contain a statement explaining the right of appeal of the order.

13VAC5-91-70. Appeals.

Any person aggrieved by DHCD's application of this chapter shall be heard by the State Review Board established by § 36-108 of the Code of Virginia. Such appeal shall be submitted within 21 calendar days of receipt of DHCD's decision. A copy of the decision of DHCD to be appealed shall be submitted with the application for appeal. Failure to submit an application for appeal within the time limit established by this section shall constitute acceptance of DHCD's decision.

13VAC5-91-80. Limitation of manufacturer's liability.

The manufacturer of a registered industrialized building shall not be required to remedy violations caused by on-site work by others not under his control or violations involving components and materials furnished by others and not included with the registered industrialized building.

13VAC5-91-90. Penalty for violation.

In accordance with § 36-83 of the Code of Virginia, any person, firm or corporation violating any provisions of this chapter shall be considered guilty of a Class 1 misdemeanor and, upon conviction, shall be fined not more than $1,000.

13VAC5-91-100. Duties and responsibilities of building officials in the installation or erection of a registered industrialized building.

A. All building officials are authorized by § 36-81 of the Code of Virginia to enforce the provisions of this chapter and shall be responsible for and authorized to do the following:

1. Verify through inspection that the registered industrialized building displays the required state registration seal and the proper label of the compliance assurance agency.

2. Verify through inspection that the registered industrialized building has not been damaged in transit to a degree that would render it unsafe. If the building has been damaged, then the building official is authorized to require tests for tightness of plumbing systems and gas piping and an operational test to ensure that all luminaries and receptacles are operable.

3. If warranted due to the nature of any violations discovered, the building official shall be permitted to require the correction of any violations of this chapter before occupancy of the registered industrialized building is permitted.

4. Notify the SBCO of any apparent violations of this chapter.

B. In accordance with § 36-99 of the Code of Virginia and the USBC, all site work associated with the installation or erection of an industrialized building is subject to the USBC. In addition, under the USBC, all administrative requirements for permits, inspections, and certificates of occupancy are also applicable.

13VAC5-91-115. Change of occupancy classification.

When the occupancy classification of a registered industrialized building is proposed to be changed, a compliance assurance agency shall inspect the building, including any disassembly necessary, to determine whether compliance may be achieved for a change of occupancy classification in accordance with this chapter. If factory plans are available, then disassembly is not required to the extent that the factory plans can be reasonably verified to reflect the actual construction. Once any necessary work is completed, the compliance assurance agency shall prepare a report documenting the method utilized for the change of occupancy and any alterations to the building to achieve compliance. When the report is complete, the compliance assurance agency shall (i) mark the building with a new compliance assurance agency label in accordance with 13VAC5-91-210, which replaces the existing label; (ii) place a new manufacturer's data plate on the building in accordance with 13VAC5-91-245, which replaces the existing manufacturer's data plate and reflects the new occupancy classification; and (iii) forward a copy of the report and new data plate to the SBCO.

13VAC5-91-120. Unregistered industrialized buildings.

The building official shall determine whether any unregistered industrialized building complies with this chapter and shall require any noncomplying unregistered building to be brought into compliance with this chapter. The building official shall enforce all applicable requirements of this chapter including those relating to the sale, rental and disposition of noncomplying buildings. The building official may require submission of full plans and specifications for each building. Concealed parts of the building may be exposed to the extent necessary to permit inspection to determine compliance with the applicable requirements. The building official may also accept reports of inspections and tests from individuals or agencies deemed acceptable to the building official.

13VAC5-91-125. Registration of unregistered industrialized buildings.

An existing unregistered industrialized building may be registered in accordance with one of the following:

1. Where an unregistered building was constructed under an industrialized building program of another state and approved under such program, a compliance assurance agency shall prepare a report based on review of the plans and specifications and inspection of the building to determine whether there is compliance with the construction requirements of this chapter that were in effect on the date of manufacture of the building. If compliance is determined, the compliance assurance agency shall (i) mark the building with a compliance assurance agency label in accordance with 13VAC5-91-210, (ii) place a new manufacturer's data plate on the building in accordance with 13VAC5-91-245, (iii) mark the building with a registration seal in accordance with 13VAC5-91-260, and (iv) forward a copy of the report and new data plate to the SBCO.

2. Where an unregistered building was not approved under an industrialized building program of another state and the date of manufacture can be verified, the compliance assurance agency shall inspect the building, including any disassembly necessary, to determine whether there is compliance with the construction requirements of this chapter that were in effect on the date of manufacture of the building. When factory plans are available, disassembly is not required to the extent that the factory plans can be verified to reflect the actual construction of the building. When compliance with the construction requirements of this chapter that were in effect on the date of manufacture of the building is achieved, the compliance assurance agency shall prepare a report documenting compliance, outlining any changes made to the building, and certifying the building in accordance with clauses (i) through (iv) of subdivision 1 of this section.

3. When the date of manufacture of the existing unregistered building cannot be verified, the building shall be evaluated for compliance with the codes and standards specified in 13VAC5-91-160. The compliance assurance agency shall inspect the building, including any disassembly necessary, to determine whether there is compliance with these construction requirements. If compliance is achieved, the compliance assurance agency shall prepare a report documenting compliance, outlining any changes made to the building, and certifying the building in accordance with clauses (i) through (iv) of subdivision 1 of this section.

13VAC5-91-140. Report to the SBCO.

If the building is moved from the jurisdiction before the violations have been corrected, the building official shall make a prompt report of the circumstances to the SBCO. The report shall include all of the following:

1. A list of the uncorrected violations.

2. All information contained on the label pertinent to the identification of the building, the manufacturer and the compliance assurance agency.

3. The number of the Virginia registration seal.

4. The new destination of the building, if known.

5. The party responsible for moving the building.

13VAC5-91-150. When modification may be granted.

The administrator shall have the power upon request in specific cases to authorize modification of this chapter so as to permit certain specified alternatives where the objectives of this law can still be fulfilled. Such request shall be in writing and shall be accompanied by the plans, specifications, and other information necessary for an adequate evaluation of the modification requested. In reviewing the use of alternative methods or materials, the administrator may consider evaluation reports from accredited third-party evaluation services.

13VAC5-91-160. Use of model codes and standards.

A. Industrialized buildings entering the production assembly line after the effective date of the ~~2018~~ 2021 edition of this chapter shall comply with all applicable requirements of the codes and standards listed in subsection B of this section except that the following codes and standards may be used for industrialized buildings entering the assembly line during a one-year period after the effective date of the ~~2018~~ 2021 edition of this chapter:

1. ICC International Building Code - ~~2015~~ 2018 Edition

2. ICC International Plumbing Code - ~~2015~~ 2018 Edition

3. ICC International Mechanical Code - ~~2015~~ 2018 Edition

4. National Fire Protection Association Standard Number 70 (National Electrical Code) - ~~2014~~ 2017 Edition

5. ICC International Fuel Gas Code - ~~2015~~ 2018 Edition

6. ICC International Energy Conservation Code - ~~2015~~ 2018 Edition

7. ICC International Residential Code - ~~2015~~ 2018 Edition

B. The following documents are adopted and incorporated by reference to be an enforceable part of this chapter:

1. ICC International Building Code - ~~2018~~ 2021 Edition

2. ICC International Plumbing Code - ~~2018~~ 2021 Edition

3. ICC International Mechanical Code - ~~2018~~ 2021 Edition

4. National Electrical Code - ~~2017~~ 2020 Edition

5. ICC International Fuel Gas Code - ~~2018~~ 2021 Edition

6. ICC International Energy Conservation Code - ~~2018~~ 2021 Edition

7. ICC International Residential Code - ~~2018~~ 2021 Edition

Note: As the ~~2018~~ 2021 editions of the International Codes are incorporated by reference as the construction standards for use with these regulations, this chapter is also referred to as the ~~2018~~ 2021 edition of the Virginia Industrialized Building Safety Regulations or the ~~2018~~ 2021 edition of this chapter.

The codes and standards referenced above may be procured from:

International Code Council, Inc.
500 New Jersey Avenue, NW, 6th Floor
Washington, DC 20001-2070

13VAC5-91-170. Amendments to codes and standards.

A. All requirements of the referenced model codes and standards that relate to fees, permits, certificates of use and occupancy, approval of plans and specifications, and other procedural, administrative and enforcement matters are deleted and replaced by the procedural, administrative and enforcement provisions of this chapter.

B. The referenced codes and standards are amended as set forth in the USBC.

13VAC5-91-180. Compliance assurance agencies.

A. Application shall be made to the SBCO for acceptance as a compliance assurance agency. Application shall be made under oath and shall be accompanied by information and evidence that is adequate for the SBCO to determine whether the applicant is specially qualified by reason of facilities, personnel, experience, and demonstrated reliability to investigate, test, and evaluate industrialized buildings for compliance with this chapter and to provide adequate follow-up and compliance assurance services at the point of manufacture.

B. Following a determination by the SBCO that an application is complete, the information contained in the application and any other information deemed necessary by the SBCO will be reviewed for approval or disapproval. If the application is approved, the applicant will be notified with an approval letter. If the application is disapproved, the applicant will be notified in writing of the reasons for the disapproval. The applicant may then resubmit the application within 30 days of the receipt of the notification of disapproval for reconsideration of approval.

C. The SBCO may suspend or revoke the approval of a compliance assurance agency upon a determination that (i) approval was based upon fraudulent or inaccurate information, (ii) a change in facts or circumstances renders the agency incapable of meeting its duties and responsibilities as a compliance assurance agency in a satisfactory manner, or (iii) the agency failed to discharge its duties and responsibilities as a compliance assurance agency in a satisfactory manner. In such cases, the SBCO will issue a suspension or revocation notice to the agency outlining the reasons for the actions and the terms, if any, for reinstatement.

13VAC5-91-190. Freedom from conflict of interest.

A compliance assurance agency shall not be affiliated with, nor influenced or controlled by, producers, suppliers or vendors of products in any manner which might affect its capacity to render reports of findings objectively and without bias. A compliance assurance agency is judged to be free of such affiliation, influence and control if it complies with all of the following conditions:

1. The agency has no managerial affiliation with producers, suppliers or vendors and is not engaged in the sale or promotion of any product or material.

2. The results of the agency's work accrue no financial benefits to the agency through stock ownership of, or other similar affiliation to, any producer, supplier or vendor of the product involved.

3. The agency's directors and other management personnel in their job capacities receive no stock option or other financial benefit from any producer, supplier or vendor of the product involved.

4. The agency has sufficient interest or activity that the loss or award of a specific contract to determine compliance of a producer's, supplier's or vendor's product with this chapter would not be a determining factor in its financial well-being.

5. The employment security status of the agency's personnel is free of influence or control by producers, suppliers or vendors.

13VAC5-91-200. Information required by the administrator.

All of the following information and criteria will be considered by the administrator in designating approval of compliance assurance agencies:

1. Names of officers and location of offices.

2. Specification and description of services proposed to be furnished under this chapter.

3. Description of qualifications of personnel and their responsibilities, including an assurance that personnel involved in system analysis, design and plans review, and compliance assurance inspections and their supervisors comply with the requirements of the American Society for Testing and Material (ASTM) Standard Number E541-10 - Standard Specification for Agencies Engaged in System Analysis and Compliance Assurance for Manufactured Building or shall obtain ICC or DHCD certifications in the

appropriate subject area within 18 months of employment and maintain such certifications in an active status.

4. Summary of experience within the organization.

5. General description of procedures and facilities to be used in proposed services, including evaluation of the model, factory follow-up, quality assurance, labeling of production buildings, and specific information to be furnished on or with labels.

6. Procedures to deal with any defective buildings resulting from oversight.

7. Acceptance of these services by independent accrediting organizations.

8. Proof of independence and absence of conflict of interest.

The ASTM Standard Number E541-10 may be procured from:

American Society for Testing and Materials
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

13VAC5-91-210. Compliance assurance agency certification label.

A. Registered industrialized buildings shall be marked with certification labels supplied by the compliance assurance agency that includes the name and address of the compliance assurance agency and the numbers of the certification labels. The labels shall be applied to registered industrialized buildings intended for sale or use in Virginia and shall be applied prior to the shipment of the building from the place of manufacture. The labels shall be applied by the compliance assurance agency or by the manufacturer when so authorized by the compliance assurance agency.

B. Registered industrialized buildings shall bear one certification label on each manufactured section or module, or as an alternative, the certification label for each manufactured section or module may be placed in one location in the completed building.

13VAC5-91-220. Mounting of compliance assurance agency certification label.

To the extent practicable, the certification label shall be installed so that it cannot be removed without destroying it. The label shall be applied in the vicinity of the electrical distribution panel or in another location that is readily accessible for inspection and shall be installed near the registration seal.

13VAC5-91-240. Control of compliance assurance agency certification label.

The labels shall be under direct control of the compliance assurance agency and shall be applied to buildings that comply fully with this chapter. The labels shall be applied by the compliance assurance agency or by the manufacturer when authorized to do so by the compliance assurance agency. The manufacturer shall place its order for labels with the compliance assurance agency. The manufacturer is not permitted to acquire labels from any other source. Each compliance assurance agency shall keep a list of the serial numbers of labels issued to each manufacturer's plant in such manner that a copy of the record can be submitted to the administrator upon request.

13VAC5-91-245. Manufacturer's data plate.

A. All of the following information shall be placed on a permanent manufacturer's data plate in the vicinity of the electrical distribution panel or in some other location that is readily accessible for inspection. The compliance assurance agency shall approve the form and location of the data plate and shall ensure that the data plate is complete:

1. Manufacturer's name and address.

2. Compliance assurance agency certification number.

3. Serial number of each module of the building.

4. Serial number of the Virginia registration seal.

5. Date of manufacture of the building.

6. List of codes and standards under which the building was evaluated and constructed and the type of construction and occupancy classification under those codes and standards.

7. Design live roof load, design floor live load, design wind speed, and design ground snow load.

8. Thermal resistance ("R") values.

9. Special conditions or limitations concerning the use of the building under the codes and standards applicable to the building; however, a list of such conditions or limitations that are furnished separately with the building shall satisfy this requirement.

10. Special instructions for handling, installation and erection of the building; however, a list of such instructions that are furnished separately with the building shall satisfy this requirement.

11. Designation of electrical service ratings, directions for water and drain connections and, where applicable, identification of permissible type of gas for appliances.

12. Name of manufacturer and model designation of major factory installed appliances.

B. The manufacturer shall maintain copies of the data plate and reports of inspection, tests and any corrective action taken for a minimum period of 10 years from the date of manufacture of the building.

13VAC5-91-250. Industrialized buildings eligible for registration.

Any industrialized building must meet all of the following requirements to be registered and eligible for a Virginia registration seal:

1. The design of the building has been found by a compliance assurance agency to be in full compliance with this chapter. Approved designs shall be evidenced by the stamp and date of approval on each design sheet by the compliance assurance agency.

2. The compliance assurance agency has conducted any necessary testing and evaluation of the building and its component parts.

3. The compliance assurance agency has provided the required inspections and other quality assurance follow-up services at the point of manufacture to assure the building complies with this chapter.

4. The building contains the appropriate evidence of such compliance through a label permanently affixed by the compliance assurance agency.

13VAC5-91-260. Registration seal for industrialized buildings.

A. Registered industrialized buildings shall be marked with approved registration seals issued by the SBCO. The seals shall be applied to a registered industrialized building intended for sale or use in Virginia prior to the shipment of the building from the place of manufacture. The seals shall be applied by the compliance assurance agency or by the manufacturer when authorized to do so by the compliance assurance agency.

B. Registered industrialized buildings shall bear one registration seal on each manufactured section or module, or, as an alternative, the registration seal for each manufactured section or module may be placed in one location in the completed building.

C. Closed panel construction shall require one registration seal for every 600 square feet, or part thereof, of floor area.

D. Approved registration seals shall be purchased by the compliance assurance agency from the SBCO in advance of use. The fee for each registration seal shall be $75. Fees shall be submitted by checks made payable to "Treasurer of Virginia" or shall be submitted by electronic means. Payment for the seals must be received by the SBCO before the seals can be sent to the user. The compliance assurance agency shall maintain permanent records of seals purchased, including a record of any manufacturers receiving such seals.

E. To the extent practicable, the registration seal shall be installed so that it cannot be removed without destroying it. The seal shall be applied in the vicinity of the electrical distribution panel or in another location that is readily accessible for inspection and shall be installed near the certification label.

F. In accordance with § 36-85.1 of the Code of Virginia, any person or corporation having paid the fee for an approved registration seal that it will not use may, unless and except as otherwise specifically provided, within one year from the date of the payment of any such fee, apply to the administrator for a refund, in whole or in part, of the fee paid; provided that no payment shall be recovered unless the approved registration seal is returned unused and in good condition to the administrator. Additionally, as a requirement of this chapter, an administrative and processing fee of 25% of the amount of the refund due shall be deducted from the refund; however, such deduction shall not exceed $250.

13VAC5-91-270. Manufacturer's installation instructions and responsibilities of installers.

A. The manufacturer of each industrialized building shall provide specifications or instructions, or both, with each building for handling, installing, or erecting the building. Such instructions may be included as part of the label from the compliance assurance agency or may be furnished separately by the manufacturer of the building. The manufacturer shall not be required to provide the foundation and anchoring equipment for the industrialized building.

B. Persons or firms installing or erecting registered industrialized buildings shall install or erect the building in accordance with the manufacturer's instructions.

C. Where the installation or erection of an industrialized building utilizes components that are to be concealed, the installer shall notify and obtain approval from the building official prior to concealment of such components unless the building official has agreed to an alternative method of verification.

Note: The Virginia Department of Professional and Occupational Regulation's Board for Contractors requires licenses for certain activities related to the industrialized building industry. For more information, contact the Board for Contractors at 9960 Mayland Drive, Suite 400, Richmond, VA 23233; (804) 367-8511.

Documents Incorporated by Reference (13VAC5-91)

International Code Council, 500 New Jersey Avenue, NW, 6th Floor, Washington, DC 20001-2070 (http://shop.iccsafe.org/codes.html):

ICC International Plumbing Code - ~~2015~~ 2018 and ~~2018~~ 2021 Editions

ICC International Mechanical Code - ~~2015~~ 2018 and ~~2018~~ 2021 Editions

ICC International Building Code – ~~2015~~ 2018 and ~~2018~~ 2021 Editions

ICC International Residential Code - ~~2015~~ 2018 and ~~2018~~ 2021 Editions

ICC International Fuel Gas Code - ~~2015~~ 2018 and ~~2018~~ 2021 Editions

ICC International Energy Conservation Code - ~~2015~~ 2018 and ~~2018~~ 2021 Editions

NFPA 70, National Electrical Code - ~~2014~~ 2017 and ~~2017~~ 2020 Editions, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471 (http://www.nfpa.org/)

ASTM Standard Number E54110 -- Standard Specification for Agencies Engaged in System Analysis and Compliance Assurance for Manufactured Building, American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 (http://www.astm.org/)

Tab 6

IBSR Proposals Recommended by Workgroups as Consensus for Approval

Proposal ID	Description	Page
IB20-21	Editorial change related to approval of intermodal shipping containers as building modules or components of an industrialized building	Tab 6 – Page 1
IB60-21	Editorial change related to the issuance of notices of violations under the IBSR	Tab 6 – Page 3
IB115-21	Clarifies that the local building official may approve a change of occupancy of a registered industrialized building	Tab 6 – Page 5
IB120-21	Clarifies options for approval of unregistered industrialized buildings	Tab 6 – Page 7
IB140-21	Clarifies that the report to the SBCO is for moved buildings with active violations	Tab 6 – Page 9
IB160-21	Incorporates the new ICC/MBI 1200-2021 and ICC/MBI 1205-2021 Offsite Construction Standards	Tab 6 – Page 11

IB20-21

Proponents: DHCD Staff

2018 Industrialized Building Safety Regulations

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-91-20. Application and compliance. A. In accordance with § 36-81 of the Code of Virginia, registered industrialized buildings shall be acceptable in all localities as meeting the requirements of the Industrialized Building Safety Law (Chapter 4 (§ 36-70 et seq.) of Title 36 of the Code of Virginia), which shall supersede the building codes and regulations of the counties, municipalities and state agencies. Local requirements affecting industrialized buildings, including zoning, utility connections, preparation of the site and maintenance of the unit shall remain in full force and effect. All building officials are authorized to and shall enforce the provisions of the Industrialized Building Safety Law (Chapter 4 (§ 36-70 et seq.) of Title 36 of the Code of Virginia) and this chapter.
B. In accordance with § 36-78 of the Code of Virginia, no person, firm or corporation shall offer for sale or rental, or sell or rent, any industrialized building subject to any provisions of this chapter unless it conforms with the applicable provisions of this chapter. Further, any industrialized building constructed before January 1, 1972, shall remain subject to the ordinances, laws or regulations in effect at the time such industrialized building was constructed. Additionally, as a requirement of this chapter, any industrialized building bearing the label of a compliance assurance agency shall remain subject to the provisions of this chapter that were effective when such building was constructed, regardless of whether the building has been relocated.

C. In accordance with § 36-99 of the Code of Virginia and in accordance with the USBC, the installation or erection of industrialized buildings and alterations, additions, or repairs to industrialized buildings are regulated by the USBC and not this chapter. The USBC provides for administrative requirements for permits, inspections, and certificates of occupancy for such work.

D. The use of off-site manufactured intermodal freight containers, moving containers, or storage containers as building modules or components of an industrialized building ~~must~~ may be approved by the administrator in accordance with 13VAC5-91-150.In reviewing the use of the intermodal freight containers as structural building components, the administrator ~~will~~ may accept evaluation reports from accredited third-party evaluation services.

E. Off-site manufactured intermodal freight containers, moving containers and storage containers placed on site temporarily or permanently for use as a storage container are not subject to this chapter.

Reason Statement: This change is editorial in nature and clarifies that these requirements are not mandatory.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This change is merely administrative in nature.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Approval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications

☐ Carryover
☐ Disapproved
☐ None

Public Comments for: IB20-21

This proposal doesn't have any public comments.

Proposal # 957

IB60-21

Proponents: DHCD Staff

2018 Industrialized Building Safety Regulations

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-91-60. Notice of violation from administrator. In accordance with § 36-82 of the Code of Virginia, whenever the administrator shall find any violation of this chapter, he shall order the person responsible ~~therefor~~ to bring the building into compliance within a reasonable ~~time, to be fixed in the order.~~ time. In addition, as a requirement of this chapter, the administrator may request assistance from the building official for enforcement of this section. Any order issued by the administrator pursuant to this section shall contain a statement explaining the right of appeal of the order.

Reason Statement: This change is editorial in nature – the previous wording was unclear what was being asked for on the notice of violation. This change simplifies the text.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This change is editorial and has no impact on cost.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Approval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: IB60-21

This proposal doesn't have any public comments.

Proposal # 1022

IB115-21

Proponents: DHCD Staff

2018 Virginia Industrialized Building Safety Regulations

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-91-115. Change of occupancy classification. When the occupancy classification of a registered industrialized building is ~~proposed to be~~ changed, the change of occupancy shall be in accordance with one of the following.

1. ~~a~~ A compliance assurance agency shall inspect the building, including any disassembly necessary to determine whether compliance may be achieved for a change of occupancy classification in accordance with this chapter. If factory plans are available, then disassembly is not required to the extent that the factory plans can be reasonably verified to reflect the actual construction. Once any necessary work is completed, the compliance assurance agency shall prepare a report documenting the method utilized for the change of occupancy and any alterations to the building to achieve compliance. When the report is complete, the compliance assurance agency shall (i) mark the building with a new compliance assurance agency label in accordance with 13VAC5-91-210, which replaces the existing label; (ii) place a new manufacturer's data plate on the building in accordance with 13VAC5-91-245, which replaces the existing manufacturer's data plate and reflects the new occupancy classification; and (iii) forward a copy of the report and new data plate to the SBCO.
2. A building official shall determine that a change of occupancy for an industrialized building meets the requirements of the USBC. The building official may require the submittal of plans approved by a registered design professional, or inspection by an approved third party. A change of occupancy of a registered industrialized building, in accordance with the USBC and approved by the building official, must be reported to SBCO and the registration seal and data plate removed prior to occupancy.

Reason Statement: This change seeks to make it clear that the building official may approve a change of occupancy on a registered industrialized building provided they follow one of the methods listed.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This proposal will not affect costs of construction and may alleviate additional regulatory burdens on homeowners seeking to modify their existing structure.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Approval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: IB115-21

This proposal doesn't have any public comments.

Proposal # 1023

IB120-21

Proponents: DHCD Staff

2018 Industrialized Building Safety Regulations

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-91-120. Unregistered industrialized buildings. The building official shall determine whether any unregistered industrialized building complies with this chapter and shall require any noncomplying unregistered building to be brought into compliance with this ~~chapter. The building official shall enforce all applicable requirements of this chapter including those relating to the sale, rental and disposition of noncomplying buildings. The building~~ chapter in accordance with one of the following:

1. The unregistered building shall be registered in accordance with 13VAC5-91-125.
2. The building official ~~may~~ shall approve the unregistered building in accordance with the USBC. The building official may require submission of full plans and specifications for each building. Concealed parts of the building may be exposed to the extent necessary to permit inspection to determine compliance with the applicable requirements. The building official may also accept reports of inspections and tests from individuals or agencies deemed acceptable to the building official.

Reason Statement: The text was reworked to make it clearer that it is not a requirement to have unregistered industrialized buildings become registered and that building officials have some leeway when approving unregistered buildings in accordance with Code of Virginia §36-99.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This proposal clarifies administrative procedures and will not affect cost.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Approval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: IB120-21

This proposal doesn't have any public comments.

Proposal # 1024

IB140-21

Proponents: DHCD Staff

2018 Industrialized Building Safety Regulations

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-91-140. Report to the SBCO. If ~~the~~ a building which has active violations is moved from ~~the~~ a jurisdiction before the violations have been corrected, the building official shall make a prompt report of the circumstances to the SBCO. The ~~re-port~~ report shall include all of the following:

1. A list of the uncorrected violations.
2. All information contained on the label pertinent to the identification of the building, the manufacturer and the compliance assurance agency.
3. The number of the Virginia registration seal.
4. The new destination of the building, if known.
5. The party responsible for moving the building.

Reason Statement: This change indicates more clearly that the report to the SBCO is for moved buildings with active violations. The previous wording implied that it was for buildings with violations and this change makes it explicit.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This proposal is editorial in nature and does not affect cost.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Approval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: IB140-21

This proposal doesn't have any public comments.

Proposal # 1025

IB160-21

Proponents: DHCD Staff

2018 Industrialized Building Safety Regulations

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-91-160. Use of model codes and standards.

A. Industrialized buildings entering the production assembly line after the effective date of the 2018 edition of this chapter shall comply with all applicable requirements of the codes and standards listed in subsection B of this section except that the following codes and standards may be used for industrialized buildings entering the assembly line during a one-year period after the effective date of the 2018 edition of this chapter:

1. ICC *International Building Code* – 2015 Edition
2. ICC *International Plumbing Code* – 2015 Edition
3. ICC *International Mechanical Code* – 2015 Edition
4. National Fire Protection Association Standard Number 70 (*National Electrical Code*) – 2014 Edition
5. ICC *International Fuel Gas Code* – 2015 Edition
6. ICC *International Energy Conservation Code* – 2015 Edition
7. ICC *International Residential Code* – 2015 Edition

B. The following documents are adopted and incorporated by reference to be an enforceable part of this chapter:

1. ICC *International Building Code* – 2018 Edition
2. ICC *International Plumbing Code* – 2018 Edition
3. ICC *International Mechanical Code* – 2018 Edition
4. *National Electrical Code* – 2017 Edition
5. ICC *International Fuel Gas Code* – 2018 Edition
6. ICC *International Energy Conservation Code* – 2018 Edition
7. ICC *International Residential Code* – 2018 Edition
8. ICC/MBI 1200-2021 Standard for Off-site Construction: Planning, Design, Fabrication and Assembly
9. ICC/MBI 1205-2021 Standard for Off-site construction: Inspection and Regulatory Compliance

Note: As the 2018 editions of the International Codes are incorporated by reference as the construction standards for use with these regulations, this chapter is also referred to as the 2018 edition of the *Virginia Industrialized Building Safety Regulations* or the 2018 edition of this chapter.

The codes and standards referenced above may be procured from:

International Code Council, Inc.
500 New Jersey Avenue, NW,6th Floor
Washington, DC 20001-2070

13VAC5-91-170. Amendments to codes and standards.

A. All requirements of the referenced model codes and standards that relate to fees, permits, certificates of use and occupancy, approval of plans and specifications, and other procedural, administrative and enforcement matters that address the same subject matter and impose differing requirements are deleted and replaced by the procedural, administrative and enforcement provisions of this chapter.
B. The referenced codes and standards are amended as set forth in the USBC.

Reason Statement: To provide additional resource for local governing bodies and regulatory agencies for the safety of off-site construction.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
The new ICC/MBI standards that are being incorporated contain requirements that are applicable to industrialized building designers, manufacturers and third party Compliance Assurance Agenies (CAAs). While the requirements in the standards are based on current industry standards and best practices, that are already being met by most in the industry, incorporation of the new standards may result in changes and additional costs for

some manufacturers or CAAs. However, standardizing the requirements for the design and regulatory approval of industrialied buildings will ultimately have a positive impact not only in Virginia, but regionally and nationally, by reducing overall costs and increasing affordability.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Approval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: IB160-21

This proposal doesn't have any public comments.

Proposal # 1026

Department Of Housing And Community Development

Base Document for the 2021 Virginia Amusement Device Regulations

09/30/2021

Summary – This document is compiled by staff of the State Building Codes Office of the Division of Building and Fire Regulation. The staff document is intended to serve as the basis for the publishing of proposed regulations for the 2021 VADR. It is not intended to create substantive changes to the regulations. Standards that are referenced are updated to the newest edition and editorial corrections are made where existing errors have been identified. Once the base document is approved by the Board of Housing and Community Development, if any code change proposals are considered and approved by the Board of Housing and Community Development to also go into the proposed regulations for the 2021 VADR, those proposals would be correlated with this base document and brought back to the Board of Housing and Community Development as a separate “proposed regulations” document for review.

Part I

General Provisions

13VAC5-31-10. Purpose.

A. The purpose of this chapter is to establish standards for the regulation, design, construction, maintenance, operation, and inspection of amusement devices.

B. The provisions of the USBC, including but not limited to all administrative procedures shall apply in the administration and enforcement of this chapter and to amusement devices to the extent such provisions are not superseded by the provisions of this chapter.

13VAC5-31-20. Definitions.

A. The following words and terms when used in this chapter shall have the following meanings unless the context clearly indicates otherwise:

"Amusement device" means (i) a device or structure open to the public by which persons are conveyed or moved in an unusual manner for diversion, but excluding snow tubing parks and rides, ski terrain parks, ski slopes, and ski trails, and (ii) passenger tramways. For the purpose of this definition, the phrase "open to the public" means that the public has full access to a device or structure at an event, irrespective of whether a fee is charged. The use of devices or structures at private events is not considered to be open to the public.

"Bungee cord" means the elastic rope to which the jumper is attached which lengthens and shortens to produce a bouncing action.

"Carabineer" means a shaped metal device with a gate used to connect sections of a bungee cord, jump rigging, equipment, or safety gear.

"Certificate of inspection" means the certificate or sticker for amusement devices distributed by DHCD.

"DHCD" means the Virginia Department of Housing and Community Development.

"Gravity ride" means a ride that is installed on an inclined surface, which depends on gravity for its operation to convey a passenger from the top of the incline to the bottom, and which conveys a passenger in or on a carrier tube, bag, bathing suit, or clothes.

"Ground operator" means a person who assists the jump master to prepare a jumper for jumping.

"Harness" means an assembly to be worn by a bungee jumper to be attached to a bungee cord. It is designed to prevent the wearer from becoming detached from the bungee system.

"Institutional trampoline" means a trampoline intended for use in a commercial or institutional facility.

"Jump master" means a person who has responsibility for the bungee jumper and who takes the jumper through the final stages to the actual jump.

"Jump zone" means the space bounded by the maximum designed movements of the bungee jumper.

"Jumper" means the person who departs from a height attached to a bungee system.

"Landing area" means the surface area of ground or water directly under the jump zone, the area where the lowering device moves the bungee jumper to be landed away from the jump space and the area covered by the movement of the lowering device.

"Local building department" means the agency or agencies of the governing body of any city, county or town in this Commonwealth charged with the enforcement of the USBC.

"Operating manual" means the document that contains the procedures and forms for the operation of bungee jumping equipment and activity at a site.

"Passenger tramway" means a device used to transport passengers uphill, and suspended in the air by the use of steel cables, chains or belts, or ropes, and usually supported by trestles or towers with one or more spans.

"Platform" means the equipment attached to the structure from which the bungee jumper departs.

"Private inspector" means a person performing inspections who is independent of the company, individual or organization owning, operating or having any vested interest in an amusement device being inspected.

"Small mechanical ride" means an amusement device, other than an inflatable amusement device, where (i) the assembly time for the device is two hours or less, (ii) the revolutions per minute of any rotation of the components of the device is not greater than seven, (iii) the device has a footprint of less than 500 square feet, and (iv) the device does not invert a patron or lift a patron more than three feet in the air, measured from the ground to the bottom of the patron's feet when the device is operating.

"Trampoline court" means a defined area comprising one or more institutional trampolines or a series of institutional trampolines.

"Ultimate tensile strength" means the greatest amount of load applied to a bungee cord prior to failure.

"USBC" means the Virginia Uniform Statewide Building Code (13VAC5-63).

B. Words and terms used in this chapter which are defined in the USBC shall have the meaning ascribed to them in that regulation unless the context clearly indicates otherwise.

C. Words and terms used in this chapter which are defined in the standards incorporated by reference in this chapter shall have the meaning ascribed to them in those standards unless the context clearly indicates otherwise.

13VAC5-31-30. Devices covered and exempt.

A. The following devices, identified by name or description, when open to the public shall be considered amusement devices subject to this chapter. The list is intended only to clarify questionable devices, while the definition of an "amusement device" in 13VAC5-31-20 is generally used to determine the applicability of this chapter.

1. Inflatable amusement devices;

2. Zip lines; and

3. Trampoline courts.

B. The following equipment or devices shall not be considered amusement devices subject to this chapter:

1. Nonmechanized playground or recreational equipment such as swing sets, sliding boards, climbing bars, jungle gyms, skateboard ramps and similar equipment where no admission fee is charged for its use or for admittance to areas where the equipment is located;

2. Coin-operated rides designed to accommodate three or less passengers;

3. Water slides or similar equipment used in community association, community club or community organization swimming pools;

4. Mechanical bulls or similar devices;

5. Devices known as mall trains, shopping mall trains, or electric trackless trains for malls; and

6. Devices known as water walking balls, euro bubbles, or similar devices.

13VAC5-31-40. Incorporated standards.

A. The following standards are hereby incorporated by reference for use as part of this chapter:

1. American National Standards Institute (ANSI) Standard B77.1-2017 for the regulation of passenger tramways; and

2. American Society for Testing and Materials (ASTM) Standard Nos. F747-15, F770-18, F1159-16, F1193-18, F1957-99 (2017), F2007-18, F2137-18, F2291-19, F2374-19, F2375-09 (2017), F2376-17a, F2460-11, F2461-18, F2959-18, F2960-16, F2970-17, F2974-19, and F3054-18 for the regulation of amusement devices.

The standards referenced above may be procured from:

	ANSI 25 W 43rd Street New York, NY 10036	ASTM 100 Barr Harbor Dr. West Conshohocken, PA 19428-2959

B. The provisions of this chapter govern where they are in conflict with any provisions of the standards incorporated by reference in this chapter.

C. The following requirements supplement the provisions of the ASTM standards incorporated by reference in this chapter:

1. The operator of an amusement device shall be at least 16 years of age, except when the person is under the supervision of a parent or guardian and engaged in activities determined not to be hazardous by the Commissioner of the Virginia Department of Labor and Industry;

2. The amusement device shall be attended by an operator at all times during operation except that (i) one operator is permitted to operate two or more amusement devices provided they are within the sight of the operator and operated by a common control panel or station and (ii) one operator is permitted to operate two small mechanical rides with separate controls provided the distance between controls is no more than 35 feet and the controls are equipped with a positive pressure switch; and

3. The operator of an amusement device shall not be (i) under the influence of any drugs which may affect the operator's judgment or ability to assure the safety of the public or (ii) under the influence of alcohol.

D. Where an amusement device was manufactured under previous editions of the standards incorporated by reference in this chapter, the previous editions shall apply to the extent that they are different from the current standards.

13VAC5-31-50. Certification of amusement device inspectors.

Any person, including local building department personnel, inspecting an amusement device relative to a certificate of inspection shall possess certification as an amusement device inspector in accordance with the Virginia Certification Standards (13VAC5-21).

Note: Continuing education and periodic training requirements for DHCD certifications are set out in the Virginia Certification Standards (13VAC5-21).

13VAC5-31-60. Appeals.

Appeals from the local building department concerning the application of this chapter shall be made to the local board of building code appeals established by the USBC. Application for appeal shall be filed with the local building department within 14 calendar days after receipt of the decision of the local building department. The board of appeals shall hear the appeal within seven calendar days after the application for appeal is filed. After final determination by the board, any person who was a party to the appeal may appeal to the State Building Code Technical Review Board, established under § 36-108 of the Code of Virginia, within 14 calendar days of receipt of the decision to be appealed. Such appeal shall be in accordance with the procedures established in the USBC, under the authority granted by § 36-98.3 of the Code of Virginia where the provisions of Chapter 6 (§ 36-97 et seq.) of Title 36 of the Code of Virginia and the USBC apply to amusement devices.

NOTE: Because of the short time frames normally associated with amusement device operations, DHCD staff will be available to assist in finding a timely resolution to disagreements between owners or operators and the local building department upon request by either party.

Part II

Enforcement, Permits and Certificates of Inspection

13VAC5-31-75. Local building department.

A. In accordance with §§ 36-98.3 and 36-105 of the Code of Virginia, the local building department shall be responsible for the enforcement of this chapter and may charge fees for such enforcement activity. The total amount charged for any one permit to operate an amusement device or devices or the renewal of such permit shall not exceed the following, except that when a private inspector is used by the owner or operator of the device, the fees shall be reduced by 75%:

1. $55 for each small mechanical ride or inflatable amusement device covered by the permit;

2. $75 for each circular ride, institutional trampoline, or flat-ride less than 20 feet in height covered by the permit, except concession go-karts.

Concession go-kart fees shall not exceed $300 per track, for tracks with up to 20 karts. An additional fee of up to $10 may be charged for each additional kart in excess of 20;

3. $100 for each spectacular ride covered by the permit that cannot be inspected as a circular ride or flat-ride in subdivision 2 of this subsection due to complexity or height, except zip lines. Zip line fees shall not exceed $150 for each zip line. For the purposes of this section, each portion from launch point to landing point shall be considered a separate zip line and each zip line between a launch point and landing point shall also be considered a separate zip line;

4. $200 for each coaster covered by the permit that exceeds 30 feet in height;

5. $400 for each coaster covered by the permit that exceeds 60 feet in height; and

6. The local building department may charge an additional fee for permits and inspections of generators and associated wiring for amusement device events. Generators subject to these fees are those used exclusively with amusement devices and that are inspected by the local building department. The fee per event shall not exceed $165 and shall not exceed the actual cost to perform the inspection or inspections.

Exception: Small portable generators serving only cord and plug connected equipment loads are not subject to the fee.

Notwithstanding the fee limitations established in this section, the local building department shall be permitted to increase the fees up to 50% when requested to perform weekend or after-hour inspections. The local building department shall also be permitted to increase fees up to 50% when a reinspection is required.

B. Notwithstanding the provisions of subsection A of this section, when an amusement device is constructed in whole or in part at a site for permanent operation at that site and is not intended to be disassembled and moved to another site, then the local building department may utilize permit and inspection fees established pursuant to the USBC to defray the cost of enforcement. This authorization does not apply to an amusement device that is only being reassembled, undergoing a major modification at a site or being moved to a site for operation.

C. A permit application shall be made to the local building department at least five days before the date in which the applicant intends to operate an amusement device. The application shall include the name of the owner, operator or other person assuming responsibility for the device, a general description of the device including any serial or identification numbers available, the location of the property on which the device will be operated, and the length of time of operation. The permit application shall indicate whether a private inspector will be used. If a private inspector is not used, the applicant shall give reasonable notice when an inspection is sought and may stipulate the day such inspection is requested provided it is during the normal operating hours of the local building department. In addition to the information required on the permit application, the applicant shall provide proof of liability insurance of an amount not less than $1 million per occurrence or proof of equivalent financial responsibility. The local building department shall be notified of any change in the liability insurance or financial responsibility during the period covered by the permit.

D. Notwithstanding the provisions of subsection C of this section, a permit application is not required for a small mechanical ride or an inflatable amusement device that has a certificate of inspection issued by any local building department in this Commonwealth either a six-month period for small mechanical rides or within a one-year period for inflatable amusement devices prior to the dates the small mechanical ride or inflatable amusement device is to be used, regardless of whether the devices has been disassembled and moved to a new site. In such cases, the local building department shall be notified and provided with the information required on a permit application as listed in subsection C of this section at least three days prior to operation. In addition, and notwithstanding the provisions of subsection A of this section, the local building department shall be permitted to charge a $50 inspection fee per event to the person notifying the local building department of an event where an inflatable amusement device is operating if the local building department chooses to inspect any or all of the inflatable amusement devices operating at that event. An inspection report shall be provided to the person notifying the local building department of the event if such an inspection is conducted.

E. Local building department personnel shall examine the permit application within five days and issue the permit if all requirements are met. A certificate of inspection for each amusement device shall be issued when the device has been found to comply with this chapter by a private inspector or by an inspector from the local building department. It shall be the responsibility of the local building department to verify that the private inspector possesses a valid certificate of competence as an amusement device inspector from the Virginia Board of Housing and Community Development. In addition, local building department personnel shall be responsible for assuring that the certificate of inspection is posted or affixed on or in the vicinity of the device in a location visible to the public. Local building department personnel shall post or affix such certificates or permit the certificates to be posted or affixed by the private inspector. Permits shall indicate the length of time the device or devices will be operated at the site, clearly identify the device or devices to which it applies and the date of expiration of the permit. Permits shall not be valid for longer than one year, except that permits for small mechanical rides shall not be valid for longer than six months.

F. In addition to obtaining a certificate of inspection in conjunction with a permit application for amusement devices permanently fixed to a site, a new certificate of inspection shall also be obtained prior to the operation of an amusement device following a major modification, prior to each seasonal operation of a device, at least once during the operating season and prior to resuming the operation of a device following an order from a local building department to cease operation. This requirement shall not apply to small mechanical rides meeting the conditions outlined in subsection D of this section.

G. For amusement devices manufactured prior to 1978, the owner or operator shall have the information required by 10.1 through 10.6 of ASTM F1193 available at the time of inspection. In addition, the operator of any amusement device shall be responsible for obtaining all manufacturer's notifications, service bulletins and safety alerts issued pursuant to ASTM F770 and the operator shall comply with all recommendations and requirements set out in those documents. A copy of all such documents shall be made available during an inspection.

H. In the enforcement of this chapter, local building department personnel shall have authority to conduct inspections at any time an amusement device would normally be open for operation or at any other time if permission is granted by the owner or operator, to issue an order to temporarily cease operation of an amusement device upon the determination that the device may be unsafe or may otherwise endanger the public and to accept and approve or deny requests for modifications of the rules of this chapter in accordance with the modification provisions of the USBC.

I. In accordance with subdivision 7 of § 36-137 of the Code of Virginia, the local building department shall collect a 2.0% levy of fees charged for permits under this chapter and transmit it quarterly to DHCD to support training programs of the Virginia Building Code Academy. Localities that maintain individual or regional training academies accredited by DHCD shall retain such levy.

J. In accordance with § 36-98.3 of the Code of Virginia and 13VAC5-31-10 B, the procedures for violations of this chapter shall be as prescribed in the USBC.

K. In accordance with § 36-98.1 of the Code of Virginia, the Virginia Department of General Services (DGS) shall function as the local building department for the application of this chapter to amusement devices located on state-owned property. In accordance with §§ 36-98.2 and 36-114 of the Code of Virginia, appeals of the application of this chapter by the DGS shall be made directly to the State Building Code Technical Review Board. Further, as a condition of this chapter, such appeals shall be filed within 14 calendar days after receipt of the decision of DGS.

13VAC5-31-85. Accidents involving serious injury or death.

A. If an accident involving the serious injury or death of a patron occurs, the operation of an amusement device shall cease and the local building department and DHCD shall be notified as soon as practicable, but in no case later than during the next working day. The operation of the device shall not resume until inspected by a private inspector or an inspector from the local building department, except where the owner or operator determines the cause was not related to malfunction or improper operation of the amusement device.

B. The owner or operator shall conduct an investigation of the accident including, at a minimum, an examination of the accident scene and interviews of any witnesses or persons involved in the accident. An accident investigation report shall be compiled which, at a minimum, shall contain a summary of the investigation and a description of the device involved, including its serial number and date of manufacture, if available. The report shall be submitted to the local building department within 24 hours of the accident except that if the local building department is closed during that period, then the report shall be submitted with four hours of the reopening of the department.

C. Local building department personnel are authorized to investigate the accident and to issue an order to cease operation when warranted and to specify the conditions under which the device may resume operation. The amusement device shall be inspected prior to resuming operation either by an inspector from the local building department or by a private inspector and found to comply with this chapter.

Part III

Gravity Rides

13VAC5-31-180. General requirements.

A. The provisions of this part are specific to gravity rides and are in addition to other applicable provisions of this chapter.

B. A ride using carriers shall be designed and constructed to retain the passengers in or on a carrier during the operation of the ride and retain the carrier on or within the track, slide, or chute system during the operation of the ride.

C. A ride that conveys passengers not in or on a carrier shall be designed and constructed to retain the passengers within the chute or slide during the ride.

D. At each loading or unloading area, a hard surface which is other than earth and which is reasonably level shall be provided. The surface shall be large enough to accommodate the intended quantity of passengers.

E. Where loading or unloading platforms are elevated more than 30 inches from the adjacent areas, guard rails conforming to the USBC shall be provided.

F. Passengers shall not have to step up or down more than 12 inches from the loading or unloading surface to enter or exit the ride.

G. The frequency of departure of carriers or riders from the loading areas shall be controlled by a ride operator. The minimum distance between departures shall be determined by the designer of the specific ride.

H. When a passenger has control of the speed or course of the carrier, the passenger shall have a clear sight distance along the course of the ride long enough to allow the passenger to avoid a collision with another person or carrier.

I. The unloading area of the ride shall be designed and constructed to bring riders and carriers to a safe stop without any action by the rider.

J. There shall be attendants at the loading and unloading area when the ride is in use. However, where the physical structure of the ride is such that it is not capable of accommodating an attendant at both the loading and unloading area and the entire ride is visible and under the supervision of a single attendant, attendants at both the loading and unloading areas shall not be required.

K. If the entire course of the ride is not visible to the operator, additional persons with communications equipment shall be provided or approved visual surveillance equipment shall be installed along the course of the ride which is not visible to the operator.

L. Any moving or hot parts that may be injurious to the ride operator or the public shall be effectively guarded to prevent contact.

M. Fencing or adequate clearance shall be provided that will prevent the riders from contact with persons or nearby objects.

Part IV

Concession Go-Karts

13VAC5-31-190. General requirements.

In addition to other applicable requirements of this chapter, concession go-karts shall be operated, maintained and inspected in accordance with ASTM F2007.

Part V

Inflatable Amusement Devices

13VAC5-31-200. General requirements.

In addition to other applicable requirements of this chapter, inflatable amusement devices shall be operated, maintained and inspected in accordance with ASTM F2374.

Part VI

Artificial Climbing Walls

13VAC5-31-210. General requirements.

In addition to other applicable requirements of this chapter, artificial climbing walls shall be operated, maintained and inspected in accordance with ASTM F1193.

Notwithstanding any requirements of this chapter to the contrary, an artificial climbing wall may be moved, setup and operated without obtaining a permit provided the wall has a certificate of inspection issued by a local building department in this Commonwealth within the prior 90 days and the expiration date of the wire ropes used with the device does not expire within that 90-day period.

Part VII

Bumper Boats

13VAC5-31-215. General requirements.

In addition to other applicable requirements of this chapter, bumper boats shall be operated, maintained and inspected in accordance with ASTM F2460.

Part VIII

Zip Lines

13VAC5-31-217. General requirements.

In addition to other applicable requirements of this chapter, zip lines shall be operated, maintained, and inspected in accordance with ASTM F2959.

Part IX

Bungee Jumping

13VAC5-31-220. General requirements.

A. The provisions of this part are specific to bungee jumping and are in addition to other applicable provisions of this chapter.

B. Bungee jumping operations that are open to the public shall be permitted from structures designed for use as part of the bungee jumping operation. Bungee jumping from other types of structures, cranes or derricks is not permitted for public participation.

C. Bungee jumping activities that involve double jumping, sandbagging, catapulting or stunt jumping shall not be permitted to be open for public participation.

13VAC5-31-230. Bungee cords.

A. Bungee cords shall be tested by an approved testing agency or by an engineer licensed in Virginia. The following criteria shall be met:

1. Each lot of bungee cords shall have a minimum of 10%, but not less than one of the cords tested to determine the lowest ultimate tensile strength of the cords tested. A load versus elongation curve based on the test result shall be provided with each lot of bungee cords; and

2. The manufacturer shall specify the maximum number of jumps for which each cord or cord type is designed and the criteria for use of the cord.

B. Bungee cords shall be retired when the cords (i) exhibit deterioration or damage; (ii) do not react according to specifications; or (iii) have reached the maximum usage expressed in number of jumps as specified by the manufacturer. Bungee cords retired from use shall be destroyed immediately by cutting the cord into five-foot lengths.

13VAC5-31-240. Jump hardware.

Jump harnesses shall be either full body-designed, which includes a waist harness worn in conjunction with a chest harness, or ankle-designed with a link to a waist harness. All jump harnesses, carabineers, cables and other hardware shall be designed and manufactured for the purpose or designed or analyzed by an engineer licensed in Virginia and shall be used and maintained in accordance with the manufacturer's or engineer's instructions.

13VAC5-31-250. Structure requirements.

Structures constructed on site for bungee jumping activities shall be designed by an engineer licensed in Virginia. Structures manufactured for bungee jumping activities shall be analyzed by an engineer licensed in Virginia and assembled and supported in accordance with the manufacturer's instructions.

13VAC5-31-260. Operational and site requirements.

A. Operators shall follow the criteria provided by the manufacturer for the use of bungee cords. A record of the number of jumps with each cord shall be maintained. All cords shall be inspected daily for wear, slippage, or other abnormalities unless the manufacturer specifies more frequent inspections.

B. The jump master or site manager shall be responsible for determining the appropriate use of all bungee cords in relation to the weight of the jumper and height of the platform. Bungee cords shall be attached to the structure at all times when in the connection area.

C. All harnesses shall be inspected prior to harnessing a jumper and shall be removed from service when they exhibit signs of excessive wear or damage. All carabineers shall be inspected daily and shall be removed from service when they exhibit signs of excessive wear or damage or fail to function as designed. The anchors shall be inspected daily and shall be replaced if showing signs of excessive wear.

D. A secondary retrieval system shall be provided in all operations. A locking mechanism on the line shall be used to stop and hold the jumper in place after being pulled back to the jump platform in a retrieval system. A dead man's switch or locking mechanism that will stop the lowering action shall be used in a friction lowering system.

E. The jump zone, preparation area and landing/recovery area shall be identified and maintained during bungee jumping activities. The landing/recovery area shall be accessible to emergency vehicles. Communication shall be maintained between all personnel involved with the jump.

F. An air bag, a minimum of 10 feet by 10 feet, shall be used. The air bag shall be rated for the maximum free fall height possible from the platform during operation. The air bag shall be located immediately below the jump space. The landing area shall be free of spectators and debris at all times and shall be free of any equipment or personnel when a jumper is being prepared on the jump platform and until the bungee cord is at its static extended state. A place to sit and recover shall be provided adjacent to, but outside, the landing area where the jumper shall be allowed to recover.

G. Where the jump space or landing area, or both, is over sea, lake, river, or harbor waters, the following shall apply:

1. The landing water area shall be at least nine feet deep and a minimum of 10 feet by 10 feet or have a minimum of 15 feet in diameter if circular;

2. The jump space and landing area shall be free of other vessels, floating and submerged objects and buoys. A sign of approved size that reads "Bungee Jumping! Keep Clear" shall be fixed to buoys on four sides of the landing area;

3. The landing vessel shall be readily available for the duration of the landing procedures;

4. The landing vessel shall have a landing pad size of at least five feet by five feet within and lower than the sides of the vessel;

5. A landing vessel shall be available that can be maneuvered in the range of water conditions expected and will enable staff to pick up a jumper; and

6. One person may operate the landing vessel where the vessel is positioned without the use of power. A separate person shall operate the vessel where power is required to maneuver into or hold the landing position.

H. Where the landing area is part of a swimming pool or the landing area is specifically constructed for bungee jumping, the following shall apply:

1. Rescue equipment shall be available, such as a life ring or safety pole;

2. The jump space and landing area shall be fenced to exclude the public; and

3. Only the operators of the bungee jump and jumper shall be within the jump zone and landing areas.

I. Storage shall be provided to protect equipment from physical, chemical and ultra-violet radiation damage. The storage shall be provided for any current, replacement and emergency equipment and organized for ready access and shall be secure against unauthorized entry.

13VAC5-31-270. Management and personnel responsibilities.

A. All bungee jumping activities shall have a minimum of one site manager, one jump master and one ground operator to be present at all times during operation of the bungee jump.

B. The site manager is responsible for the following:

1. Controlling the entire operation;

2. Site equipment and procedures;

3. Determining whether it is safe to jump;

4. Selection of, and any training of personnel;

5. Emergency procedures; and

6. Maintaining records.

C. A jump master shall be located at each jump platform and shall have thorough knowledge of, and is responsible for, the following:

1. Overseeing the processing of jumpers, selection of the bungee cord, adjustment of the rigging, final check of jumper's preparation, and countdown for and observation of the jump;

2. Verifying that the cord is attached to the structure at all times when the jumper is in the jump area;

3. Rescue and emergency procedures; and

4. Ensuring that the number of jumps undertaken in a given period of time will allow all personnel to safely carry out their responsibilities.

D. The ground operator shall have knowledge of all equipment used and of jump procedures and shall have the following responsibilities:

1. Ensuring that the jumper is qualified to jump;

2. Assisting the jump master to prepare the jumper and attach the jumper to the harness and rigging;

3. Assisting the jumper to the recovery area; and

4. Maintaining a clear view of the landing area.

E. Each site shall have an operating manual that shall include the following:

1. Site plan, job descriptions (including procedures), inspections and maintenance requirements of equipment including rigging, hardware, bungee cords, harnesses, and lifelines; and

2. An emergency rescue plan.

F. The daily operating procedures shall be conducted in accordance with ASTM F770.

G. The qualification and preparation of jumpers shall include obtaining any pertinent medical information, jumper weight and a briefing of jumping procedures and safety instructions.

Part X

Accessibility Requirements for Amusement Devices

13VAC5-31-280. Scope.

This part shall apply to newly designed and constructed amusement devices for permanent installation and does not apply to amusement devices regularly assembled or disassembled. This part also does not apply to mobile, portable, or temporary amusement devices set up for short periods of time such as at traveling carnivals, state and county fairs, and festivals. For the purposes of this part, newly designed and constructed amusement devices are those that are new upon first use by patrons and the first permanent installation of the ride and would not include a ride that was moved within a park or to another park after several seasons of use.

13VAC5-31-290. Requirements.

Amusement devices subject to this part shall comply with applicable requirements of 36 CFR Part 1191–Americans With Disabilities Act (ADA) Accessibility Guidelines for Buildings and

Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines (69 FR 44151-44455 (July 23, 2004)).

Part XI

Trampoline Courts

13VAC5-31-300. Trampoline courts.

In addition to other applicable requirements of this chapter, trampoline courts shall be operated, maintained, and inspected in accordance with ASTM F2970.

13VAC5-31-300. Trampoline courts.

In addition to other applicable requirements of this chapter, trampoline courts shall be operated, maintained, and inspected in accordance with ASTM F2970.

Tab 8

VADR Proposals Recommended by Workgroups as Consensus for Approval

Proposal ID	**Description**	**Page**
AD20-21	Adds definition for "serious injuries/illnesses"	Tab 8 – Page 1
AD30-21	Clarifies that non-mechanized playground equipment is not considered an amusement device	Tab 8 – Page 3
AD40-21	Updates the ASTM referenced standards with the most current editions	Tab 8 – Page 5

AD20-21

Proponents: Amusement Device Technical Advisory Committee (ADTAC)

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-31-20. Definitions.

A. The following words and terms when used in this chapter shall have the following meanings unless the context clearly indicates otherwise:

"Serious Injuries/Illnesses" means a personal injury/illness that results in death, dismemberment, significant disfigurement, permanent loss of the use of a body organ, member, function, or system, a compound fracture, or other significant injury/illness that requires immediate admission and overnight hospitalization and observation by a licensed physician.

B. Words and terms used in this chapter which are defined in the USBC shall have the meaning ascribed to them in that regulation unless the context clearly indicates otherwise.

C. Words and terms used in this chapter which are defined in the standards incorporated by reference in this chapter shall have the meaning ascribed to them in those standards unless the context clearly indicates otherwise.

Reason Statement: The VADR (13VAC5-31-85) states "If an accident involving the serious injury or death of a patron occurs, the operation of an amusement device shall cease and the local building department and DHCD shall be notified as soon as practicable, but in no case later than during the next working day. This proposal is a recommendation from the Amusement Device Technical Advisory Committee (ADTAC) and provides a definition for "serious injury/illness", as referenced in 13VAC5-31-85. The definition is borrowed from ASTM F747 "Standard Terminology Relating to Amusement Rides and Devices".

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This proposal is for clarification only and is not anticipated to have a cost impact.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency
No resiliency impact.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Approval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover
☐ Disapproved
☐ None

Public Comments for: AD20-21

This proposal doesn't have any public comments.

Proposal # 970

AD30-21

Proponents: Amusement Device Technical Advisory Committee (ADTAC)

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-31-30. Devices covered and exempt.
A. The following devices, identified by name or description, when open to the public shall be considered amusement devices subject to this chapter. The list is intended only to clarify questionable devices, while the definition of an “amusement device” in 13VAC5-31-20 is generally used to determine the applicability of this chapter.

1. Inflatable amusement devices;
2. Zip lines; and
3. Trampoline courts

I. B. The following equipment or devices shall not be considered amusement devices subject to this chapter:

1. Nonmechanized playground or recreational equipment such as swing sets, sliding boards, climbing bars, jungle gyms, skateboard ramps and similar equipment. ~~where no admission fee is charged for its use or for admittance to areas where the equipment is located~~;
2. Coin-operated rides designed to accommodate three or less passengers;
3. Water slides or similar equipment used in community association, community club or community organization swimming pools;
4. Mechanical bulls or similar devices;
5. Devices known as mall trains, shopping mall trains, or electric trackless trains for malls; and
6. Devices known as water walking balls, euro bubbles, or similar devices.

Reason Statement: This proposal is a recommendation form the Amusement Device Technical Advisory Committee (ADTAC) to clarify that non-mechanized palyground equipment that you typically see in a backyard, at a school, ina public park, etc, is not considered an amusement device. If it is mechanized equipment, or it is not typical backyard playground equipment, the existing "amusement device" definition should be utliized to determine if it is a regulated amusement device. This change will clarify that a typical backyard swingset is not an amusement device, just because it is located within an area that you must pay admission to enter; however, a giant fair slide is not playground equipment and would meet the "amusement device" definition as it is open to the public and move sthe rider in an unusual manner.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This proposal is for clarification only and is not anticipated to have a cost impact.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency
No resiliency impact.

Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Approval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: AD30-21

This proposal doesn't have any public comments.

Proposal # 969

AD40-21

Proponents: Amusement Device Technical Advisory Committee (ADTAC)

2018 Virginia Amusement Device Regulations

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-31-40. Incorporated standards.
A. The following standards are hereby incorporated by reference for use as part of this chapter:

1. American National Standards Institute (ANSI) Standard No. B77.1-2017 for the regulation of passenger tramways; and
2. American Society for Testing and Materials (ASTM) Standard Nos. ~~F747-15~~ F747-21a, ~~F770-18~~ F770-21a, ~~F1159-16~~ F1159-16e1, ~~F1193-18~~ F1193-18a, F1957-99 (2017), F2007-18, ~~F2137-18~~ F2137-19, ~~F2291-19~~ F2291-21, ~~F2374-19~~ F2374-21a, F2375-09 (2017), ~~F2376-17a~~ F2376-21a, ~~F2460-18~~ F2460-19, ~~F2461-18~~ F2461-20a, ~~F2959-18~~ F2959-21, F2960-16, ~~F2970-17~~ F2970-20, ~~F2974-19~~ F2974-20, and F3054-18 for the regulation of amusement devices.

   The standards referenced above may be procured from:

ANSI	ASTM
25 W 43rd Street	100 Barr Harbor Dr.
New York, NY 10036	West Conshohocken, PA 19428-2959

1. B. The provisions of this chapter govern where they are in conflict with any provisions of the standards incorporated by reference in this chapter.
2. C. The following requirements supplement the provisions of the ASTM standards incorporated by reference in this chapter:

   1. The operator of an amusement device shall be at least 16 years of age, except when the person is under the supervision of a parent or guardian and engaged in activities determined not to be hazardous by the Commissioner of the Virginia Department of Labor and Industry;
   2. The amusement device shall be attended by an operator at all times during operation except that (i) one operator is permitted to operate two or more amusement devices provided they are within the sight of the operator and operated by a common control panel or station and (ii) one operator is permitted to operate two small mechanical rides with separate controls provided the distance between controls is no more than 35 feet and the controls are equipped with a positive pressure switch; and
   3. The operator of an amusement device shall not be (i) under the influence of any drugs which may affect the operator's judgment or ability to assure the safety of the public or (ii) under the influence of alcohol.

3. D. Where an amusement device was manufactured under previous editions of the standards incorporated by reference in this chapter, the previous editions shall apply to the extent that they are different from the current standards.

Reason Statement: This code change proposal updates the ASTM standards for the regulation of amusement devices to their most current editions.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This code change proposal will not increase or decrease the cost of construction.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Approval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

- [ ] Approved
- [ ] Approved with Modifications
- [ ] Carryover
- [ ] Disapproved
- [ ] None

Public Comments for: AD40-21

This proposal doesn't have any public comments.

Proposal # 982

Tab 9

VADR Proposals Recommended by Workgroups as Consensus for Disapproval

Proposal ID	**Description**	**Page**
AD75-21	Requires riders, parents or guardians of riders, and operators to comply with Chapter 45 of Title §59.1 of the Code of Virginia, "The Amusement Device Rider Safety Act".	Tab 9 – Page 1

AD75-21

Proponents: Charles Littlefield (caseylittlefieldmcp@gmail.com)

2018 Virginia Building and Fire Code Related Regulations

Revise as follows:

13VAC5-31-75. Local building department.
A. In accordance with §§ 36-98.3 and 36-105 of the Code of Virginia, the local building department shall be responsible for the enforcement of this chapter and may charge fees for such enforcement activity. The total amount charged for any one permit to operate an amusement device or devices or the renewal of such permit shall not exceed the following, except that when a private inspector is used, the fees shall be reduced by 75%:

1. $55 for each small mechanical ride or inflatable amusement device covered by the permit;
2. $75 for each circular ride, institutional trampoline, or flat-ride less than 20 feet in height covered by the permit, except concession go-karts.

   Concession go-kart fees shall not exceed $300 per track, for tracks with up to 20 karts. An additional fee of up to $10 may be charged for each additional kart in excess of 20;
3. $100 for each spectacular ride covered by the permit that cannot be inspected as a circular ride or flat-ride in subdivision 2 of this subsection due to complexity or height, except zip lines.

   Zip line fees shall not exceed $150 for each zip line. For the purpose of this section, each portion from launch point to landing point shall be considered a separate zip line and each zip line between a launch point and landing point shall also be considered a separate zip line;
4. $200 for each coaster covered by the permit that exceeds 30 feet in height;
5. $400 for each coaster covered by the permit that exceeds 60 feet in height; and
6. The local building department may charge an additional fee for permits and inspections of generators and associated wiring for amusement device events. Generators subject to these fees are those used exclusively with amusement devices and that are inspected by the local building department. The fee per event shall not exceed $165 and shall not exceed the actual cost to perform the inspection or inspections.

   Exception: Small portable generators serving only cord and plug connected equipment loads are not subject to the fee.

   Notwithstanding the fee limitations established in this section, the local building department shall be permitted to increase the fees up to 50% when requested to perform weekend or after-hour inspections. The local building department shall also be permitted to increase fees up to 50% when a reinspection is required.

1. B. Notwithstanding the provisions of subsection A of this section, when an amusement device is constructed in whole or in part at a site for permanent operation at that site and is not intended to be disassembled and moved to another site, then the local building department may utilize permit and inspection fees established pursuant to the USBC to defray the cost of enforcement. This authorization does not apply to an amusement device that is only being reassembled, undergoing a major modification at a site or being moved to a site for operation.
2. C. A permit application shall be made to the local building department at least five days before the date in which the applicant intends to operate an amusement device. The application shall include the name of the owner, operator or other person assuming responsibility for the device, a general description of the device including any serial or identification numbers available, the location of the property on which the device will be operated, and the length of time of operation. The permit application shall indicate whether a private inspector will be used. If a private inspector is not used, the applicant shall give reasonable notice when an inspection is sought and may stipulate the day such inspection is requested provided it is during the normal operating hours of the local building department. In addition to the information required on the permit application, the applicant shall provide proof of liability insurance of an amount not less than $1 million per occur-rence or proof of equivalent financial responsibility. The local building department shall be notified of any change in the liability insurance or financial responsibility during the period covered by the permit.
3. D. Notwithstanding the provisions of subsection C of this section, a permit application is not required for a small mechanical ride or an inflatable amusement device that has a certificate of inspection issued by any local building department in this Commonwealth either a six-month period for small mechanical rides or within a one-year period for inflatable amusement devices prior to the dates the small mechanical ride or inflatable amusement device is to be used, regardless of whether the device has been disassembled and moved to a new site. In such cases, the local building department shall be notified and provided with the information required on a permit application as listed in subsection C of this section at least three days prior to operation. In addition, and notwithstanding the provisions of subsection A of this section, the local building department shall be permitted to charge a $50 inspection fee per event to the person notifying the local building department of an event where an inflatable amusement device is operating if the local building department chooses to inspect any or all of the inflatable amusement devices operating at that event. An inspection report shall be provided to the person notifying the local building department of the event if such an inspection is conducted.
4. E. Local building department personnel shall examine the permit application within five days and issue the permit if all requirements are met. A certificate of inspection for each amusement device shall be issued when the device has been found to comply with this chapter by a private inspector or by an inspector from the local building department. It shall be the responsibility of the local building department to verify that the private

inspector possesses a valid certificate of competence as an amusement device inspector from the Virginia Board of Housing and Community Development. In addition, local building department personnel shall be responsible for assuring that the certificate of inspection is posted or affixed on or in the vicinity of the device in a location visible to the public. Local building department personnel shall post or affix such certificates or permit the certificates to be posted or affixed by the private inspector. Permits shall indicate the length of time the device or devices will be operated at the site, clearly identify the device or devices to which it applies and the date of expiration of the permit. Permits shall not be valid for longer than one year, except that permits for small mechanical rides shall not be valid for longer than six months.

5. F. In addition to obtaining a certificate of inspection in conjunction with a permit application for amusement devices permanently fixed to a site, a new certificate of inspection shall also be obtained prior to the operation of an amusement device following a major modification, prior to each seasonal operation of a device, at least once during the operating season and prior to resuming the operation of a device following an order from a local building department to cease operation. This requirement shall not apply to small mechanical rides meeting the conditions outlined in subsection D of this section.
6. G. For amusement devices manufactured prior to 1978, the owner or operator shall have the information required by 10.1 through 10.6 of ASTM F1193 available at the time of inspection. In addition, the operator of any amusement device shall be responsible for obtaining all manufacturer's notifications, service bulletins and safety alerts issued pursuant to ASTM F770 and the operator shall comply with all recommendations and requirements set out in those documents. A copy of all such documents shall be made available during an inspection.
7. H. In the enforcement of this chapter, local building department personnel shall have authority to conduct inspections at any time an amusement device would normally be open for operation or at any other time if permission is granted by the owner or operator, to issue an order to temporarily cease operation of an amusement device upon the determination that the device may be unsafe or may otherwise endanger the public and to accept and approve or deny requests for modifications of the rules of this chapter in accordance with the modification provisions of the USBC.
8. I. In accordance with subdivision 7 of § 36-137 of the Code of Virginia, the local building department shall collect a 2.0% levy of fees charged for permits under this chapter and transmit it quarterly to DHCD to support training programs of the Virginia Building Code Academy. Localities that maintain individual or regional training academies accredited by DHCD shall retain such levy.
9. J. In accordance with § 36-98.3 of the Code of Virginia and 13VAC5-31-10 B, the procedures for violations of this chapter shall be as prescribed in the USBC.
10. K. In accordance with § 36-98.1 of the Code of Virginia, the Virginia Department of General Services (DGS) shall function as the local building department for the application of this chapter to amusement devices located on state-owned property. In accordance with §§ 36-98.2 and 36-114 of the Code of Virginia, appeals of the application of this chapter by the DGS shall be made directly to the State Building Code Technical Review Board. Further, as a condition of this chapter, such appeals shall be filed within 14 calendar days after receipt of the decision of DGS.
11. L. In addition to the provisions of this Chapter, riders, parents or guardians of riders, and operators shall also comply with Chapter 45 of Title §59.1 of the Code of Virginia, "The Amusement Device Rider Safety Act".

Reason Statement: Adding language into the VADR about the Patron Safety Act gives users the ability to cite specific code when an accident or injury occurs because of the actions of a patron or Rider. Most Jurisdictions in the State aren't aware this language actually exists so bringing it into the regulations assures that should an accident occur and it was determined that the patron or rider is a fault, proper language can be cited. This language also helps carnivals and fairs provide guidance when misbehaving patrons or riders don't follow established rules.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
This Code change is for reference only and will not impact the cost of construction.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency

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Workgroup Recommendation

2021 Workgroups Workgroup Action: Consensus Disapproval

2021 Workgroups Reason:

Board Decision

C & S Action: None

Board Reason: N/A

Board Decisions

☐ Approved
☐ Approved with Modifications
☐ Carryover

☐ Disapproved
☐ None

Public Comments for: AD75-21

This proposal doesn't have any public comments.

Proposal # 1153