AGENDA

Statewide Fire Prevention Code (SFPC) Sub-workgroup

May 11, 2022

9:00 a.m.

Virtual Meeting: https://vadhcd.adobeconnect.com/va2021cdc/

I) Welcome and introductions

II) Discussion

A) Fire Safety During Construction – Andrew Milliken proposals
- FP3303.3.1-21
- B3302.4-21
- EB1209.1-21

B) Code Change Proposals:
- FP1207-21
- FP107.11-21
- FP111.2-21
- FP906.1-21
- FP912.2-21
- FP5601.2.2.1-21
- FP5705.5-21

III) Other

IV) Assignments and Next Steps

FP3303.3.1-21

IFC: 3303.3.1, 3305.9, 3307.2.1, 3311.1, [BE] 3312.1, 3314.1, 3314.2, 3314.3

Proponents: VFSB Codes and Standards Committee (amilliken@staffordcountyva.gov)

2021 International Fire Code

Revise as follows:

3303.3.1 Violations. ~~Failure~~ Failure to properly conduct, document and maintain documentation required by this section shall constitute an unlawful act in accordance with Section ~~112.1 and shall result in the issuance of a notice of violation to the site safety director in accordance with Section 112.3. Upon the third offense~~ 111 and, the *fire code official* ~~is authorized to issue a stop work order in accordance with Section 113, and work shall not resume until satisfactory assurances of future compliance have been presented to and *approved* by the *fire code official.*~~ may request a stop work order be issued by the Building Official.

3305.9 Separations between construction areas. Separations used in Type I and Type II construction to separate construction areas from occupied portions of the building shall be maintained in accordance with the applicable building code. ~~constructed of materials that comply with one of the following:~~

1. ~~Noncombustible materials.~~
2. ~~Materials that exhibit a flame spread index not exceeding 25 when tested in accordance with ASTM E84 or UL 723.~~
3. ~~Materials exhibiting a peak heat release rate not exceeding 300 kW/m^2 when tested in accordance with ASTM E1354 at an incident heat flux of 50 kW/m^2 in the horizontal orientation on specimens at the thickness intended for use.~~

3307.2.1 Pipe cleaning and purging. The cleaning and purging of flammable gas piping systems, including cleaning new or existing piping systems, purging piping systems into service and purging piping systems out of service, shall comply with NFPA 56.

Exceptions:

1. *Compressed gas* piping systems other than fuel gas piping systems where in accordance with Chapter 53.
2. Piping systems regulated by the ~~International~~ Virginia *Fuel Gas Code*.
3. Liquefied petroleum gas systems in accordance with Chapter 61.

3311.1 Required access. *Approved* vehicle access for fire fighting shall be provided to all construction or demolition sites. Vehicle access shall be provided to within 100 feet (30 480 mm) of buildings and temporary or permanent fire department connections. Vehicle access shall be provided by either temporary or permanent roads, capable of supporting vehicle loading under all weather conditions. Vehicle access shall be maintained until permanent fire apparatus access roads are available.

[BE] 3312.1 Stairways ~~required~~. Where building construction exceeds 40 feet (12 192 mm) in height above the lowest level of fire department vehicle access, a temporary or permanent *stairway* shall be ~~provided.~~ maintained in accordance with the applicable building code. As construction progresses, such *stairway* shall be ~~extended to within one floor of the highest point of construction having secured decking or flooring.~~ maintained in accordance with the applicable building code.

3314.1 Where required. ~~In buildings buildings required to~~ Where required by the applicable building code, a temporary or permanent standpipe shall be maintained and remain in an operable condition so as to be available for use by the fire department. ~~to have standpipes by Section 905.3.1, not less than one standpipe shall be provided for use during construction. Such standpipes shall be installed prior to construction exceeding 40 feet (12 192 mm) in height above the lowest level of fire department vehicle access. Such standpipes shall be provided with fire department hose connections at locations adjacent to *stairways* complying with Section 3312.1. As construction progresses, such standpipes shall be extended to within one floor of the highest point of construction having secured decking or flooring.~~

Delete without substitution:

~~**3314.2 Buildings being demolished.** Where a building is being demolished and a standpipe is existing within such a building, such standpipe shall be maintained in an operable condition so as to be available for use by the fire department. Such standpipe shall be demolished with the building but shall not be demolished more than one floor below the floor being demolished.~~

~~**3314.3 Detailed requirements.** Standpipes shall be installed in accordance with the provisions of Section 905.~~

~~**Exception:** Standpipes shall be either temporary or permanent in nature, and with or without a water supply, provided that such standpipes comply with the requirements of Section 905 as to capacity, outlets and materials.~~

Reason Statement: Clean up of Chapter 33 Fire Safety Durning Construction to remove construction provisions and correlate better with the VCC and VEBC.

Resiliency Impact Statement: This proposal will increase Resiliency
By improving the SFPC, the resiliency of communities is increased by protecting them from the hazards associated with poor fire safety practices during construction.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
No cost impact.

B3302.4-21

IBC®: 3302.4 (New), 3302.5 (New), [F] 3312.1, [F] 3313.1, [F] 3313.2, [F] 3313.3, [F] 3313.3.1, [F] 3313.3.2, [F] 3313.3.3, [F] 3313.4, [F] 3313.5

Proponents: VFSB Codes and Standards Committee (amilliken@staffordcountyva.gov)

2021 International Building Code

Add new text as follows:

3302.4 Separations between construction areas. Separations used in Type I and Type II construction to separate construction areas from occupied portions of the building shall be constructed of materials that comply with one of the following:

1.Noncombustible materials.

2.Materials that exhibit a flame spread index not exceeding 25 when tested in accordance with ASTM E84 or UL 723.

3.Materials exhibiting a peak heat release rate not exceeding 300 $kW/m^2$when tested in accordance with ASTM E1354 at an incident heat flux of 50 kW/m^2in the horizontal orientation on specimens at the thickness intended for use

3302.5 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction. Buildings of Types IV-A, IV-B and IV-C construction designed to be greater than six stories above grade plane shall comply with the following requirements during construction unless otherwise approved by the building code official:

1.Standpipes shall be provided in accordance with Section 3311.

2.A water supply for fire department operations, as approved by the fire code official and the fire chief.

3.Where building construction exceeds six stories above grade plane and noncombustible protection is required by Section 602.4 at least one layer of noncombustible protection shall be installed on all building elements on floor levels, including mezzanines, more than four levels below active mass timber construction before additional floor levels can be erected.

Exception:Shafts and vertical exit enclosures shall not be considered part of the active mass timber construction.

4.Where building construction exceeds six stories above grade plane, required exterior wall coverings shall be installed on floor levels, including mezzanines, more than four levels below active mass timber construction before additional floor levels can be erected.

Exception:Shafts and vertical exit enclosures shall not be considered part of the active mass timber construction.

Revise as follows:

[F] 3312.1 Completion before occupancy. In buildings where an *automatic sprinkler system* is required by this code, it shall be unlawful to occupy any portion of a building or structure until the *automatic sprinkler system* installation has been tested and *approved*, except as provided in Section ~~111.3.~~ 116.1.1.

[F] 3313.1 Where required. An *approved* water supply for fire protection, either temporary or permanent, shall be made available as soon as combustible building materials arrive on the site, on commencement of vertical combustible construction, and on installation of a standpipe system in buildings under construction, in accordance with ~~Sections 3313.2 through 3313.5.~~ the Virginia Statewide Fire Prevention Code.

~~**Exception:** The *fire code official* is authorized to reduce the fire-flow requirements for isolated buildings or a group of buildings in rural areas or small communities where the development of full fire-flow requirements is impractical.~~

Delete without substitution:

~~**[F] 3313.2 Combustible building materials.** When combustible building materials of the building under construction are delivered to a site, a minimum fire flow of 500 gallons per minute (1893 L/m) shall be provided. The fire hydrant used to provide this fire flow supply shall be within 500 feet (152 m) of the combustible building materials, as measured along an approved fire apparatus access lane. Where the site configuration is such that one fire hydrant cannot be located within 500 feet (152 m) of all combustible building materials, additional fire hydrants shall be required to provide coverage in accordance with this section.~~

~~**[F] 3313.3 Vertical construction of Types III, IV and V construction.** Prior to commencement of vertical construction of Type III, IV or V buildings that utilize any combustible building materials, the fire flow required by Sections 3313.3.1 through 3313.3.3 shall be provided, accompanied by fire hydrants in sufficient quantity to deliver the required fire flow and proper coverage.~~

~~**[F] 3313.3.1 Fire separation up to 30 feet.** Where a building of Type III, IV or V construction has a *fire separation distance* of less than 30 feet (9144 mm) from property lot lines, and an adjacent property has an *existing structure* or otherwise can be built on, the water supply shall provide either a minimum of 500 gallons per minute (1893 L/m), or the entire fire flow required for the building when constructed, whichever is greater.~~

~~**[F] 3313.3.2 Fire separation of 30 feet up to 60 feet.** Where a building of Type III, IV or V construction has a *fire separation distance* of 30 feet (9144 mm) up to 60 feet (18 288 mm) from property lot lines, and an adjacent property has an *existing structure* or otherwise can be built on, the water supply shall provide a minimum of 500 gallons per minute (1893 L/m), or 50 percent of the fire flow required for the building when constructed, whichever is greater.~~

~~**[F] 3313.3.3 Fire separation of 60 feet or greater.** Where a building of Type III, IV or V construction has a fire separation of 60 feet (18 288 mm) or greater from a property lot line, a water supply of 500 gallons per minute (1893 L/m) shall be provided.~~

~~**[F] 3313.4 Vertical construction, Types I and II construction.** If combustible building materials are delivered to the construction site, water supply in accordance with Section 3313.2 shall be provided. Additional water supply for fire flow is not required prior to commencing vertical construction of Type I and II buildings.~~

~~**[F] 3313.5 Standpipe supply.** Regardless of the presence of combustible building materials, the construction type or the *fire separation distance*, where a standpipe is required in accordance with Section 3313, a water supply providing a minimum flow of 500 gallons per minute (1893 L/m) shall be provided. The fire hydrant used for this water supply shall be located within 100 feet (30 480 mm) of the fire department connection supplying the standpipe.~~

Reason Statement: Clean up of Chapter 33 Fire Safety Durning Construction to relocate construction provisions from the SFPC and correlate better with the SFPC and VEBC. Sections 3309.3 and 3309.4 are relocating the deleted construction sections from the SFPC. Section 3312.1 corrects the reference to 116.1.1 for temporary occupancy. Section 3313.1 is revised with 2021 language and references the SFPC for fire flow requirements. It also includes deleting sections 3313.2 through 3313.5 which are to be in the SFPC.

Resiliency Impact Statement: This proposal will increase Resiliency
By improving Chapter 33 of the VCC, the resiliency of communities is increased by protecting them from the hazards associated with poor fire safety practices during construction.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
No cost impact.

EB1209.1-21

VEBC: 1201.8 (New), 1209.1

Proponents: VFSB Codes and Standards Committee (amilliken@staffordcountyva.gov)

2018 Virginia Existing Building Code

Add new text as follows:

1201.8 Separations between construction areas. Separations used in Type I and Type II construction to separate construction areas from occupied portions of the building shall be constructed of materials that comply with one of the following:

1.Noncombustible materials.

2.Materials that exhibit a flame spread index not exceeding 25 when tested in accordance with ASTM E84 or UL 723.

3.Materials exhibiting a peak heat release rate not exceeding 300 kW/m2when tested in accordance with ASTM E1354 at an incident heat flux of 50 kW/m2in the horizontal orientation on specimens at the thickness intended for use

Revise as follows:

1209.1 When required. An approved water supply for fire protection, either temporary or permanent, shall be made available as soon as combustible material arrives on the ~~site.~~ site, on commencement of vertical combustible construction, and on installation of a standpipe system during alterations, repairs, or additions to any building or structure in accordance with the Virginia Statewide Fire Prevention Code.

Reason Statement: Clean up of Section 1209.1 to provide 2021 language and reference the SFPC for fire flow and associated details. It also correlates better with the VCC and SFPC.
Section 1201.8 has been added due to comments during the SFPC Sub-workgroup where it was recommended to add this section to the VEBC rather than just the VCC since it could involve an already occupied area. This language is identical to the language removed from the SFPC and belongs in the VEBC.

Resiliency Impact Statement: This proposal will increase Resiliency
By improving the fire safety provisions of the VEBC, the resiliency of communities is increased by protecting them from the hazards associated with poor fire safety practices during construction.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
No cost impact.

FP1207-21

VFC: SECTION 1206

Proponents: DHCD Staff (sbco@dhcd.virginia.gov) on behalf of the SFPC Sub-workgroup.

2018 Virginia Statewide Fire Prevention Code

Revise as follows:

SECTION ~~1206~~ 1207 ELECTRICAL ENERGY STORAGE SYSTEMS.

Revise Section 1207 as shown on the attached document "20220418 SFPC SWG Meeting - Section 1207 Results".

Reason Statement: Section 1207 of the IFC - Energy Storage Systems - has received numerous revisions from the 2018 to the 2021 version of the code. A number of said revisions contain construction requirements which do not belong in the SFPC - a maintenance and operation code. The entire Section has been reviewed and edited by the SFPC Sub-workgroup to delete construction provisions, or, revise with maintenance type language where appropriate. These efforts are a continuation of the edit efforts that occurred over the previous code development cycles. The attached document "20220418 SFPC SWG Meeting - Section 1207 Results" shows all the proposed changes in legislative format.

Resiliency Impact Statement: This proposal will neither increase nor decrease Resiliency
Although it may appear that the proposal deletes certain construction code provisions, those requirements are in fact addressed by the applicable building code.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
It could be argued that the revisions proposed could potentially reduce costs as a result of clarifying which code provisions are to be applied to any given scenario.

Attached Files

- **20220418 SFPC SWG Meeting - Section 1207 Results.pdf**
  https://va.cdpaccess.com/proposal/1137/1511/files/download/655/

2018 VIRGINIA STATEWIDE FIRE PREVENTION CODE

Make the following change to Chapter 1 of the SFPC:

TABLE 107.2 OPERATIONAL PERMIT REQUIREMENTS (to be filled in by local jurisdiction)

An operational permit is required for stationary and mobile energy storage systems regulated by Section 1207.

2021 INTERNATIONAL FIRE CODE

Make the following changes to Section 1207 of the 2021 IFC (2021 IFC 1207-series sections and subsections not listed here to remain unchanged):

SECTION 1207
ELECTRICAL ENERGY STORAGE SYSTEMS (ESS)

1207.1.2 Permits. Permits shall be ~~obtained for ESS as follows:~~ required as set forth in Section 107.2.

1. ~~Construction permits shall be obtained for stationary ESS installations and for mobile ESS charging and storage installations covered by Section 1207.10.1. Permits shall be obtained in accordance with Section 105.6.5.~~
2. ~~Operational permits shall be obtained for stationary ESS installations and for mobile ESS deployment operations covered by Section 1207.10.3. Permits shall be obtained in accordance with Section 105.5.14.~~

1207.1.3 ~~Construction documents.~~ Documents. ~~The~~ At the minimum, the following information shall be provided with the operational permit application:

1. Location and layout diagram of the room or area in which the ESS is ~~to be installed.~~ located.
2. Details on the hourly *fire-resistance ratings* of assemblies enclosing the ESS.
3. The quantities and types of ESS ~~to be installed~~.
4. Manufacturer's specifications, ratings and listings of each ESS.
5. Description of energy (battery) management systems and their operation.
6. Location and content of required signage.
7. Details on fire suppression, smoke or fire detection, thermal management, ventilation, exhaust and *deflagration* venting systems, if provided.
8. Support arrangement ~~associated with the installation~~, including any required seismic restraint.
9. ~~A commissioning plan complying with Section 1207.2.1.~~
10. A decommissioning plan ~~complying~~ in accordance with Section 1207.2.3.

1207.1.4 Hazard mitigation analysis. ~~A~~ As part of the operational permit application, a failure modes and effects analysis (FMEA) or other ~~*approved*~~ hazard mitigation analysis approved in accordance with the applicable building code, shall be provided ~~in accordance with Section 104.8.2~~ to the Fire Official under any of the following conditions:

1. Where ESS technologies not specifically identified in ~~Table 1207.1.1~~ the applicable building code are provided.
2. More than one ESS technology is provided in a room or enclosed area where there is a potential for adverse interaction between technologies.
3. Where allowed as a basis for increasing maximum allowable ~~quantities. See Section 1207.5.2.~~ quantities in accordance with the applicable building code.

The FMEA shall be prepared by a qualified engineer, specialist, laboratory or fire safety specialty organization acceptable to the *fire code official* and shall analyze the fire safety properties of the design, operation or use of the building or premises and the facilities and appurtenances situated thereon, to recommend necessary changes. The *fire code official* is authorized to require that the FMEA be prepared by, and bear the stamp of, a *registered design professional*.

~~**1207.1.4.1 Fault condition.** The hazard mitigation analysis shall evaluate the consequences of the following failure modes. Only single failure modes shall be considered.~~

1. ~~A thermal runaway condition in a single ESS rack, module or unit.~~
2. ~~Failure of any battery (energy) management system.~~
3. ~~Failure of any required ventilation or exhaust system.~~
4. ~~Voltage surges on the primary electric supply.~~
5. ~~Short circuits on the load side of the ESS.~~
6. ~~Failure of the smoke detection, fire detection, fire suppression or gas detection system.~~
7. ~~Required spill neutralization not being provided or failure of a required secondary containment system.~~

~~**1207.1.4.2 Analysis approval.** The *fire code official* is authorized to approve the hazardous mitigation analysis provided that the consequences of the hazard mitigation analysis demonstrate:~~

1. ~~Fires will be contained within unoccupied ESS rooms or areas for the minimum duration of the fire-resistance-rated separations identified in Section 1207.7.4.~~
2. ~~Fires in occupied work centers will be detected in time to allow occupants within the room or area to safely evacuate.~~
3. ~~Toxic and highly toxic gases released during fires will not reach concentrations in excess of the IDLH level in the building or adjacent *means of egress* routes during the time deemed necessary to evacuate occupants from any affected area.~~
4. ~~Flammable gases released from ESS during charging, discharging and normal operation will not exceed 25 percent of their lower flammability limit (LFL).~~
5. ~~Flammable gases released from ESS during fire, overcharging and other abnormal conditions will be controlled through the use of ventilation of the gases, preventing accumulation, or by *deflagration* venting.~~

1207.1.4.3 Additional protection measures. ~~Construction, equipment~~ Equipment and systems that are required for the ESS to comply with the hazardous mitigation analysis, ~~including but not limited to those specifically described in Section 1207,~~ shall be ~~installed,~~ maintained ~~and tested~~ in accordance with ~~nationally recognized standards and specified design parameters.~~ the applicable building code.

1207.1.5 Large-scale fire test. ~~Where required elsewhere in Section 1207,~~ ESS approved by the building official based on large-scale fire testing ~~shall be conducted on a representative ESS in accordance with UL 9540A. The testing shall be~~ conducted or witnessed and reported by an *approved* testing laboratory in accordance with the applicable building code, shall be maintained such ~~and show~~ that a fire involving one ESS will not propagate to an adjacent ESS, and where installed within buildings, enclosed areas and walk-in units will be contained within the room, enclosed area or walk-in unit for a duration equal to the *fire-resistance rating* of the room separation specified in ~~Section 1207.7.4.~~ the applicable building code. ~~The test report shall be provided to the *fire code official* for review and approval in accordance with Section 104.8.2.~~

1207.2.1 Commissioning. ~~Commissioning of~~ Prior to operational permit issuance, newly installed ESS and existing ESS that have been retrofitted, replaced or previously decommissioned and are returning to service shall be ~~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:~~ commissioned in accordance with the applicable building code. The fire official shall be provided, upon request, with 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.

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*.

~~**1207.2.1.1 Initial acceptance testing.** During the commissioning process an ESS shall be evaluated for proper operation in accordance with the manufacturer's instructions and the commissioning plan prior to final approval.~~

1207.2.1.2 Commissioning report. A report describing the results of the system commissioning, including the results of the initial acceptance testing required ~~in Section 1207.2.1.1~~ by the applicable building code, shall be provided to the *fire code official* ~~prior to final inspection~~ , upon request. ~~and approval and~~ A copy of the report shall be maintained at an *approved* on-site location.

1207.2.3 Decommissioning. ~~The code official shall be notified prior to the decommissioning of an ESS.~~ Decommissioning shall be performed in accordance with the decommissioning plan ~~that includes the following:~~ approved in accordance with the applicable building code. The fire code official shall also be notified by the ESS owner prior to the decommissioning of an ESS.

1. ~~A narrative description of the activities to be accomplished for removing the ESS from service, and from the facility in which it is located.~~
2. ~~A listing of any 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.~~

1207.3.3 Utility interactive systems. ~~Inverters~~ When required by the applicable building code, inverters shall be *listed* and *labeled* in accordance with UL 1741. Only inverters *listed* and *labeled* for utility interactive system use and identified as interactive shall be allowed to operate in parallel with the electric utility power system to supply power to common loads.

1207.3.4 Energy storage management system. ~~Where required by the ESS listing, an *approved*~~ Approved energy storage management ~~system~~ systems, required by the ESS listing, that ~~monitors~~ monitor and ~~balances~~ balance cell voltages, currents and temperatures within the manufacturer's specifications shall be ~~provided.~~ maintained. The system shall disconnect electrical connections to the ESS or otherwise place it in a safe condition if potentially hazardous temperatures or other conditions such as short circuits, over voltage or under voltage are detected.

1207.3.5 Enclosures. Enclosures of ESS shall be ~~of noncombustible construction.~~ maintained in accordance with the applicable building code.

1207.3.6 ~~Repairs.~~ Repairs or Alterations. Repairs or alterations of ESS shall only be done by qualified personnel. Repairs and alterations ~~with other than identical parts~~ shall be ~~considered retrofitting and comply with Section 1207.3.7.~~ in accordance with the applicable building code. Repairs shall be documented in the service records log.

~~**1207.3.7 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.~~
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. ~~Systems that have been retrofitted shall be commissioned in accordance with Section 1207.2.1.~~
6. ~~Retrofits shall be documented in the service records log.~~

~~**1207.3.7.1 Retrofitting lead acid and nickel cadmium.** Section 1207.3.7 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.~~

~~**1207.3.8 Replacements.** Replacements of ESS shall be considered new ESS installations and shall comply with the provisions of Section 1207 as applicable to new ESS. The ESS being replaced shall be decommissioned in accordance with Section 1207.2.3.~~

~~**1207.3.9 Reused and repurposed equipment.** Equipment and materials shall only be reused or reinstalled as permitted in Section 104.8.1. Storage batteries previously used in other applications, such as electric vehicle propulsion, shall not be reused in applications regulated by Chapter 12 unless *approved* by the *fire code official* and unless the equipment is refurbished by a battery refurbishing company *approved* in accordance with UL 1974.~~

1207.4 General ~~installations~~ maintenance requirements. Stationary and mobile ESS shall comply with the requirements of Sections 1207.4.1 through 1207.4.12.

1207.4.2 Working clearances. Access and working space shall be ~~provided and~~ maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment in accordance with the applicable NFPA 70 and the manufacturer's instructions.

1207.4.3 Fire-resistance-rated separations. ~~Rooms~~ Fire-resistance-rated separations for rooms and other indoor areas containing ESS shall be ~~separated from other areas of the building in accordance with Section 1207.7.4. ESS shall be permitted to be in the same room with the equipment they support.~~ maintained in accordance with the applicable building code and Chapter 7.

~~**1207.4.4 Seismic and structural design.** Stationary ESS shall comply with the seismic design requirements in Chapter 16 of the *International Building Code*, and shall not exceed the floor loading limitation of the building.~~

1207.4.7 Toxic and highly toxic gases. Hazardous exhaust systems for ESS that have the potential to release toxic and highly toxic gas during charging, discharging and normal use conditions ~~shall be provided with a hazardous exhaust system in accordance with Section 502.8 of the *International Mechanical Code*~~. shall be operated and maintained.

1207.4.10 Occupied work centers. ~~Electrochemical~~ Cabinets containing electromechanical ESS located in rooms or areas occupied by personnel not directly involved with maintenance, service and testing of the systems shall ~~comply with the following:~~ be secured and provided with signage complying with Section 1207.4.8.

1. ~~Electrochemical ESS located in occupied work centers shall be housed in locked noncombustible cabinets or other enclosures to prevent access by unauthorized personnel.~~
2. ~~Where electrochemical ESS are contained in cabinets in occupied work centers, the cabinets shall be located within 10 feet (3048 mm) of the equipment that they support.~~
3. ~~Cabinets shall include signage complying with Section 1207.4.8.~~

1207.4.11 Open rack installations. Where electrochemical ESS are ~~installed~~ located in a separate equipment room and only authorized personnel have access to the room, they shall be permitted to be ~~installed~~ located on an open rack for ease of maintenance.

1207.5 Electrochemical ESS protection. The protection of electrochemical ESS shall be maintained in accordance with Sections 1207.5.1 through 1207.5.8 ~~where required by Sections 1207.7 through 1207.10~~.

~~**TABLE 1207.5**~~
~~**MAXIMUM ALLOWABLE QUANTITIES OF ELECTROCHEMICAL ESS**~~

~~TECHNOLOGY~~	~~MAXIMUM ALLOWABLE QUANTITIES[a]~~
~~STORAGE BATTERIES~~	
~~Flow batteries[b]~~	~~600 kWh~~
~~Lead-acid, all types~~	~~Unlimited~~
~~Lithium-ion~~	~~600 kWh~~
~~Nickel metal hydride (Ni-MH)~~	~~Unlimited~~
~~Nickel-cadmium (Ni-Cd)~~	~~Unlimited~~
~~Other battery technologies~~	~~200 kWh~~
~~CAPACITORS~~	
~~All types~~	~~20 kWh~~
~~OTHER ELECTROCHEMICAL ESS~~	
~~All types~~	~~20 kWh~~

~~For SI: 1 kilowatt hour = 3.6 megajoules.~~
~~a. For electrochemical ESS units rated in amp-hours, kWh shall equal rated voltage times the amp-hour rating divided by 1,000.~~
~~b. Shall include vanadium, zinc-bromine, polysulfide-bromide and other flowing electrolyte-type technologies.~~

1207.5.1 Size and separation. ~~Electrochemical ESS shall be segregated into groups not exceeding 50 kWh (180 megajoules). Each group shall be separated a minimum of 3 feet (914 mm) from other groups and from walls in the storage room or area. The storage arrangements shall comply with Chapter 10.~~ The configuration and size of electromechanical ESS groups approved in accordance with the applicable building code shall be maintained in accordance with the applicable building code. The separation between different electromechanical ESS groups and between electromechanical ESS and walls in the storage room or area shall be maintained in accordance with the applicable building code.

~~**Exceptions:**~~

1. ~~Lead-acid and nickel-cadmium battery systems in facilities under the exclusive control of communications utilities and operating at less than 50 VAC and 60 VDC in accordance with NFPA 76.~~

2. ~~The *fire code official* is authorized to approve larger capacities or smaller separation distances based on large-scale fire testing complying with Section 1207.1.5.~~

1207.5.2 Maximum allowable quantities. *Fire areas* within rooms, areas and walk-in units containing electrochemical ESS shall not exceed the maximum allowable quantities in ~~Table 1207.5.~~ the applicable building code.

~~**Exceptions:**~~

1. ~~Where approved by the fire code official, rooms, areas and walk-in units containing electrochemical ESS that exceed the amounts in Table 1207.5 shall be permitted based on a hazardous mitigation analysis in accordance with Section 1207.1.4 and large-scale fire testing complying with Section 1207.1.5.~~
2. ~~Lead-acid and nickel-cadmium battery systems installed in facilities under the exclusive control of communications utilities, and operating at less than 50 VAC and 60 VDC in accordance with NFPA 76.~~
3. ~~Dedicated-use buildings in compliance with Section 1207.7.1.~~

1207.5.2.1 Mixed electrochemical energy systems. Where rooms, areas and walk-in units contain different types of electrochemical energy technologies, the total aggregate quantities of the systems shall ~~be determined based on the sum of percentages of each technology type quantity divided by the maximum allowable quantity of each technology type. The sum of the percentages shall not exceed 100 percent of the maximum allowable quantity.~~ not exceed those allowed by the applicable building code.

1207.5.3 Elevation. ~~Electrochemical~~ Unless otherwise approved in accordance with the applicable building code, electromechanical ESS 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 access.
2. Where the floor is located below the lowest *level of exit discharge*.

~~**Exceptions:**~~

1. ~~Lead-acid and nickel-cadmium battery systems less than 50 VAC and 60 VDC installed in facilities under the exclusive control of communications utilities in accordance with NFPA 76.~~
2. ~~Where *approved*, installations shall be permitted in underground vaults complying with NFPA 70, Article 450, Part III.~~
3. ~~Where *approved* by the *fire code official,* installations shall be permitted on higher and lower floors.~~

1207.5.4 Fire detection. ~~An~~ Where required or provided in accordance with the applicable building code, *approved* automatic smoke detection ~~system~~ systems or radiant energy-sensing fire detection ~~system~~ systems ~~complying with Section 907.2 shall be~~ installed in rooms, indoor areas and walk-in units containing electrochemical ~~ESS.~~ ESS, shall be maintained in accordance with Chapter 9 and the applicable building code. ~~An~~ Where required or provided in accordance with the applicable building code, *approved* radiant energy-sensing fire detection ~~system~~ systems ~~shall be~~ installed to protect open parking garage and rooftop ~~installations.~~ , installations shall be maintained in accordance with Chapter 9 and the applicable building code. ~~Alarm~~ Where required or provided in accordance with the applicable building code, signals from detection systems shall continue to be transmitted to a central station, proprietary or remote station service in accordance with NFPA 72, or where *approved* to a constantly attended location.

1207.5.4.1 System status. Where required ~~by the *fire code official*,~~ or provided in accordance with the applicable building code, visible annunciation ~~shall be~~ provided on cabinet exteriors or in other *approved* locations to indicate that potentially hazardous conditions associated with the ESS ~~exist.~~ exist, it shall be maintained in accordance with the applicable building code.

1207.5.5 Fire suppression systems. ~~Rooms~~ Automatic fire suppression systems required by the applicable building code for rooms and areas within buildings and walk-in units containing electrochemical ESS shall be ~~protected by an automatic fire suppression system designed and installed~~ maintained in accordance with ~~one of the following:~~ Chapter 9 and the applicable building code.

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.~~

~~2. Where *approved*, an *automatic sprinkler system* designed and installed in accordance with Section 903.3.1.1 with a sprinkler hazard classification based on large-scale fire testing complying with Section 1207.1.5.~~

~~3. The following alternative automatic fire-extinguishing systems designed and installed in accordance with Section 904, provided that the installation is *approved* by the *fire code official* based on large-scale fire testing complying with Section 1207.1.5:~~

~~3.1. NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*.~~

~~3.2. NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*.~~

~~3.3. NFPA 750, *Standard on Water Mist Fire Protection Systems*.~~

~~3.4. NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*.~~

~~3.5. NFPA 2010, *Standard for Fixed Aerosol Fire-Extinguishing Systems*.~~

~~**Exception:** Fire suppression systems for lead-acid and nickel-cadmium battery systems at facilities under the exclusive control of communications utilities that operate at less than 50 VAC and 60 VDC shall be provided where required by NFPA 76.~~

1207.5.5.1 Water-reactive systems. ~~Electrochemical ESS that utilize water-reactive materials shall be protected by an *approved* alternative~~ Alternative automatic fire-extinguishing ~~system~~ systems approved in accordance with ~~Section 904, where the installation is *approved* by the *fire code official*~~ the applicable building code, based on large-scale fire testing ~~complying with Section 1207.1.5.~~ , for the protection of electrochemical ESS that utilize water-reactive materials, shall be maintained in accordance with the applicable building code.

1207.5.6 Maximum enclosure size. ~~Outdoor~~ Unless otherwise approved in accordance with the applicable building code, outdoor walk-in units housing ESS shall not exceed 53 feet by 8 feet by 9.5 feet high (16 154 mm × 2438 mm × 2896 mm), not including bolt-on HVAC and related equipment~~, as *approved*~~. Outdoor walk-in units exceeding these limitations shall be considered indoor installations and comply with the requirements in Section 1207.7.

1207.5.8 Means of egress separation. ESS located outdoors and in open parking garages shall continue to be separated from any *means of egress* ~~as required by the *fire code official*~~ in accordance with the applicable building code to ensure safe egress under fire conditions~~, but in no case less than 10 feet (3048 mm)~~.

~~**Exception:** The fire code official is authorized to approve a reduced separation distance if large-scale fire testing complying with Section 1207.1.5 is provided that shows that a fire involving the ESS will not adversely impact occupant egress.~~

1207.6 Electrochemical ESS technology-specific protection. Electrochemical ESS installations shall ~~comply with the requirements of this section in accordance with the applicable requirements of Table 1207.6.~~ be maintained in accordance with this section and the applicable building code.

~~**TABLE 1207.6**~~
~~**ELECTROCHEMICAL ESS TECHNOLOGY-SPECIFIC REQUIREMENTS**~~

COMPLIANCE REQUIRED[b]		BATTERY TECHNOLOGY				OTHER ESS AND BATTERY TECHNOLOGIES[b]	CAPACITOR ESS[b]
Feature	Section	Lead-acid	Ni-Cd and Ni-MH	Lithium-ion	Flow		
Exhaust ventilation	1207.6.1	Yes	Yes	No	Yes	Yes	Yes
Explosion control	1207.6.3	Yes[a]	Yes[a]	Yes	No	Yes	Yes
Safety caps	1207.6.4	Yes	Yes	No	No	Yes	Yes
Spill control and neutralization	1207.6.2	Yes[c]	Yes[c]	No	Yes	Yes	Yes
Thermal runaway	1207.6.5	Yes[d]	Yes	Yes[e]	No	Yes[e]	Yes

~~a. Not required for 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.~~

~~b. Protection shall be provided unless documentation acceptable to the fire code official is provided in accordance with Section 104.8.2 that provides justification why the protection is not necessary based on the technology used.~~

~~c. Applicable to vented-type (i.e., flooded) nickel-cadmium and lead-acid batteries.~~

~~d. Not required for vented-type (i.e., flooded) lead-acid batteries.~~

~~e. The thermal runaway protection is permitted to be part of a battery management system that has been evaluated with the battery as part of the evaluation to UL 1973~~.

1207.6.1 Exhaust ventilation. Where required ~~by Table 1207.6 or elsewhere in this~~ or provided in accordance with the applicable building code, exhaust ventilation of rooms, areas and walk-in units containing electrochemical ESS shall be ~~provided~~ maintained in accordance with the ~~*International Mechanical Code* and Section 1207.6.1.1 or 1207.6.1.2.~~ applicable building code.

1207.6.1.1 Ventilation based on LFL. ~~The~~ Where required or provided in accordance with the applicable building code, exhaust ventilation ~~system shall be~~ systems 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.~~ shall be maintained in accordance with the applicable building code.

1207.6.1.2 Ventilation based on exhaust rate. ~~Mechanical~~ Continuous mechanical exhaust ventilation, or activated by a gas detection system, ~~shall~~ required by the applicable building code to 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.~~ unit, shall be maintained in accordance with the applicable building code. ~~The ventilation shall be either continuous or shall be activated by a gas detection system in accordance with Section 1207.6.1.2.4.~~

1207.6.1.2.1 Standby power. ~~Mechanical~~ Where standby power is required by the applicable building code for exhaust ventilation ~~shall be provided with a minimum of 2 hours of standby power in accordance with Section 1203.2.5~~. , the standby power shall be maintained in accordance with the applicable building code.

~~**1207.6.1.2.2 Installation instructions.** Required mechanical exhaust ventilation systems shall be installed in accordance with the manufacturer's installation instructions and the *International Mechanical Code*~~.

1207.6.1.2.3 Supervision. ~~Required~~ Where mechanical exhaust ventilation systems ~~shall~~ are required by the applicable building code to be supervised by an *approved* central station, proprietary or remote station service in accordance with the applicable NFPA 72, the system shall continue to be supervised. ~~or~~ Or, it shall initiate an audible and visible signal at an *approved* constantly attended on-site ~~location.~~ location in accordance with the applicable building code.

1207.6.1.2.4 Gas detection system. ~~Where required by Section 1207.6.1.2,~~ Continuous gas detection systems required by the applicable building code for rooms, areas and walk-in units containing ESS shall be ~~protected by an *approved* continuous gas detection system that complies with Section 916 and with the following:~~ maintained in accordance with the applicable building code.

~~1. The gas detection system shall be designed to activate the mechanical ventilation system when the level of flammable gas in the room, area or walk-in unit exceeds 25 percent of the LFL.~~

~~2. The mechanical ventilation system shall remain on until the flammable gas detected is less than 25 percent of the LFL.~~

~~3. The gas detection system shall be provided with a minimum of 2 hours of standby power in accordance with Section 1203.2.5.~~

~~4. Failure of the gas detection system shall annunciate a trouble signal at an approved central station, proprietary or remote station service in accordance with NFPA 72, or shall initiate an audible and visible trouble signal at an approved constantly attended on-site location.~~

1207.6.2 Spill control and neutralization. ~~Where required by Table 1207.6 or elsewhere in this code,~~ Spill control and neutralization required by the applicable building code for areas containing free-flowing liquid electrolyte or hazardous materials shall be ~~provided with spill control and neutralization in accordance with this section.~~ maintained in accordance with the applicable building code.

~~**1207.6.2.1 Spill control.** Spill control shall be provided to prevent the flow of liquid electrolyte or hazardous materials to adjoining rooms or areas. The method shall be capable of containing a spill from the single largest battery or vessel.~~

~~**1207.6.2.2 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~~.

1207.6.3 Explosion control. ~~Where required by Table 1207.6 or elsewhere in this code, explosion control complying with Section 911 shall be provided for rooms, areas or walk-in units containing electrochemical ESS technologies.~~ Explosion control shall be maintained in accordance with Chapter 9 and the applicable building code.

~~**Exceptions:**~~

1. ~~Where approved, explosion control is permitted to be waived by the fire code official based on large-scale fire testing complying with Section 1207.1.5 that demonstrates that flammable gases are not liberated from electrochemical ESS cells or modules where tested in accordance with UL 9540A.~~
2. ~~Where approved, explosion control is permitted to be waived by the fire code official based on documentation provided in accordance with Section 104.7 that demonstrates that the electrochemical ESS technology to be used does not have the potential to release flammable gas concentrations in excess of 25 percent of the LFL anywhere in the room, area, walk-in unit or structure under thermal runaway or other fault conditions.~~

1207.6.4 Safety caps. ~~Where required by Table 1207.6 or elsewhere in this code, vented batteries and other ESS shall be provided with flame-arresting safety caps.~~ Flame-arresting safety caps for vented batteries, provided or required in accordance with the applicable building code, shall be maintained.

1207.6.5 Thermal runaway. Where ~~required by Table 1207.6 or elsewhere in this code,~~ the applicable building code requires batteries and other ESS ~~shall~~ to be provided with a *listed* device or other *approved* method to prevent, detect and minimize the impact of thermal ~~runaway.~~ runaway, such listed devices or approved methods shall be maintained in accordance with the applicable building code.

1207.7 Indoor installations. Indoor ESS installations shall be maintained in accordance with ~~Sections 1207.7.1 through 1207.7.4.~~ the applicable building code.

~~**TABLE 1207.7**~~
~~**INDOOR ESS INSTALLATIONS**~~

~~COMPLIANCE REQUIRED~~		~~DEDICATED-USE BUILDINGS[a]~~	~~NONDEDICATED-USE BUILDINGS[b]~~
~~Feature~~	~~Section~~		
~~Dwelling units and sleeping units~~	~~1207.7.3~~	~~NA~~	~~Yes~~
~~Elevation~~	~~1207.5.3~~	~~Yes~~	~~Yes~~
~~Fire suppression systems~~	~~1207.5.5~~	~~Yes[c]~~	~~Yes~~
~~Fire-resistance-rated separations~~	~~1207.7.4~~	~~Yes~~	~~Yes~~
~~General installation requirements~~	~~1207.4~~	~~Yes~~	~~Yes~~
~~Maximum allowable quantities~~	~~1207.5.2~~	~~No~~	~~Yes~~
~~Size and separation~~	~~1207.5.1~~	~~Yes~~	~~Yes~~
~~Smoke and automatic fire detection[e]~~	~~1207.5.4~~	~~Yes[d]~~	~~Yes~~
~~Technology specific protection~~	~~1207.6~~	~~Yes~~	~~Yes~~

~~NA = Not Allowed.~~
~~a. See Section 1207.7.1.~~
~~b. See Section 1207.7.2.~~
~~c. Where approved by the fire code official, fire suppression systems are permitted to be omitted in dedicated-use buildings located more than 100 feet (30.5 m) from buildings, lot lines, public ways, stored combustible materials, hazardous materials, high-piled stock and other exposure hazards.~~
~~d. Where approved by the fire code official, alarm signals are not required to be transmitted to a central station, proprietary or remote station service in accordance with NFPA 72, or a constantly attended location where local fire alarm annunciation is provided and trained personnel are always present.~~
~~e. Lead-acid and nickel-cadmium battery systems installed in Group U buildings and structures less than 1,500 square feet (139 m^2) under the exclusive control of communications utilities, and operating at less than 50 VAC and 60 VDC in accordance with NFPA 76, are not required to have an approved automatic smoke or fire detection system.~~

1207.7.1 Dedicated-use buildings. ~~For the purpose of Table 1207.7, dedicated-use ESS buildings shall be~~ Buildings classified as Group F-1 occupancies and ~~comply with all the following:~~ approved as dedicated-use ESS buildings in accordance with the applicable building code, shall only be used and occupied as approved.

1. ~~The building shall only be used for ESS, electrical energy generation and other electrical grid-related operations.~~
2. ~~Occupants in the rooms and areas containing ESS are limited to personnel that operate, maintain, service, test and repair the ESS and other energy systems.~~
3. ~~No other occupancy types shall be permitted in the building.~~
4. ~~Administrative and support personnel shall be permitted in areas within the buildings that do not contain ESS, provided that:~~
   - 4.1. ~~The areas do not occupy more than 10 percent of the building area of the story in which they are located.~~
   - 4.2. ~~A means of egress is provided from the incidental use areas to the public way that does not require occupants to traverse through areas containing ESS or other energy system equipment.~~

1207.7.2 Nondedicated-use buildings. ~~For the purpose of Table 1207.7, nondedicated-use buildings include all buildings~~ Buildings that contain ESS and ~~do not comply with Section 1207.7.1 dedicated-use building requirements.~~ were approved as nondedicated-use buildings in accordance with the applicable building code, shall be used or occupied as approved.

1207.7.3 Dwelling units and sleeping units. Unless otherwise approved in accordance with the applicable building code, ESS shall not be ~~installed~~ allowed in *sleeping units* or in *habitable spaces* of *dwelling units*.

1207.7.4 Fire-resistance-rated separations. *Fire-resistance-rated* separations for ~~Rooms~~ rooms and areas containing ESS ~~shall include *fire-resistance-rated* separations as follows:~~ , required by the applicable building code, shall be maintained in accordance with the applicable building code.

1. ~~In dedicated-use buildings, rooms and areas containing ESS shall be separated from areas in which administrative and support personnel are located.~~
2. ~~In nondedicated-use buildings, rooms and areas containing ESS shall be separated from other areas in the building.~~

~~Separation shall be provided by 2-hour *fire barriers* constructed in accordance with Section 707 of the *International Building Code* and 2-hour *horizontal assemblies* constructed in accordance with Section 711 of the *International Building Code*, as appropriate.~~

1207.8 Outdoor installations. Outdoor installations shall be maintained in accordance with ~~Sections 1207.8.1 through 1207.8.3. Exterior wall installations for individual ESS units not exceeding 20 kWh shall be in accordance with Section 1207.8.4.~~ the applicable building code.

~~TABLE 1207.8~~
~~OUTDOOR ESS INSTALLATIONS[a]~~

~~COMPLIANCE REQUIRED~~		~~REMOTE INSTALLATIONS[a]~~	~~INSTALLATIONS NEAR EXPOSURES[b]~~
~~Feature~~	~~Section~~		
~~All ESS installations~~	~~1207.4~~	~~Yes~~	~~Yes~~
~~Clearance to exposures~~	~~1207.8.3~~	~~Yes~~	~~Yes~~
~~Fire suppression systems~~	~~1207.5.5~~	~~Yes[c]~~	~~Yes~~
~~Maximum allowable quantities~~	~~1207.5.2~~	~~No~~	~~Yes~~
~~Maximum enclosure size~~	~~1207.5.6~~	~~Yes~~	~~Yes~~
~~Means of egress separation~~	~~1207.5.8~~	~~Yes~~	~~Yes~~
~~Size and separation~~	~~1207.5.1~~	~~No~~	~~Yes[d]~~
~~Smoke and automatic fire detection~~	~~1207.5.4~~	~~Yes~~	~~Yes~~

~~Technology-specific protection~~	~~1207.6~~	~~Yes~~	~~Yes~~
~~Vegetation control~~	~~1207.5.7~~	~~Yes~~	~~Yes~~

~~a. See Section 1207.8.1.~~
~~b. See Section 1207.8.2.~~
~~c. Where approved by the fire code official, fire suppression systems are permitted to be omitted.~~
~~d. In outdoor walk-in units, spacing is not required between ESS units and the walls of the enclosure.~~

1207.8.1 Remote outdoor installations. For the purpose of ~~Table~~ <u>Section</u> 1207.8, ~~remote outdoor installations include~~ ESS located more than 100 feet (30 480 mm) from buildings, lot lines, public ways, stored combustible materials, hazardous materials, high-piled stock and other exposure ~~hazards.~~ <u>, shall be considered remote outdoor installations.</u>

1207.8.2 Installations near exposures. For the purpose of ~~Table~~ Section 1207.8, ~~installations near exposures include~~ all outdoor ESS installations that do not ~~comply with~~ <u>meet the criteria set forth by</u> Section 1207.8.1 ~~remote outdoor location requirements.~~ <u>, shall be considered installations near exposures.</u>

1207.8.3 Clearance to exposures. <u>Where the applicable building code requires a minimum of 10 feet (3048 mm) separation between</u> ESS located outdoors ~~shall be separated by a minimum of 10 feet (3048 mm) from~~ <u>and</u> the following ~~exposures:~~ <u>exposures, the separation shall be maintained in accordance with the applicable building code:</u>

1. Lot lines.
2. Public ways.
3. Buildings.
4. Stored combustible materials.
5. Hazardous materials.
6. High-piled stock.
7. Other exposure hazards.

~~**Exceptions:**~~

1. ~~Clearances are permitted to be reduced to 3 feet (914 mm) where a 1-hour free-standing fire barrier suitable for exterior use and extending 5 feet (1524 mm) above and 5 feet (1524 mm) beyond the physical boundary of the ESS installation is provided to protect the exposure.~~
2. ~~Clearances to buildings are permitted to be reduced to 3 feet (914 mm) where noncombustible exterior walls with no openings or combustible overhangs are provided on the wall adjacent to the ESS and the fire-resistance rating of the exterior wall is a minimum of 2 hours.~~
3. ~~Clearances to buildings are permitted to be reduced to 3 feet (914 mm) where a weatherproof enclosure constructed of noncombustible materials is provided over the ESS, and it has been demonstrated that a fire within the enclosure will not ignite combustible materials outside the enclosure based on large-scale fire testing complying with Section 1207.1.5.~~

1207.8.4 Exterior wall installations. <u>Where the applicable building code allows</u> ESS ~~shall be permitted~~ to be installed outdoors on exterior walls of buildings ~~when all of the following conditions are met:~~ <u>, they shall be maintained in accordance with the applicable building code.</u>

1. ~~The maximum energy capacity of individual ESS units shall not exceed 20 kWh.~~
2. ~~The ESS shall comply with applicable requirements in Section 1207.~~
3. ~~The ESS shall be installed in accordance with the manufacturer's instructions and their listing.~~
4. ~~Individual ESS units shall be separated from each other by at least 3 feet (914 mm).~~
5. ~~The ESS shall be separated from doors, windows, operable openings into buildings or HVAC inlets by at least 5 feet (1524 mm).~~

~~**Exception:** Where approved, smaller separation distances in Items 4 and 5 shall be permitted based on large-scale fire testing complying with Section 1207.1.5.~~

1207.9 Special installations. Rooftop and open parking garage ESS installations shall ~~comply with Sections 1207.9.1 through 1207.9.6.~~ <u>be maintained in accordance with the applicable building code.</u>

~~**TABLE 1207.9**~~
~~**SPECIAL ESS INSTALLATIONS**~~

~~**COMPLIANCE REQUIRED**~~		~~**ROOFTOPS**[a]~~	~~**OPEN PARKING GARAGES**[b]~~
~~**Feature**~~	~~**Section**~~		
~~All ESS installations~~	~~1207.4~~	~~Yes~~	~~Yes~~
~~Clearance to exposures~~	~~1207.9.3~~	~~Yes~~	~~Yes~~
~~Fire suppression systems~~	~~1207.9.4~~	~~Yes~~	~~Yes~~
~~Maximum allowable quantities~~	~~1207.5.2~~	~~Yes~~	~~Yes~~
~~Maximum enclosure size~~	~~1207.5.6~~	~~Yes~~	~~Yes~~
~~Means of egress separation~~	~~1207.5.8~~	~~Yes~~	~~Yes~~
~~Open parking garage installations~~	~~1207.9.6~~	~~No~~	~~Yes~~
~~Rooftop installations~~	~~1207.9.5~~	~~Yes~~	~~No~~
~~Size and separation~~	~~1207.5.1~~	~~Yes~~	~~Yes~~
~~Smoke and automatic fire detection~~	~~1207.5.4~~	~~Yes~~	~~Yes~~
~~Technology-specific protection~~	~~1207.6~~	~~Yes~~	~~Yes~~

~~a. See Section 1207.9.1.~~
~~b. See Section 1207.9.2.~~

1207.9.1 Rooftop installations. For the purpose of ~~Table~~ <u>Section</u> 1207.9, rooftop ESS installations are those located on the roofs of buildings.

1207.9.2 Open parking garage installations. For the purpose of ~~Table~~ <u>Section</u> 1207.9, open parking garage ESS installations are those located in a structure or portion of a structure that complies with ~~Section 406.5 of the *International Building Code*.~~ <u>the Open Parking Garage provisions set forth by the applicable building code.</u>

1207.9.3 Clearance to exposures. <u>Where the applicable building code requires a minimum of 10 feet (3048 mm) separation between</u> ESS located on rooftops ~~and~~ <u>or</u> in open parking garages ~~shall be separated by a minimum of 10 feet (3048 mm) from~~ <u>and</u> the following ~~exposures:~~ <u>exposures, the separation shall be maintained in accordance with the applicable building code.</u>

1. Buildings, except the building on which rooftop ESS is mounted.
2. Any portion of the building on which a rooftop system is mounted that is elevated above the rooftop on which the system is installed.
3. Lot lines.
4. Public ways.
5. Stored combustible materials.
6. Locations where motor vehicles can be parked.
7. Hazardous materials.
8. Other exposure hazards.

~~**Exceptions:**~~

~~1. Clearances are permitted to be reduced to 3 feet (914 mm) where a 1-hour free-standing fire barrier suitable for exterior use and extending 5 feet (1524 mm) above and 5 feet (1524 mm) beyond the physical boundary of the ESS installation is provided to protect the exposure.~~

2. ~~Clearances are permitted to be reduced to 3 feet (914 mm) where a weatherproof enclosure constructed of noncombustible materials is provided over the ESS, and it has been demonstrated that a fire within the enclosure will not ignite combustible materials outside the enclosure based on large-scale fire testing complying with Section 1207.1.5.~~

1207.9.4 Fire suppression systems. ~~ESS located in walk-in units on rooftops or in walk-in units in open parking garages shall be provided with automatic fire suppression systems within the ESS enclosure in accordance with Section 1207.5.5. Areas containing ESS other than walk-in units in open parking structures on levels not open above to the sky shall be provided with an automatic fire suppression system complying with Section 1207.5.5.~~

~~**Exception:** A fire suppression system is not required in open parking garages if large-scale fire testing complying with Section 1207.1.5 is provided that shows that a fire will not impact the exposures in Section 1207.9.3.~~

Automatic fire suppression systems required by the applicable building code for the following, shall be maintained in accordance with Chapter 9 and the applicable building code:

1. Automatic fire suppression systems, installed within the ESS enclosure, for ESS located in walk-in units on rooftops.
2. Automatic fire suppression systems, installed within the ESS enclosure, for ESS located in walk-in units in open parking garages.
3. Automatic fire suppression systems in areas containing ESS other than walk-in units in open parking structures on levels not open above to the sky.

1207.9.5 Rooftop installations. The following features required by the applicable building code for ESS and associated equipment that are located on rooftops and not enclosed by building construction shall ~~comply with the following:~~ be maintained in accordance with the applicable building code.

1. Stairway access to the roof for emergency response and fire department personnel ~~shall be~~ provided either through a bulkhead from the interior of the building or a stairway on the exterior of the building.
2. Service walkways ~~at least 5 feet (1524 mm) in width shall be~~ provided for service and emergency personnel from the point of access to the roof to the system.
3. Distance required by the applicable building code between ESS and associated equipment ~~shall be located from~~ , and the edge of the roof ~~a distance equal to at least the height of the system, equipment or component but not less than 5 feet (1524 mm)~~.
4. The roofing materials under and within ~~5 feet (1524 mm) horizontally~~ the horizontal distance, specified by the applicable building code, from an ESS or associated equipment ~~shall be noncombustible or shall have a Class A rating when tested in accordance with ASTM E108 or UL 790~~.
5. ~~A~~ Class I standpipe ~~outlet~~ outlets ~~shall be~~ installed at an approved location on the roof level of the building or in the stairway bulkhead at the top level.
6. The ESS ~~shall be the minimum of 10 feet (3048 mm)~~ separation from the fire service access point on the rooftop.

1207.9.6 Open parking garages. ESS and associated equipment that are located in open parking garages shall ~~comply with all of the following:~~ be maintained in accordance with the applicable building code.

1. ~~ESS shall not be located within 50 feet (15 240 mm) of air inlets for building HVAC systems.~~

   ~~**Exception:** This distance shall be permitted to be reduced to 25 feet (7620 mm) if the automatic fire alarm system monitoring the radiant-energy sensing detectors de-energizes the ventilation system connected to the air intakes upon detection of fire.~~

2. ~~ESS shall not be located within 25 feet (7620 mm) of *exits* leading from the attached building where located on a covered level of the parking structure not directly open to the sky above.~~
3. ~~An *approved* fence with a locked gate or other *approved* barrier shall be provided to keep the general public at least 5 feet (1524 mm) from the outer enclosure of the ESS.~~

TABLE 1207.10
MOBILE ENERGY STORAGE SYSTEMS (ESS)

COMPLIANCE REQUIRED		DEPLOYMENT[a]
Feature	**Section**	
All ESS installations	1207.4	Yes~~[b]~~
Fire suppression systems	1207.5.5	Yes~~[c]~~
Maximum allowable quantities	1207.5.2	Yes
Maximum enclosure size	1207.5.6	Yes
Means of egress separation	1207.5.8	Yes
Size and separation	1207.5.1	Yes~~[d]~~
Smoke and automatic fire detection	1207.5.4	Yes~~[e]~~
Technology-specific protection	1207.6	Yes
Vegetation control	1207.5.7	Yes

a. See Section 1207.10.2.
~~b. Mobile operations on wheeled vehicles and trailers shall not be required to comply with Section 1207.4.4 seismic and structural load requirements.~~
~~c. Fire suppression system connections to the water supply shall be permitted to use approved temporary connections.~~
~~d. In walk-in units, spacing is not required between ESS units and the walls of the enclosure.~~
~~e. Alarm signals are not required to be transmitted to an approved location for mobile ESS deployed 30 days or less.~~

1207.10.3 Permits. ~~Construction and operational permits shall be provided for charging and storage of mobile ESS and operational permits shall be provided for deployment of mobile ESS as required by Section 1207.1.2.~~ Permits shall be required as set forth in Section 107.2.

1207.10.4 ~~**Construction documents.**~~ ~~*Construction documents*~~ **Documents.** Documents complying with Section 1207.1.3 shall be provided with the ~~construction~~ operational permit application for mobile ESS charging and storage locations.

1207.10.4.1 Deployment documents. ~~The~~ At the minimum, the following information shall be provided with the ~~operation~~ operational permit applications for mobile ESS deployments:

1. Relevant information for the mobile ESS equipment and protection measures in the ~~*construction*~~ *documents* required by Section 1207.1.3.
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 1207.10.7.5.
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 1207.1.6.1.

1207.10.5 Approved locations. Locations where mobile ESS are charged, stored and deployed shall be restricted to the locations approved in accordance with the applicable building code and ~~established~~ identified on the ~~construction and~~ operational permits.

1207.10.6 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 following sections, as applicable:

1. Indoor charging and storage shall comply with Section 1207.7.
2. Outdoor charging and storage shall comply with Section 1207.8.
3. Charging and storage on rooftops and in open parking garages shall comply with Section 1207.9.

Exceptions:

1. Electrical connections ~~shall be~~ permitted by the applicable building code to be made using temporary wiring complying with the manufacturer's instructions, the UL 9540 listing and ~~NFPA 70.~~ NFPA 70, shall be maintained in accordance with the applicable building code.
2. Fire suppression system connections to the water supply ~~shall be~~ permitted by the applicable building code to use approved temporary ~~connections.~~ connections, shall be maintained in accordance with the applicable building code.

1207.10.7.2 Restricted locations. ~~Deployed~~ Unless otherwise approved in accordance with the applicable building code, mobile ESS operations shall not be located indoors, in covered parking garages, on rooftops, below grade or under building overhangs.

1207.10.7.3 Clearance to exposures. ~~Deployed~~ Where the applicable building code requires a minimum of 10 feet (3048 mm) separation between deployed mobile ESS ~~shall be separated by a minimum of 10 feet (3048 mm) from~~ and the following ~~exposures:~~ exposures, the separation shall be maintained in accordance with the applicable building code.

1. Public ways.
2. Buildings.
3. Stored combustible materials.
4. Hazardous materials.
5. High-piled storage.
6. Other exposure hazards.

~~Deployed~~ Where the applicable building code requires deployed mobile ESS ~~shall~~ to be separated by a minimum of 50 feet (15 240 mm) from public seating areas and from tents, canopies and membrane structures with an *occupant load* of 30 or ~~more.~~ more, the separation shall be maintained.

1207.10.7.4 Electrical connections. Electrical connections shall be ~~made~~ maintained in accordance with the manufacturer's instructions ~~and~~ , the UL 9540 ~~listing.~~ listing and the applicable building code. Temporary wiring for electrical power connections shall comply with NFPA 70. ~~Fixed~~ Unless otherwise allowed by the applicable building code, fixed electrical wiring shall not be provided.

1207.10.7.5 Local staging. Mobile ESS in transit from the charging and storage location to the deployment location and back shall not be parked within 100 feet (30 480 mm) of an occupied building for more than 1 hour during transit, unless specifically *approved* by the *fire code official* when the operational permit is issued.

1207.10.7.6 Fencing. ~~An *approved* fence~~ Fences with ~~a~~ locked ~~gate~~ gates or other *approved* ~~barrier~~ barriers ~~shall be~~ required or provided in accordance with the applicable building code to keep the general public at least 5 feet (1524 mm) from the outer enclosure of a deployed mobile ~~ESS.~~ ESS, shall be maintained in accordance with the applicable building code.

1207.11 ESS in Group R-3 and R-4 occupancies. ESS in Group R-3 and R-4 occupancies shall be ~~installed and~~ maintained in accordance with Sections 1207.11.1 through 1207.11.9. The temporary use of an *owner* or occupant's electric-powered vehicle as an ESS shall be in accordance with Section 1207.11.10.

1207.11.1 Equipment listings. ESS shall be *listed* and *labeled* in accordance with UL 9540. Unless otherwise approved in accordance with the applicable building code, ESS *listed* and *labeled* solely for utility or commercial use shall not be used for residential applications.

~~**Exceptions:**~~

1. ~~Where approved, repurposed unlisted battery systems from electric vehicles are allowed to be installed outdoors or in detached dedicated cabinets located not less than 5 feet (1524 mm) from exterior walls, property lines and public ways.~~
2. ~~ESS less than 1 kWh (3.6 megajoules).~~

1207.11.2 ~~Installation.~~ Maintenance. ESS shall be ~~installed~~ maintained in accordance with the manufacturer's instructions ~~and~~ , their ~~listing.~~ listing and the applicable building code.

1207.11.2.1 Spacing. ~~Individual~~ Where individual units ~~shall~~ are required by the applicable building code to be separated from each other by at least 3 feet (914 mm) of spacing unless smaller separation distances are documented to be adequate based on large-scale fire testing ~~complying with Section 1207.1.5.~~ , the separation shall be maintained in accordance with the applicable building code.

1207.11.3 Location. Unless otherwise approved in accordance with the applicable building code, ESS shall be ~~installed~~ located only in the following locations:

1. Detached garages and detached accessory structures.
2. Attached garages separated from the *dwelling unit* living space and *sleeping units* in accordance with Section 406.3.2 of the ~~*International Building Code*.~~ Virginia Construction Code.
3. Outdoors on exterior walls located a minimum of 3 feet (914 mm) from doors and windows.
4. Utility closets and storage or utility spaces within *dwelling units* and *sleeping units.*

1207.11.4 Energy ratings. ~~Individual~~ Unless otherwise approved in accordance with the applicable building code, individual ESS units shall have a maximum rating of 20 kWh. The aggregate rating structure shall not exceed:

1. 40 kWh within utility closets and storage or utility spaces.
2. 80 kWh in attached or detached garages and detached accessory structures.
3. 80 kWh on exterior walls.
4. 80 kWh outdoors on the ground.

1207.11.5 ~~Electrical installation.~~ Inverters. ~~ESS shall be installed in accordance with NFPA 70. Inverters~~ Where required by the applicable building code, inverters shall be *listed* and *labeled* in accordance with UL 1741 or provided as part of the UL 9540 listing. Systems connected to the utility grid shall use inverters *listed* for utility ~~interaction.~~ interaction in accordance with the applicable building code.

1207.11.6 Fire detection. ~~Rooms~~ Smoke alarms required by the applicable building code for rooms and areas within *dwellings units*, *sleeping units* and attached garages in which ESS are installed, shall be ~~protected by smoke alarms in accordance with Section 907.2.10~~. maintained in accordance with the applicable building code. ~~A~~ Where smoke alarms cannot be installed based on their listing, *heat* ~~*detector*~~ detectors *listed* and interconnected to the smoke alarms ~~shall be~~ installed in accordance with the applicable building code ~~locations~~ within *dwelling units*, *sleeping units* and attached garages ~~where smoke alarms cannot be installed based on their listing.~~ , shall be maintained in accordance with Chapter 9 and the applicable building code.

1207.11.7 Protection from impact. Stationary storage battery systems installed in a location subject to vehicle damage shall be protected by *approved* barriers. Appliances in garages ~~shall also be~~ installed in accordance with ~~Section 304.3 of the *International Mechanical Code*.~~ the applicable building code, shall be maintained in accordance with the applicable building code.

1207.11.8 Ventilation. ~~Indoor~~ Exhaust ventilation installed in accordance with the applicable building code for indoor installations of ESS that include batteries that produce hydrogen or other flammable gases during charging, shall be ~~provided with exhaust ventilation in accordance with Section 1207.6.1.~~ maintained in accordance with the applicable building code.

1207.11.9 Toxic and highly toxic gas. Unless otherwise approved in accordance with the applicable building code, ESS that have the potential to release toxic or highly toxic gas during charging, discharging and normal use conditions shall not be installed within Group R-3 or R-4 occupancies.

1207.11.10 Electric vehicle use. The temporary use of an *owner* or occupant's electric-powered vehicle to power a *dwelling unit* or *sleeping unit* while parked in an attached or detached garage or outside shall comply with the vehicle manufacturer's instructions and the applicable NFPA 70.

2018 VIRGINIA CONSTRUCTION CODE

Add Section 433 (exact Section number TBD based on other, unrelated proposals), to read:

SECTION 433
ELECTRICAL ENERGY STORAGE SYSTEMS (ESS)

433.1 Scope. Electrical Energy Storage Systems shall comply with the applicable provisions of the International Fire Code.

FP107.11-21

VFC: 107.11, 107.12, 108.1.1

Proponents: Joshua Davis (joshua.davis@vdfp.virginia.gov)

2018 Virginia Statewide Fire Prevention Code

Revise as follows:

107.11 State Fire Marshal's office permit fees for explosives, blasting agents, theatrical flame effects, and fireworks. Complete *permit* applications shall be submitted to and received by the *State Fire Marshal's* Office not less than 15 days prior to the planned use or event. A $500 expedited handling fee will be assessed on all permit applications submitted less than 15 days prior to the planned use or event. Inspection fees will be assessed at a rate of ~~$60~~ $150 per staff member per hour during normal business hours (Monday through Friday, 8:30 a.m. to 4:30 p.m.) and at a rate of ~~$90~~ $225 per hour at all other times (nights, weekends, holidays). *State Fire Marshal's Office* permit fees shall be as follows:

1. Storage of *explosives* and *blasting agents*, 12-month *permit* $250 first *magazine*, plus $150 per each additional *magazine* on the same *site*.
2. Use of *explosives* and *blasting agents*, nonfixed *site,* 6-month *permit* $250 per *site*, plus inspection fees.
3. Use of *explosives* and *blasting agents*, fixed *site*, 12-month *permit* $250 per *site*.
4. Sale of *explosives* and *blasting agents*, 12-month permit $250 per *site*.
5. Manufacture *explosives* (unrestricted), *blasting agents*, and *fireworks*, 12-month *permit* $250 per *site*.
6. Manufacture *explosives* (restricted), 12-month *permit* ~~$20~~ $200 per *site*.
7. *Fireworks* display in or on state-owned property $300 plus inspection fees.
8. *Pyrotechnics* or proximate audience displays in or on state-owned property $300 plus inspection fees.
9. Flame effects in or on state-owned property $300 plus inspection fees.
10. Flame effects incidental to a permitted *pyrotechnics* display $150 (flame effects must be individual or group effects that are attended and manually controlled).

Exception: Permit fees shall not be required for the storage of *explosives* or *blasting agents* by state and local law enforcement and fire *agencies*.

107.12 Other State Fire Marshal's office required permits, annual compliance ~~inspection~~ inspections and fees. Operational permits are required by the State Fire Marshal's office in accordance with this section. Fees for permits and for compliance inspections performed by the *State Fire Marshal's* office shall be as follows:

1. Annual compliance inspection fees for nightclubs ~~Nightclubs~~.
   - 1.1. ~~$350~~ $500 for *occupant load* of 100 or less.
   - 1.2. ~~$450~~ $600 for *occupant load* of 101 to 200.
   - 1.3. ~~$500~~ $650 for *occupant load* of 201 to 300.
   - 1.4. ~~$500~~ $650 plus ~~$50~~ $100 for each 100 occupants where *occupant loads* exceed 300.
2. Annual compliance inspection fees for private ~~Private~~ college dormitories with or without assembly areas. If containing assembly areas, such assembly areas are not included in the computation of square footage.
   - 2.1. ~~$150~~ $350 for 3,500 square feet (325 m^2) or less.
   - 2.2. ~~$200~~ $400 for greater than 3,500 square feet (325 m^2) up to 7000 square feet (650 m^2).
   - 2.3. ~~$250~~ $450 for greater than 7,000 square feet (650 m^2) up to 10,000 square feet (929 m^2).
   - 2.4. ~~$250~~ $450 plus $50 for each additional 3,000 square feet (279 m^2) where square footage exceeds 10,000 square feet (929 m^2).

3. Annual compliance inspection fees for assembly ~~Assembly~~ areas that are part of private college dormitories.
   3.1. ~~$50~~ $200 for 10,000 square feet (929 m^2) or less provided the assembly area is within or attached to a dormitory *building*.
   3.2. ~~$100~~ $250 for greater than 10,000 square feet (929 m^2) up to 25,000 square feet (2323 m^2) provided the assembly area is within or attached to a dormitory *building*, such as gymnasiums, auditoriums or cafeterias.
   3.3. ~~$100~~ $250 for up to 25,000 square feet (2323 m^2) provided the assembly area is in a separate or separate *buildings* such as gymnasiums, auditoriums or cafeterias.
   3.4. ~~$150~~ $300 for greater than 25,000 square feet (2323 m^2) for assembly areas within or attached to a dormitory *building* or in a separate or separate *buildings* such as gymnasiums, auditoriums or cafeterias.

4. Annual compliance inspection fees for hospitals ~~Hospitals~~.
   4.1. ~~$300~~ $450 for 1 to 50 beds.
   4.2. ~~$400~~ $550 for 51 to 100 beds.
   4.3. ~~$500~~ $650 for 101 to 150 beds.
   4.4. ~~$600~~ $750 for 151 to 200 beds.
   4.5. ~~$600~~ $750 plus ~~$100~~ $200 for each additional 100 beds where the number of beds exceeds 200.

5. Annual compliance inspection fees for facilities ~~Facilities~~ licensed by the Virginia Department of Social Services and family day homes licensed by the Virginia Department of Education, based on licensed capacity ~~as follows~~:
   5.1. ~~$50~~ $200 for 1 to 8.
   5.2. ~~$75~~ $225 for 9 to 20.
   5.3. ~~$100~~ $250 for 21 to 50.
   5.4. ~~$200~~ $350 for 51 to 100.
   5.5. ~~$300~~ $450 for 101 to 150.
   5.6. ~~$400~~ $550 for 151 to 200.
   5.7. ~~$500~~ $650 for 201 or more.

   Exception: Annual compliance inspection fees for any *building* or groups of *buildings* on the same *site* may not exceed ~~$2500.~~ $3500.

6. Registered ~~complaints~~ complaint investigation fees.
   6.1. ~~No charge for first visit (initial complaint), and if violations are found.~~ $150 per hour for each State Fire Marshal's Office staff during normal business hours (Monday through Friday, 8:30 a.m. to 4:30 p.m.) and at a rate of $225 per hour at all other times (nights, weekends, and holidays).
   6.2. ~~$51 per hour for each *State Fire Marshal's* office staff for all subsequent visits.~~

7. *Required permits and fees for bonfires* ~~*Bonfires*~~ (small and large) on state-owned property.
   7.1. For a small *bonfire* pile with a total fuel area more than 3 feet (914 mm) in diameter and more than 2 feet (610 mm) in height, but not more than 9 feet (2743 mm) in diameter and not more than 6 feet (1829 mm) in height, the permit fee is ~~$50.~~ $200. If an application for a *bonfire permit* is received by the *State Fire Marshal's* office less than 15 days prior to the planned event, the permit fee shall be ~~$100.~~ $250. If an application for a *bonfire permit* is received by the *State Fire Marshal's* office less than 7 days prior to the planned event, the permit fee shall be ~~$150.~~ $300.
   7.2. For a large *bonfire* pile with a total fuel area more than 9 feet (2743 mm) in diameter and more than 6 feet (1829 mm) in height, the permit fee is ~~$150.~~ $250. If an application for a *bonfire permit* is received by the *State Fire Marshal's* office less than 15 days prior to the planned event, the permit fee shall be ~~$300.~~ $400. If an application for a *bonfire permit* is received by the *State Fire Marshal's* office less than 7 days prior to the planned event, the permit fee shall be ~~$450.~~ $550.

8. Required operational permits and permit fees for hazardous materials processing or storage.

   8.1. Aviation facilities. $200 annual operational permit for Group H or Group S occupancy for aircraft servicing or repair and aircraft fuel-servicing vehicles. Additional permits required by other sections of this code include, but are not limited to, hot work, hazardous materials and flammable or combustible finishes.

   8.2. Waste handling. $200 annual operational permit for facilities conducting operations similar to wrecking yards, junk yards, and waste material handling or recycling centers.

   8.3. Combustible storage and hazardous operations.

      8.3.1. $200 annual operational permit for facilities storing or handling more than 100 cubic feet of combustible fibers, rags, or scrap textiles.

      8.3.2. $200 annual operational permit for facilities such as grain elevators, flour or feed mills, or other pulverizing processing producing combustible dust.

      8.3.3. $200 annual operational permit for storage of Flammable and combustible liquids:

         8.3.3.1. Service station or repair garage, or
         8.3.3.2. UST closure or temporary out of service

   8.4. Flammable finishes. $200 annual operational permit for spraying or dipping operations utilizing flammable or combustible products or flammable floor refinishing operations exceeding 350 square feet in size.

   8.5. High-piled and combustible storage. $200 annual operational permit for facilities storing more than 500 square feet of materials in arrangements greater than 12 feet in height.

   8.6. Plant extraction systems. $200 annual operational permit for plant oil processing and extraction systems.

   8.7. Tire storage and rebuilding operations. $200 annual operational permit for facilities storing more than 2,500 cubic feet of tires including scrap tires or operating tire rebuilding plants.

   8.8. Welding and other hot work.

      8.8.1. $200 operational permit for facilities conducting welding, open torches, or other hot work (except where used for construction purposes)

      8.8.2. $200 annual operational permit for hot work program.

   8.9. $200 annual permit for flammable and combustible liquids storage.

9. Other required operational permits and permit fees.

   9.1. Mobile food preparation vehicles. $200 annual operational permit for mobile food preparation vehicles equipped with appliances that produce smoke or grease laden vapors.

      Exception: Recreational vehicles used for private recreation.

   9.2. Tents, canopies and membrane structures. $200 annual operational permit for any individual or adjacent tent(s), stage canopy, or air-supported structure(s) covering an area of more than 900 square feet unless used exclusively for recreational camping purposes.

   9.3. Special amusement building occupancies. $200 annual operational permit for any temporary or permanent amusement facilities where the means of egress is not readily apparent, is intentionally confounding, or is not readily available.

108.1.1 Permits required. Operational *permits* may be required by the fire official in accordance with Table 107.2. The fire official shall require operational *permits* for the manufacturing, storage, *handling*, use and sale of *explosives.* Issued *permits* shall be kept on the premises designated therein at all times and shall be readily available for inspection by the fire official.

Exceptions:

1. Operational *permits* will ~~not~~ be required by the *State Fire Marshal* ~~except for the manufacturing, storage, *handling*, use and sale of *explosives* in localities not enforcing the SFPC~~ in accordance with Sections 107.11 and 107.12.
2. Operational *permits* will not be required for the manufacturing, storage, *handling* or use of *explosives* or *blasting agents* by the Virginia Department of State Police provided notification to the fire official is made annually by the Chief Arson Investigator listing all storage locations.

Reason Statement: The Virginia Statewide Fire Prevention Code, which is amended and adopted by the Commonwealth of Virginia Board of Housing and Community Development, and set forth in Section 27-94 et seq. the Code of Virginia, shall be enforced, including the imposition of fees to defray costs, as may be necessary for the administration and enforcement. The Virginia Statewide Fire Prevention Code sets certain procedures for the Virginia State Fire Marshal's Office's fee schedule which here in are recommended to be adjusted comparable with other localities in Virginia. The 2006 SFPC list the initial fees for the State Fire Marshal's Office and have not been adjusted for the past 15 plus years. To better serve the Commonwealth of Virginia and to defray costs, as may be necessary for the administration and enforcement.

Resiliency Impact Statement: This proposal will increase Resiliency
The mission of the State Fire Marshal's Office is to make fire safety a way of life in the Commonwealth of Virginia. We accomplish this through inspection and compliance of the Virginia Statewide Fire Prevention Code. The State Fire Marshal's Office continually strives to better serve our citizens and the communities which we are tasked with protecting. The proposed increase in fees will be critical to the future services provided by the State Fire Marshal's Office and to better maintain safe buildings across Virginia. The demand for services from the Fire Marshal has steadily increased over the past 15 years. Therefore, the Virginia State Fire Marshal and the Director of Virginia Fire Programs propose an increase in certain fees set forth in the Virginia Statewide Fire Prevention Code, permits and fees Section 107.

Cost Impact: The code change proposal will increase the cost of construction
The proposed fees will not impact construction cost, however, they will impact those business that fall within these inspections and permits. This increase is comparable with localities around Virginia and are in line with the increase in the State Fire Marshal's Office operational budget. The fees imposed pursuant to this section shall be used to defray the cost of administration and enforcement under the Statewide Fire Prevention Code.

Attached Files

- **Stafford County FD local fee schedule for fire prevention code permits.pdf**
  https://va.cdpaccess.com/proposal/1046/1493/files/download/696/
- **SFMO proposed fire code amendment fee and hourly rate increase 2021.pdf**
  https://va.cdpaccess.com/proposal/1046/1493/files/download/695/
- **Fire Prevention Code Permit Fee Schedule_201210051427510124.pdf**
  https://va.cdpaccess.com/proposal/1046/1493/files/download/694/
- **Fee Schedule 2019 Albemarle County.pdf**
  https://va.cdpaccess.com/proposal/1046/1493/files/download/693/
- **city_of_fairfax_permit_fee_schedule.pdf**
  https://va.cdpaccess.com/proposal/1046/1493/files/download/692/
- **Chapter 15.25- Fire Code- 1-9-2020.pdf**
  https://va.cdpaccess.com/proposal/1046/1493/files/download/691/

https://library.municode.com/va/stafford_county/codes/code_of_ordinances?nodeId=COCO_CH12FIPRPR_ARTVIFIPRCO_S12-62AMADDEVISTFIPRCO

Sec. 12-62. - Amendments, additions, and deletions to the Virginia Statewide Fire Prevention Code.

The Virginia Statewide Fire Prevention Code adopted by county Code section 12-60(a), is hereby amended and changed pursuant to Virginia Code § 27-97 in the following respects:

101.1 Title. Delete this section and replace with the following:

The regulations set forth herein, as modified and amended in County Code section 12-62, together with the additional regulations in county code chapter 12, shall be known as the "Fire Prevention Code," and herein referred to as such.

Add the following subsection:

106.3.2. Inspection by others. The fire official may designate other persons as he deems necessary and appropriate, to make fire safety inspections. Such persons may use the fire prevention code as the basis for such inspections.

107.2. Permits required. Delete this section and replace with the following:

Operational permits shall be required by the fire official in accordance with Table 107.2. Fees for such permits, as set by the board, shall be paid prior to issuance of the permit.

Exception: Such permits shall not be required for the storage of explosives or blasting agents by the Virginia Department of State Police provided notification to the fire official is made annually by the Chief Arson investigator listing all storage locations.

TABLE 107.2

Type	When Required	Duration	Fee

Section 1: Facilities, Occupancies and Precautions Against Fire

Assembly/Educational Occupancies Facilities operating in an assembly or educational occupancy classification

Annual $200.00

Aviation Facility Facilities involving aviation operations/storage Annual $200.00

Covered Mall Building Facilities designated as or in a covered mall

(by main address, not individual suites) Annual $200.00

Commercial Cooking Operation of a commercial cooking appliances in occupancies other than assembly or dwellings Annual $200.00

Commercial Open Burning Site and land clearing operations for commercial, industrial, or residential land development Per Burn Site (90 Days Max) $200.00

Dry Cleaning Facility Facilities where textiles are cleaned by using solvents Annual $200.00

Exhibit or Trade Shows Facilities operating temporary indoor exhibit or trade shows involving more than 50 vendors

Per Event

(90 Days Max) $200.00

Hazardous Production Materials Facility (HPM) Facilities using NFPA 704 classification 3 or 4 materials involved with semi-conductor manufacturing or other hazardous material processing Annual $200.00

Lumber Yards and Woodworking Operations Facilities storing or processing more than 100,000 board feet of lumber Annual $200.00

Mobile Food Preparation Vehicles Mobile food preparation vehicles equipped with appliances that produce smoke or grease laden vapors.

Exception: Recreational vehicles used for private recreation. Per Event

(90 Days Max)

or Annual $200.00

Organic Coating Manufacturing Facility Facilities manufacturing more than 1 gallon of organic coatings per day Annual $200.00

Private Fire Hydrants Fire hydrants not serviced by Stafford County Utilities Annual $200.00

Special Amusement Occupancies Temporary or permanent amusement facilities where the means of egress is not readily apparent, is intentionally confounding, or is not readily available. Per Event

(90 Days Max)

or Annual $200.00

State-regulated Care Facilities (SRCF) State-regulated care facilities except R-5 occupancies. Annual $200.00

Tents, Canopies and Membrane Structures Any individual or adjacent tent(s), canopy, or air-supported structure(s) covering an area of more than 900 square feet unless used exclusively for recreational camping purposes. Separate permits are required for every 15,000 square feet of total tent coverage area. Per Event

(90 Days Max) $200.00

Vehicle Display Inside of a Building Any display, operation or demonstration of a liquid or gas fueled vehicle in an assembly occupancy building Per Event

(90 Days Max) $200.00

Vehicle Repair Shop Garages Facilities conducting motor vehicle (including boat) repairs Annual $200.00

Waste Handling

Facility Facilities conducting operations similar to wrecking yards, junk yards, and waste material handling or recycling centers Annual $200.00

Section 2: Combustible Storage and Hazardous Operations

Aerosols Facilities operating with more than 500 pounds of class 2 or 3 aerosol products Annual $200.00

Combustible Dust-Producing OperationsFacilities such as grain elevators, flour or feed mills, or other pulverizing processing producing combustible dust Annual $200.00

Combustible Fibers Facilities storing or handling more than 100 cubic feet of combustible fibers, rags, or scrap textiles Annual $200.00

Compressed Gases Facilities storing or using INERT compressed gasses when exceeding 6,000 cubic feet of gas (such as nitrogen but does NOT include LPG) Annual $200.00

Flammable Finishes Spraying or dipping operations utilizing flammable or combustible products or flammable floor refinishing operations exceeding 350 square feet in size Per Event

(90 Days Max)

or Annual $200.00

Fruit and Crop

Ripening Operations Facilities conducting fruit or crop ripening using ethylene gas Per Event

(90 Days Max) $200.00

Fumigation and Insecticidal Fogging Operations Facilities or enclosed areas using flammable or toxic fumigation or insecticidal fogging Per Event

(90 Days Max) $200.00

High-Piled and Combustible Storage Facilities storing more than 500 square feet of materials in arrangements greater than 12 feet in height Annual $200.00

Industrial Oven Operations Facilities operating large industrial size ovens or "furnaces" Annual $200.00

Magnesium Operations Facilities that melt, cast, heat or grind more than 10 pounds of magnesium Annual $200.00

Plant Extraction Systems Plant oil processing and extraction systems Annual $200.00

Tire Storage and Rebuilding Operations Facilities storing more than 2,500 cubic feet of tires including scrap tires or operating tire rebuilding plants Annual $200.00

Welding and other Hot Work Facilities conducting welding, open torches, or other hot work (except where used for construction purposes) Per Event

(90 Days Max) $200.00

Hot Work Program When approved, the fire official shall issue a permit to carry out a Hot Work Program. This program allows approved personnel to regulate their facility's hot work operations. The approved personnel shall be trained in the fire safety aspects denoted in this chapter and shall be responsible for issuing permits requiring compliance with the requirements found in this chapter. These permits shall be issued only to their employees or hot work operations under their supervision. Annual $200.00

Section 3: Fireworks and other Explosives

Blasting Operations involving the use of explosives in any amount for demolition, stone removal, or other purposes

Per Blast Site

(90 Days Max) $200.00

Explosive or Fireworks Storage Manufacture, storage or handling of any amount of fireworks or other explosives

Annual $200.00

Fireworks: Aerial Display Operations involving an outdoor aerial display of fireworks Per Event $500.00

Fireworks: Indoor Pyrotechnics Display or Special Effects Operations involving indoor display of fireworks, pyrotechnics or other special effects Per Event $500.00

Fireworks: Itinerant Vendor Temp facilities selling fireworks from June 1 to July 15

As noted $1,000.00

Fireworks: Distributor or Wholesaler Facilities distributing or selling fireworks to only permanent or itinerant vendors Annual $200.00

Fireworks: Permanent Vendor Facilities selling fireworks from a permanent address and permanent structure throughout the year Annual $200.00

Section 4: Hazardous Materials (Use Appendix E of the International Fire Code for further classification and information)

Corrosive Materials Facilities using, storing or handling more than 55 gal. or 1,000 lbs. Annual $200.00

Cryogenic Fluids Facilities using, storing or handling more than 1 gallon inside or 50 gallons outside Annual $200.00

Flammable and Combustible Liquids Facilities using, storing, manufacturing,

processing or handling more than:

Class 1 Liquids: 5 gal. Inside or 10 gal. Outside

Class 2 or 3A Liquids: 25 gal. Inside or 60 gal. Outside

Except for:

1) The storage or use of Class I liquids in the fuel tank of a motor vehicle, aircraft, motorboat, mobile power plant, mobile heating plant, unless such storage in the opinion of the fire official, would cause an unsafe condition.

2) The storage or use of paints, oils, varnishes or similar flammable mixtures when such liquids are stored for maintenance, painting or similar purposes for a period of not more than 30 days.

3) The storage of fuel oil used in connection with oil-burning equipment. Annual $200.00

Flammable Gases Facilities using, storing or handling more than 200 cubic feet Annual $200.00

Flammable Solids Facilities using, storing or handling more than 100 pounds Annual $200.00

Highly Toxic Materials Facilities using, storing or handling more than 10 gallons, or 100 pounds, or any amount of toxic gas. Annual $200.00

Liquefied Petroleum Gas (LPG) Facilities using, storing or handling more than 10 water gallons capacity of LPG with exception to single containers or aggregate quantity of less than 500 gallon water capacity for residential use. Annual $200.00

Organic Peroxides Facilities using, storing or handling ANY amount of class 1 through 4 (permit not required for class 5) Annual $200.00

Oxidizers Facilities using, storing or handling more than 55 gallons, 500 pounds or 504 cubic feet (see VSFPC for specifics) Annual $200.00

Pyrophoric Materials Facilities using, storing or handling ANY amount Annual $200.00

Pyroxylin Plastics Facilities using, storing or handling more than 25 pounds Annual $200.00

Unstable Materials Facilities using, storing or handling more than 10 gal. or 100 lbs. Annual $200.00

Water-Reactive

Materials Facilities using, storing or handling more than 55 gal. or 500 lbs. Annual $200.00

Add the following subsection:

107.5.1 Duration of permit. Permits shall remain in effect for no more than 12 months from the date issued unless otherwise specified in Table 107.2 or unless suspended or revoked in accordance with the code.

Add the following subsection:

107.10.1 Non-refundable fees. All required permit fees identified in table 107.2 are non-refundable once the required inspection is completed.

Add the following section:

109.4. Approvals. Approval as the result of an inspection shall not be construed to be an approval of any violation of the provisions of the fire prevention code or another regulation. Inspections presuming to give authority to violate or cancel provisions of the fire prevention code or any other regulation shall not be valid.

Add the following section:

109.5 Inspections performed outside business hours. Inspections may be performed outside of normal government business hours when approved by the fire official. Fees for these inspections may be assessed at the overtime rate for the inspector in addition to any permit fees.

Add the following section:

110.7. Imminent threat to human health or safety or to property. If the fire official shall determine that the violation creates an imminent threat to human health or safety or to property, the fire official may restrain, correct or abate such violation and institute appropriate legal proceeding to collect the full cost of such response from the owner and the tenant or other person in control of the premises.

202. General Definitions. Add or replace the following words, terms and definitions:

Corrosive: A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact. A chemical shall be considered corrosive if, when tested on the intact skin of albino rabbits by the method described in DOTn 49 CFR 173.137, such chemical destroys or changes irreversibly the structure of the tissue at the point of contact following an exposure period of 4 hours. This term does not refer to action on inanimate surfaces. A substance shall be considered corrosive if it has a pH less than or equal to 2, or a pH greater than or equal to 12.5 on a pH scale of 0-14.

Fire Chief: The head of the Stafford County Department of Fire, Rescue and Emergency Services, also referred to as the fire and rescue chief, county fire chief, or chief of the fire department.

Fire Lane: An area designated by pavement markings or signs in which parking shall be prohibited, whether on public or private property, to ensure ready access for and to fire fighting and rescue equipment and facilities. A fire lane is a type of fire department access road.

Fire Marshal's Office: The county fire marshal, and, under the authority of the fire marshal, deputy or assistant fire marshals, and members of the fire marshal's staff, also referred to as the Fire Prevention Division or the fire official.

Fireworks: Any article, device, or any substance or combination of substances designed for the purpose of producing a visible or audible effect by combustion, explosion, deflagration, or detonation, regardless of its name or form of construction. This shall include, but not be limited to, those items known as firecrackers, cherry bombs, Roman candles, torpedoes, skyrockets and any other substance or thing of whatever form of construction containing nitrates, chlorates, oxalate, sulfide of lead, barium, antimony, nitroglycerine, phosphorus or any other explosive or flammable compound or substance.

Fireworks Retailer: Any person selling fireworks or offering fireworks for sale at retail within the county which shall include itinerant fireworks retailers and permanent fireworks retailers.

Fireworks Wholesaler: A person, firm or corporation offering fireworks for sale or selling fireworks to a retailer. Such term shall include a manufacturer of fireworks, a representative of any such manufacturer, a distributor, a jobber and a middleman of any description dealing in fireworks, any of whom shall sell or offer to sell or offer to sell fireworks to a retailer within the county.

Immediately: Without delay.

Itinerant Fireworks Retailer: Any person selling fireworks or offering fireworks for sale at retail within the county from a temporary location from June 1 to July 15 each year.

Legal Counsel: County Attorney or the Commonwealth's Attorney for the County of Stafford.

Occupant: Any person physically located or situated in or on any property, structure, space or vehicle irrespective of the length of time or the reason for such occupancy.

Permanent Fireworks Retailer: Any person selling fireworks or offering fireworks for sale at retail within the county from a permanent address and a permanent structure throughout the year.

Virginia State Fire Marshal's Office Cost Recovery Rate Increase (Draft) 2021

Amendments proposal to the Virginia Statewide Fire Prevention Code; related fees and cost recovery for operational permits.

The Virginia Statewide Fire Prevention Code (VSFPC), which is adopted and promulgated by the Virginia Board of Housing and Community Development, as set forth in the Code of Virginia, § 27-97, provides for enforcement authority for prescribed regulations for the protection of life and property from the hazards of fire or explosion and for the handling, storage, sale and use of fireworks, explosives or blasting agents. Specific enforcement authority for the State Fire Marshal is provided for in § 27-98 and provides authority for the State Fire Marshal to enforce the VSFPC in jurisdictions in which the local government do not enforce the Code and may establish such procedures or requirements as necessary for the administration and enforcement for the Code. Additionally, § 27-98 provides for the State Fire Marshal to charge fees to recover for the actual cost of administering and enforcing the Code. The requirements for operational permits, state annual compliance fees, and fees for registered complaints are establishes in the VSFPC.

Due to the increased cost for providing code enforcement services the Virginia State Fire Marshal and the Director of Virginia Fire Programs propose an increase in certain fees set forth in the Virginia Statewide Fire Prevention Code, Section 107 Permits and Fees and Section 108 Operational Permits.

The SFMO is currently the Fire Official for 60 of the 95 counties in Virginia and includes code enforcement of all State owned facilities regardless of which jurisdiction they reside. This proposal sets out to adjust the existing fee schedule for services provided by the State Fire Marshal's Office (SFMO) given fees for service has not been adjusted for the past 15 years.

The SFMO provides specific services that is partially funding from general fund monies and supplemented by the Internal Service Fund which is monies received for contracted or recovery services provided by the SFMO. The proposed fee and cost recovery increase is specific for a fee increase to recover actual cost for the administration and enforcement of the Code. Code enforcement services include but not be limited to:

- Annual Fire Prevention compliance Inspections
- Re-inspections
- Complaint based inspections
- Operational Permits
- Construction and Site Inspections
- Fireworks, Flame Effects, and Pyrotechnics
- Reduced Cigarette Ignition Propensity inspections

Cost associated with administration of code enforcement include but not limited to:

- Staff compensation for code enforcement services
- Vehicle cost and associated annual maintenance
- IT equipment, support, and required cost and maintenance of software solutions

- Required Personal Protective Equipment and replacement cost
- Tools and equipment
- Fire Inspector certification, continuing education requirements, and professional development
- Administrative support

The State Fire Marshal's Office continually strives to better serve our citizens and the communities which we are tasked with protecting. The proposed increase in fees will be critical to the future services provided by the State Fire Marshal's Office and to better maintain safe buildings across Virginia. The addition of annual operational permit fees is intended to establish a risk assessment of facilities to the State Fire Marshal, those locations where Hazardous Material (as classified with national recognized reference standards or through approved qualified organizations) is stored, dispensed or processed.

Hourly rate increase

The SFMO hourly rate (cost recovery rate) should be set on the following factors that affect the SFMO's operational budget.

1. The average pay worksheet for staff in the SFMO (the average per hour rate).

   $ 1,338,084 Total Salaries of 21 Positions

   $ 70,426 Average Annual Salary

   $ 34 Average per Hour Based 2080 hours worked in a year

2. Cost associate with SFMO vehicles usage. The SFMO is supported with leased vehicles and as such need to add in compensation for the use of these vehicles when providing fire code inspections and support to other state agencies.

   $ 25 per hour for vehicle use recovery

3. The SFMO receives support from the Virginia Department of Fire Programs IT department to maintain and support operation of data systems such as DEB - BITS;
   SFMO - Imagetrend, RCIP, SFMD.

   $ 66 per hour for IT support

4. Administrative support for record entry and processing reports for billing and cost recovery.

   $ 25 per hour for Administrative support

5. Total recovery cost per hour for individual SFMO staff and inspectors

   $ 150 SFMO per hour

   $ 150 - Total cost for contracted and construction inspection services or recovery services by the SFMO per hour.

CODIFIED ORDINANCES OF LOUDOUN COUNTY
PART SIXTEEN – FIRE PREVENTION AND COMPLIANCE
FIRE MARSHAL'S OFFICE
CHAPTER 1602
Adoption of State Law and Local Amendments

Adopted 2-7-2011

1602.01 ADOPTION OF SECTION 27-94 *et seq.* (Statewide Fire Prevention Code) of Code of Virginia.

The Virginia Statewide Fire Prevention Code as set forth in Section 27-94 *et seq.* of the *Code of Virginia* shall be enforced in the County. Except as specifically modified by this Chapter, all the provisions and requirements of the Statewide Fire Prevention Code, are hereby adopted, mutatis mutandis, and made part of this Chapter as if fully set forth and shall be known as the Loudoun County Fire Prevention Code. No person within the County shall violate or fail, neglect or refuse to comply with any provision of the Loudoun County Fire Prevention Code and in no event shall the penalty imposed for the violation of any provision or requirement adopted herein exceed the penalty imposed for a similar offense under such Section 27-94 *et seq.* of the Code of Virginia of 1950, as amended

1602.02 ENFORCEMENT; APPOINTMENT OF FIRE MARSHAL

There shall be appointed by the Board of Supervisors in and for the County a Fire Marshal, who shall be responsible for the enforcement of this Chapter. The duties of such Fire Marshal shall include investigation into the origin and cause of every fire and explosion occurring within the limits for which he/she is appointed. The investigation and prosecution of all offenses involving hazardous materials, fires, fire bombings, bombings, attempts or threats to commit such offenses, false alarms relating to such offenses, possession and manufacture of explosive devices, substances and fire bombs and environmental crimes shall be the responsibility of the fire marshal, his/her designee and legal counsel. As used herein, the terms "Fire Official", "Enforcing Agency" and "Code Official" shall refer to the Fire Marshal for the purposes of this chapter. The Fire Marshal and his/her office shall be a part of the Department of Fire Rescue and Emergency Management.

1602.02.01.1 POWERS; OFFICE OF THE FIRE MARSHAL

(a) The Fire Marshal and all duly appointed assistants shall be authorized to order immediate compliance with the provisions of this Chapter and to exercise all powers authorized hereunder.

(b) In addition to such other duties as may be prescribed by law, the local fire marshal and those assistants appointed pursuant to Section §27-36 of the Code of Virginia designated by the fire marshal shall have the same police powers as a sheriff, police officer or law-enforcement officer to include the authority to arrest, to procure and serve warrants of arrest and search warrants, and to issue summons in the investigation and prosecution of all offenses, and related offenses, involving the violation of fire prevention and fire safety laws and related ordinances, hazardous materials, fires, fire bombings, bombings, attempts or threats to commit such offenses, possession and manufacture of explosive devices, substances and fire bombs.

(c) The police powers granted in this section shall not be exercised by the Fire Marshal or any assistant until such person has satisfactorily completed a course for Fire Marshals with police powers, which course shall be approved by the Virginia Fire Services Board. In addition, the Fire Marshal and those assistants with police powers shall continue to exercise those powers only upon satisfactory participation in in-service and advanced courses and programs, which courses shall be approved by the Virginia Fire Services Board. The Fire Marshal and his assistants, before entering upon their duties, shall respectively take an oath, pursuant to *Code of Virginia*, Title 27-37.

1602.03 ENFORCEMENT PROCEDURES; AUTHORITY

The enforcement procedures of this Chapter shall be instituted by the Fire Marshal and administered in accordance with this chapter.

1602.04 ADMINISTRATION

The Fire Marshal shall establish such procedures or requirements as may be necessary for the administration and enforcement of this Chapter.

1602.05 VIOLATIONS

It shall be unlawful for any owner or any other person, firm, or corporation, on or after the effective date of the Loudoun County Fire Prevention Code, to violate any provisions thereof. Any such violation shall constitute a Class 1 misdemeanor and any owner, or any other person, firm, or corporation convicted of such violation shall be subject to punishments set forth in Chapter 202.08(b) of the Codified Ordinances of Loudoun County.

1602.06 LOCAL BOARD OF FIRE PREVENTION CODE APPEALS

The Loudoun County Building Code and Appeals Board shall be designated as the Appeals Board to hear grievances arising from the application of the Loudoun County Fire Prevention Code.

1602.07 SMOKE DETECTORS IN CERTAIN BUILDINGS

In accordance with the authorities specified in Section 15.2-922 of the Code of Virginia, smoke detectors shall be installed in the following structures or buildings:

(a) Any building containing one or more dwelling units,

(b) Any hotel or motel regularly used or offered for, or intended to be used to provide overnight sleeping accommodations for one or more persons, and,

(c) rooming houses regularly used, offered for, or intended to be used to provide overnight sleeping accommodations.

1602.07.01 Smoke detectors installed pursuant to this section shall be installed in conformance with the provisions of the Uniform Statewide Building Code. Smoke detectors shall be either battery operated or AC powered units. The owner of any unit which is rented or leased, at the beginning of each tenancy and at least annually thereafter, shall furnish the tenant with a certificate that all required smoke detectors are present, have been inspected, and are in good working order. Except for smoke detectors located in hallways, stairwells, and other public or common areas of multifamily buildings, interim testing, repair and maintenance of smoke detectors in rented or leased units shall be the responsibility of the tenant. The owner of any unit which is rented or leased shall be obligated to service, repair or replace any malfunctioning smoke detectors within five days of receipt of written notice from the tenant that such smoke detector is in need of service, repair, or replacement.

1602.07.02 Article not exempt from compliance with code

Nothing in this article shall excuse any owner for the required buildings from compliance with all other applicable provision of the Virginia Uniform Statewide Building Code in Chapter 14 of the County of Loudoun Codified Ordinances pertaining to buildings and building regulations.

1602.08 RESERVED

1602.09 RESERVED

1602.10 RESERVED

1602.11 AMENDMENTS.

The following sections of the Statewide Fire Prevention Code are hereby amended as follows: (Editors note: The Loudoun County Fire Prevention Code hereby deletes, modifies or amends the sections of the SFPC as set forth below. Refer to the SFPC for original language).

Chapter 1
Administration

107.2 Fire Prevention Code Operational Permits may be required by the Fire Marshal as permitted under the Statewide Fire Prevention Code. The application process and issuance of permits is in accordance with the Loudoun County Fire Marshal's Fire Prevention Operational Permit Fee Schedule.

All permits issued under this Chapter requiring the payment of a fee, shall be issued by the Fire Marshal or his designated agent.

FIRE PREVENTION OPERATIONAL PERMIT FEE SCHEDULE

DESCRIPTION	PERMIT REQUIRED (Yes or No)	PERMIT FEE	CODE REFERENCE
Aerosol products. An operational permit is required to manufacture, store or handle an aggregate quantity of Level 2 or Level 3 aerosol products in excess of 500 pounds (227 kg) net weight.	**Yes**	**$ 90**	**2801.2**
Amusement buildings. An operational permit is required to operate a special amusement building.	**Yes**	**$ 90**	**Table 107.2**
Aviation facilities. An operational permit is required to use a Group H or Group S occupancy for aircraft servicing or repair and aircraft fuel-servicing vehicles. Additional permits required by other sections of this code include, but are not limited to, hot work, hazardous materials and flammable or combustible finishes.	**Yes**	**$ 90**	**1101.3**
Carnivals and fairs. An operational permit is required to conduct a carnival or fair.	**Yes**	**$ 90**	**Table 107.2**
Battery systems. An operational permit is required to install stationary lead-acid battery systems having a liquid capacity of more than 50 gallons (189 L).	**Yes**	**$ 90**	**Table 107.2**
Cellulose nitrate film. An operational permit is required to store, handle or use cellulose nitrate film in a Group A occupancy.	**Yes**	**$ 90**	**301.2**
Combustible dust-producing operations. An operational permit is required to operate a grain elevator, flour starch mill, feed mill, or a plant pulverizing aluminum, coal, cocoa, magnesium, spices or sugar, or other operations producing combustible dusts as defined in Chapter 2.	**Yes**	**$ 90**	**1301.2**
Combustible fibers. An operational permit is required for the storage and handling of combustible fibers in quantities greater than 100 cubic feet (2.8 m^3). **Exception:** An operational permit is not required for	**Yes**	**$ 90**	**2901.3**

<table>
<tr><th colspan="3">DESCRIPTION</th><th>PERMIT REQUIRED (Yes or No)</th><th>PERMIT FEE</th><th>CODE REFERENCE</th></tr>
<tr><td colspan="3">agricultural storage.</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Compressed gas. An operational permit is required for the storage, use or handling at normal temperature and pressure (NTP) of compressed gases in excess of the amounts listed below.
Exception: Vehicles equipped for and using compressed gas as a fuel for propelling the vehicle.</td><td rowspan="11">Yes</td><td rowspan="11">$ 90</td><td rowspan="11">3001.2</td></tr>
<tr><td colspan="3">PERMIT AMOUNTS FOR COMPRESSED GASES</td></tr>
<tr><td>TYPE OF GAS</td><td colspan="2">AMOUNT (cubic feet at NTP)</td></tr>
<tr><td>Corrosive</td><td colspan="2">200</td></tr>
<tr><td>Flammable (except cryogenic fluids and liquefied petroleum gases)</td><td colspan="2">200</td></tr>
<tr><td>Highly toxic</td><td colspan="2">Any Amount</td></tr>
<tr><td>Inert and simple asphyxiate</td><td colspan="2">6,000</td></tr>
<tr><td>Oxidizing (including oxygen)</td><td colspan="2">504</td></tr>
<tr><td>Pyrophoric</td><td colspan="2">Any Amount</td></tr>
<tr><td>Toxic</td><td colspan="2">Any Amount</td></tr>
<tr><td colspan="3">For SI: 1 cubic foot = 0.02832 m²</td></tr>
<tr><td colspan="3">Covered mall buildings. An operational permit is required for:
1. The placement of retail fixtures and displays, concession equipment, displays of highly combustible goods and similar items in the mall.
2. The display of liquid- or gas-fired equipment in the mall.
3. The use of open-flame or flame-producing equipment in the mall.</td><td>Yes</td><td>$ 90</td><td>Table 107.2</td></tr>
<tr><td colspan="3">Cryogenic fluids. An operational permit is required to produce, store, transport on site, use, handle or dispense cryogenic fluids in excess of the amounts listed below.
Exception: Operational permits are not required for vehicles equipped for and using cryogenic fluids as a fuel for propelling the vehicle or for refrigerating the lading.</td><td rowspan="5">Yes</td><td rowspan="5">$ 90</td><td rowspan="5">3201.2</td></tr>
<tr><td colspan="3">PERMIT AMOUNTS FOR CRYOGENIC FLUIDS</td></tr>
<tr><td>TYPE OF CRYOGENIC FLUIDS</td><td>INSIDE BUILDING (gallons)</td><td>OUTSIDE BUILDING (gallons)</td></tr>
<tr><td>Flammable</td><td>More than 1</td><td>60</td></tr>
<tr><td>Inert</td><td>60</td><td>500</td></tr>
</table>

DESCRIPTION			PERMIT REQUIRED (Yes or No)	PERMIT FEE	CODE REFERENCE
Oxidizing (includes oxygen)	10	50			
Physical or health hazard not indicated above	Any Amount	Any Amount			
For SI: 1 gallon = 3.785 L.					
Dry cleaning plants. An operational permit is required to engage in the business of dry cleaning or to change to a more hazardous cleaning solvent used in existing dry cleaning equipment.			**Yes**	**$ 90**	**1201.2**
Exhibits and trade shows. An operational permit is required to operate exhibits and trade shows.			**Yes**	**$ 90**	**Table 107.2**
Explosives, ammunition and blasting agents: Storage, approved overnight Transportation, each vehicle (valid 6 months) Use, each blasting site or blasting location Firm or company license			**Yes**	 **$ 90** **$ 24** **$ 60** **$ 60**	 **3301.2** **3301.2** **3301.2** **3301.2**
Extremely Hazardous Substances (EHS)			**Yes**	**$ 600**	**Table 107.2**
Fireworks Retailer and/or Wholesaler Private Display, not open to the public			 **Yes** **Yes**	 **$ 600** **$ 600**	 **3301.2** **3301.2**
Fire hydrants and valves. An operational permit is required to use or operate fire hydrants or valves intended for fire suppression purposes which are installed on water systems and accessible to a fire apparatus access road that is open to or generally used by the public. **Exception:** An operational permit is not required for authorized employees of the water company that supplies the system or the fire department to use or operate fire hydrants or valves. Permits or monitoring devices are issued through the respective water purveyor company.			**No**		
Fire Lane Plan Review (existing)			**Yes**	**$ 95**	**Table 107.2**

DESCRIPTION	PERMIT REQUIRED (Yes or No)	PERMIT FEE	CODE REFERENCE
Flammable and combustible liquids. An operational permit is required: 1. To use or operate a pipeline for the transportation within facilities of flammable or combustible liquids. This requirement shall not apply to the offsite transportation in pipelines regulated by the Department of Transportation (DOT) (see Section 3501.1.2) nor does it apply to piping systems (see Section 3503.6). 2. To store, handle or use Class I liquids in excess of 5 gallons (19 L) in a building or in excess of 10 gallons (37.9 L) outside of a building, except that a permit is not required for the following: 2.1. The storage or use of Class I liquids in the fuel tank of a motor vehicle, aircraft, motorboat, mobile power plant or mobile heating plant, unless such storage, in the opinion of the fire official, would cause an unsafe condition. 2.2. The storage or use of paints, oils, varnishes or similar flammable mixtures when such liquids are stored for maintenance, painting or similar purposes for a period of not more than 30 days. 3. To store, handle or use Class II or Class IIIA liquids in excess of 25 gallons (95 L) in a building or in excess of 60 gallons (227 L) outside a building, except for fuel oil used in connection with oil-burning equipment. 4. To remove Class I or Class II liquids from an underground storage tank used for fueling motor vehicles by any means other than the approved, stationary on-site pumps normally used for dispensing purposes. 5. To operate tank vehicles, equipment, tanks, plants, terminals, wells, fuel-dispensing stations, refineries, distilleries and similar facilities where flammable and combustible liquids are produced, processed, transported, stored, dispensed or used. 6. To install, alter, remove, abandon, place temporarily out of service (for more than 90 days) or otherwise dispose of an underground, protected above-ground or above-ground flammable or combustible liquid tank. 7. To change the type of contents stored in a flammable or combustible liquid tank to a material, which poses a greater hazard than that for which the tank was designed and constructed. 8. To manufacture, process, blend or refine flammable or combustible liquids.	**Yes**	**$ 90**	**3401.4**
Floor finishing. An operational permit is required for floor	**Yes**	**$ 90**	**1501.2**

DESCRIPTION	PERMIT REQUIRED (Yes or No)	PERMIT FEE	CODE REFERENCE
finishing or surfacing operations exceeding 350 square feet (33 m^2) using Class I or Class II liquids.			
Fruit and crop ripening. An operational permit is required to operate a fruit-, or crop-ripening facility or conduct a fruit-ripening process using ethylene gas	**Yes**	**$ 90**	**1601.2**
Fumigation and thermal insecticide fogging. An operational permit is required to operate a business of fumigation or thermal insecticide fogging and to maintain a room, vault or chamber in which a toxic or flammable fumigant is used.	**Yes**	**$ 90**	**1701.2**

DESCRIPTION	PERMIT REQUIRED (Yes or No)	PERMIT FEE	CODE REFERENCE
Hazardous materials. An operational permit is required to store, transport on site, dispense, use or handle hazardous materials in excess of the amounts listed below.	**Yes**	**$ 600**	**2701.5**

PERMIT AMOUNTS FOR HAZARDOUS MATERIALS

TYPE OF MATERIAL	AMOUNT
Combustible liquids	See flammable and combustible liquids
Corrosive materials	
Gases	See compressed gases
Liquids	55 gallons
Solids	1000 pounds
Explosive materials	See explosives
Flammable materials	
Gases	See compressed gases
Liquids	See flammable and combustible liquids
Solids	100 pounds
Highly toxic materials	
Gases	See compressed gases
Liquids	Any amount
Solids	Any amount
Oxidizing materials	
Gases	See compressed gases
Liquids	
Class 4	Any amount
Class 3	1 gallon[a]
Class 2	10 gallons
Class 1	55 gallons
Solids	
Class 4	Any amount
Class 3	10 pounds[b]
Class 2	100 pounds
Class 1	500 pounds
Organic peroxides	
Gases	See compressed gases
Liquids	
Class I	Any amount
Class II	Any amount
Class III	1 gallon
Class IV	2 gallons
Class V	No permit required

DESCRIPTION		PERMIT REQUIRED (Yes or No)	PERMIT FEE	CODE REFERENCE
Solids				
Class I	Any amount			
Class II	Any amount			
Class III	10 pounds			
Class IV	20 pounds			
Class V	No permit required			
Pyrophoric materials				
Gases	See compressed gases			
Liquids	Any amount			
Solids	Any amount			
Toxic materials				
Gases	See compressed gases			
Liquids	10 gallons			
Solids	100 pounds			
Unstable (reactive) materials				
Liquids				
Class 4	Any amount			
Class 3	Any amount			
Class 2	5 gallons			
Class 1	10 gallons			
Solids				
Class 4	Any amount			
Class 3	Any amount			
Class 2	50 pounds			
Class 1	100 pounds			
Water-reactive materials				
Liquids				
Class 3	Any amount			
Class 2	5 gallons			
Class 1	55 gallons			
Solids				
Class 3	Any amount			
Class 2	50 pounds			
Class 1	500 pounds			
For SI: 1 gallon = 3.785 L, 1 pound = 0.454 kg.				
HPM facilities. An operational permit is required to store, handle or use hazardous production materials.		**Yes**	**$ 90**	**1801.5**
High piled storage. An operational permit is required to use a building or portion thereof as a high-piled storage area exceeding 500 square feet (46 m²).		**Yes**	**$ 90**	**Table 107.2**

DESCRIPTION	PERMIT REQUIRED (Yes or No)	PERMIT FEE	CODE REFERENCE
Hot work operations. An operational permit is required for hot work including, but not limited to: 1. Public exhibitions and demonstrations where hot work is conducted. 2. Use of portable hot work equipment inside a structure. **Exception:** Work that is conducted under a construction permit. 3. Fixed-site hot work equipment such as welding booths. 4. Hot work conducted within a hazardous fire area. 5. Application of roof coverings with the use of an open-flame device. 6. When approved, the fire official shall issue a permit to carry out a Hot Work Program. This program allows approved personnel to regulate their facility's hot work operations. The approved personnel shall be trained in the fire safety aspects denoted in this chapter and shall be responsible for issuing permits requiring compliance with the requirements found in this chapter. These permits shall be issued only to their employees or hot work operations under their supervision.	Yes	$90	2601.2
Industrial ovens. An operational permit is required for operation of industrial ovens regulated by Chapter 21.	**Yes**	**$ 90**	**2101.2**
Lumber yards and woodworking plants. An operational permit is required for the storage or processing of lumber exceeding 100,000 board feet (8,333 ft³) (236 m³).	**Yes**	**$ 90**	**1901.2**
Liquid- or gas-fueled vehicles or equipment in assembly or mercantile buildings. An operational permit is required to display, operate or demonstrate liquid- or gas-fueled vehicles or equipment in assembly or mercantile buildings.	**Yes**	**$ 90**	**Table 107.2**
LP-gas. An operational permit is required for: 1. Storage and use of LP-gas. **Exception:** An operational permit is not required for individual containers with a 500-gallon (1893 L) water capacity or less serving occupancies in Group R-3. 2. Operation of cargo tankers that transport LP-gas.	**Yes** **0-499 gals** **500+ gals**	 **$0** **$ 90**	**3801.2**
Magnesium. An operational permit is required to melt, cast, heat treat or grind more than 10 pounds (4.54 kg) of magnesium.	**Yes**	**$ 90**	**3601.2**
Miscellaneous combustible storage. An operational permit is required to store in any building or upon any premises in excess of 2,500 cubic feet (71 m³) gross volume	**Yes**	**$ 90**	**315.1**

DESCRIPTION	PERMIT REQUIRED (Yes or No)	PERMIT FEE	CODE REFERENCE
of combustible empty packing cases, boxes, barrels or similar containers, rubber tires, rubber, cork or similar combustible material.			
Open burning. An operational permit is required to operate a special incineration device as defined by the State Air Pollution Control Board.	**Yes**	**$ 120**	**307.2**
Open flames and candles. An operational permit is required to remove paint with a torch; use a torch or open-flame device in a hazardous fire area; or to use open flames or candles in connection with assembly areas, dining areas of restaurants or drinking establishments.	**Yes Torches** **No Candles**	**$ 90**	**308.4.1**
Organic coatings. An operational permit is required for any organic-coating manufacturing operation producing more than 1 gallon (4 L) of an organic coating in one day.	**Yes**	**$ 90**	**2001.2**
Places of Assembly or Educational. An operational permit is required to operate a place of assembly or educational occupancy with a rated occupancy greater than 49 persons.	**Yes**	**$ 90**	**Table 107.2**
Private fire hydrants. An operational permit is required for the removal from service, use or operation of private fire hydrants. **Exception:** An operational permit is not required for private industry with trained maintenance personnel, private fire brigade or fire departments to maintain, test and use private hydrants.	**No**		
Pyrotechnic special effects material. An operational permit is required for use and handling of pyrotechnic special effects material.	**Yes**	**$ 90**	**Table 107.2**
Pyroxylin plastics. An operational permit is required for storage or handling of more than 25 pounds (11 kg) of cellulose nitrate (pyroxylin) plastics and for the assembly or manufacture of articles involving pyroxylin plastics.	**Yes**	**$ 90**	**4201.2**
Refrigeration equipment. An operational permit is required to operate a mechanical refrigeration unit or system regulated by Chapter 6.	**Yes**	**$ 90**	**601.2**
Repair garages and service stations. An operational permit is required for operation of repair garages and automotive, marine and fleet service stations.	**Yes**	**$ 90**	**2201.2**
Rooftop heliports. An operational permit is required for the operation of a rooftop heliport	**Yes**	**$ 90**	**1101.3**
Spraying or dipping. An operational permit is required to conduct a spraying or dipping operation utilizing flammable or combustible liquids or the application of combustible powders regulated by Chapter 15.	**Yes**	**$ 90**	**1501.2**
Storage of scrap tires and tire byproducts. An	**Yes**	**$ 90**	**2501.2**

DESCRIPTION	PERMIT REQUIRED (Yes or No)	PERMIT FEE	CODE REFERENCE
operational permit is required to establish, conduct or maintain storage of scrap tires and tire byproducts that exceeds 2,500 cubic feet (71m³) of total volume of scrap tires and for indoor storage of tires and tire byproducts.			
Temporary membrane structures, tents and canopies. An operational permit is required to operate an air-supported temporary membrane structure or a tent. **Exceptions:** 1. Tents used exclusively for recreational camping purposes. 2. Tents and air-supported structures that cover an area of 900 square feet or less, including all connecting areas or spaces with a common means of egress. 3. Fabric canopies and awnings open on all sides which comply with all the following: 3.1 Individual canopies shall have a maximum size of 700 square feet (65m²). 3.2 The aggregate area of multiple canopies placed side by side without a fire break clearance of 12 feet (3658 mm) shall not exceed 700 square feet (65m²) total. **3.3** A minimum clearance of 12 feet (3658) to structures and other tents shall be provided.	**Yes**	**$ $90**	**2403.4**
Tent Event. An operational permit is required for an event with 20 tents of any size.	**Yes**	**$ 360 per every 20 tents**	
Tire rebuilding plants. An operational permit is required for the operation and maintenance of a tire-rebuilding plant.	**Yes**	**$ 90**	**Table 107.2**
Waste handling. An operational permit is required for the operation of wrecking yards, junk yards and waste material-handling facilities	**Yes**	**$ 90**	**2501.2**
Wood products. An operational permit is required to store chips, hogged material, lumber or plywood in excess of 200 cubic feet (6 m³).	**Yes**	**$ 90**	**Table 107.2**

Note: Oxidizing materials:

a. 20 gallons when Table 2703.1.1(1) Note k applies and hazard identification signs in accordance with Section 2703.5 are provided for quantities of 20 gallons or less.

b. 200 pounds when Table 2703.1.1(1) Note k applies and hazard identification signs in accordance with Section 2703.5 are provided for quantities of 200 pounds or less.

Chapter 2
Definitions

Bonfire: An outdoor fire utilized for ceremonial purposes. Bonfires must consist of seasoned wood, piled neatly, no more than 5 feet in diameter by 5 feet in height and ignited with a small quantity of paper. Bonfires shall not burn longer than 3 hours. Any increase to the maximum size and duration of a bonfire may be approved by the Fire Marshal based upon a determination that fire safety requirements of the situation and the desirable duration of burn warrant the increase. Bonfires shall not be utilized for waste disposal purposes.

Built up area: Any area with a substantial portion covered by industrial, commercial or residential buildings.

Campfire: An outdoor recreational fire, no larger than 3 feet in diameter by 2 feet in height and used for cooking purposes.

Clean lumber: Wood or wood products that have been cut or shaped and include wet, air dried and kiln-dried wood products. Clean lumber does not include wood products that have been painted, pigment-stained or pressure-treated.

Land Clearing Debris: Brush, stumps and other vegetation and similar matter generated from site clearing. This shall not include demolition materials, refuse or similar debris products from other sites.

Nuisance: Dangerous or unhealthy substances which have escaped, spilled, been released or which have been allowed to accumulate in or on any place. Smoke or odors that are created by the burning of materials may be considered a nuisance if it permeates surrounding buildings or does not readily dissipate due to atmospheric conditions.

Open Burning: Combustion of solid waste without control of combustion air to maintain adequate temperature for efficient combustion, containment of the combustion reaction in an enclosed device or control of the products' emission.

Person: Includes a corporation, firm, partnership, association, organization and any other group acting as a unit, as well as individuals. It shall also include an executor, administrator, trustee, receiver or other representative appointed according to law. Whenever the word “person” appears in any section of this code prescribing a penalty or fine, as to partnerships or associations, the word shall include the partners or members thereof, and as to corporations, shall include the officer, agents or members thereof who are responsible for any violation of such section.

Virginia Forestry Fire Laws: State law pertaining to open burning, specifically Sections § 10.1-1135 through § 10.1-1161 of the Code of Virginia which mandate certain requirements and conditions for open burning.

Virginia State Air Pollution Control Board's Regulations Concerning Emissions Standards for Open Burning: (9 VAC 5-40-5600): Regulations promulgated under the authority of the Code of Virginia (§ 10.1-1308) that pertain to the abatement, control and prohibition of air pollution throughout or in any part of the Commonwealth.

Yard Waste: Grass, grass clippings, tree trimmings, bushes, shrubs and clippings from bushes and shrubs.

Chapter 3
General Precautions Against Fire

Section 307 Open Burning and Recreational Fires

Delete Statewide Fire Prevention Code 307.1 through 307.5.

307.1 Prohibited Open Burning

1. Between May 1 and September 30, open burning is prohibited. Exception: Campfires are allowed provided they are located no closer than 50 feet from a structure.
2. During periods designated by the Virginia Department of Forestry, open burning is restricted.
3. Burning of household trash, garbage, refuse, household waste, commercial waste, construction waste, combustible liquid, debris waste, hazardous waste, impregnated lumber, junk, rubber, plastics, stumps, tires, tar based materials, oil or petroleum based products, products of salvage operations, chemicals, animal carcasses and similar materials is prohibited.
4. Open burning of yard waste in urban or built up areas is prohibited.
5. Any other burning that creates a nuisance is prohibited.
6. Open burning that is offensive or objectionable because of smoke or odor emissions or when atmospheric conditions or local circumstances make such fires hazardous shall be prohibited.

307.2 Permitted Open Burning

1. Open burning is allowed as limited by this section unless prohibited by Section 307.1
2. Burning of yard waste in non-urban areas where materials are generated on site. The burning may not be closer than 50 feet from a structure.
3. Agricultural burning, such as clearing of a field or fence row, for materials generated on site. The burning may be no closer than 50 feet from a structure and 1,000 feet from an occupied structure, unless prior permission has been given by the occupant and may not pose a hazard to highways and airfields.
4. Bonfires, located no closer than 50 feet from a structure.
5. Burning of product generated by land clearing operations approved by the Fire Marshal and shall also comply with provisions of the Virginia State Air Pollution Control Board (9 VAC 5-40-5600) and shall not be within 1,000 from an occupied structure.
6. Warming barrels containing clean lumber at a construction site, as approved by the Fire Marshal. Such burning shall be contained within a barrel or similar container, be covered or screened to prevent flying embers and may be no closer than 15 feet from a structure.
7. Campfires located no closer than 50 feet from a structure,
8. Burning that is approved through the Virginia State Air Pollution Control Board regional director for the purpose of training firefighting resources. Exception: Training schools having permanent facilities for firefighting instruction are not required to obtain approval.
9. Other open burning as approved by the Fire Marshal as needed for public safety, abatement of hazard, destruction of pests or other common good.

307.3 Attendance
Allowable open burning, to include bonfires or recreational fires shall be constantly attended by responsible, competent persons over the age of 18 years old as may be necessary to contain the fire until the fire is extinguished. A minimum of one portable fire extinguisher with a minimum 4-A rating or other approved on-site fire-extinguishing equipment, such as dirt, sand, water barrel, garden hose or water truck, shall be available for immediate utilization.

307.4 Notification. Notification to the Loudoun County Emergency Communications Center is required prior to and at the conclusion of any allowable open burning event permitted under this section.
Exception: Campfires.

307.5 Extinguishment. The Fire Marshal shall order extinguishment, either by the responsible party or local firefighting resources of any open burning which violates the provisions of this section or otherwise creates a nuisance.

307. 6 Grills: Open flame grills, hibachis, gas grills, manufactured fireplaces or firepits, etc., shall not be utilized within 15 feet of any apartment, apartment building, condominium, commercial business, health care facilities, housing for the aged or housing for the physically and/or mentally impaired.

Exception:
One and two-family dwellings.

Chapter 4
Emergency Planning and Preparedness

408.3.5 Posting Egress Plans: All classrooms, libraries, laboratories and other areas of public access within an educational occupancy shall be posted with evacuation plans in a conspicuous area of each room.

Chapter 5
Fire Service Features

503.1Exemptions: 1(a). Fire Apparatus Access Roads, to include Fire Lanes, shall be designed in accordance with the Loudoun County Facilities Standards Manual.

503.4.1 Enforcement: Any violations of Section 503.4 shall be enforced by the Fire Marshal or designated representative; any authorized law enforcement officer or any law enforcement official of Loudoun County under Chapter 486, of the Codified Ordinances of the County.

505.1 Addressing of Premises: Addressing of premises shall be in accordance with Chapter 1026 of the Codified Ordinances of Loudoun County.

507.5.3.1 Rural fire protection. Features such as dry hydrants, underground water storage tanks and related water supply accessories shall be maintained by the owner according to the conditions of acceptance**.**

Chapter 9
Fire Protection Systems

901.10: Misuse of 9-1-1 system: No person shall use a prerecorded message transmitted directly to a "9-1-1" telephone number, nor shall any person install, operate or maintain an automatic dialing device which is programmed to transmit a prerecorded message or code signal directly to a "9-1-1" telephone number.

Chapter 24
Tents and Other Membrane Structures

2403.4.1 No vendor or other person shall erect a tent without first having applied for a permit.

Chapter 33
Explosives and Fireworks

3301.2.3.2 Applicant Restrictions: No person, corporation or other entity, having been convicted of a violation under this Chapter shall be eligible to obtain a permit for the display or sale of fireworks, or participate in any manner in the transportation, sale, or display of fireworks for period of five (5) years from the date of conviction.

3301.2.4.1 Insurance for Blasting: The minimum amount of a certificate of insurance shall not be less than $5,000,000 (five million dollars). This certificate of insurance shall further indemnify the County of Loudoun, its agents and employees from any and all actions which may result from the permitted blasting.

3301.2.4.2 Insurance for fireworks display: The applicant for a permit shall furnish a certificate of insurance in the amount of five million dollars ($5,000.000). This certificate of insurance shall further indemnify the County of Loudoun, named as an additional insured, its agents and employees from any and all actions which may result from the permitted display.

3301.1.3 Exception 4: The possession, storage, sale, handling and use of specific types of Division 1.4G fireworks listed as permissible.

3301.9: Transportation: The transportation of explosive materials shall comply with applicable provisions of this Chapter and the regulations governing the transportation of hazardous materials as promulgated by the Virginia Waste Management Board.

3301.9.1 Vehicle prohibitions: The attachment of any type of trailer behind a truck, a tractor/semi-trailer or truck full-trailer combination for transporting explosive is prohibited.

3301.9.2 Vehicle restrictions: Vehicles containing explosives shall not be taken into a garage or repair shop for repairs or storage.

3301.9.3 Vehicle contents: Only explosives and related material authorized by the applicable provisions of Title 49 of the Code of Federal Regulations listed in Appendix A shall be carried in the body of an explosive transport vehicle.

3301.9.4 Emergency conditions: The Department of Fire, Rescue and Emergency Management and the Office of the Loudoun County Sheriff shall be promptly notified when a vehicle transporting explosives is involved in an accident, breaks down, or catches fire. Only in the event of such an emergency shall the transfer of explosives from one vehicle to another be allowed on highways within the County and only when qualified supervision is provided. Except in such an emergency, a vehicle transporting explosives shall not be parked, before reaching its destination, on highways within the jurisdiction or adjacent to or in proximity to any school, hospital, bridge, tunnel, dwelling, building or place where people work congregate or assemble.

3301.9.5 Drivers: Vehicles transporting explosives shall be in the custody of drivers who possess a valid driver's license with proper endorsements. Such drivers shall be familiar with all State and County traffic regulations and all provisions of this Article governing the transporting of explosives.

3301.9.6 Enforcement: The Fire Marshal may enforce the regulations contained herein pertaining to the intra-County transportation of explosives.

3301.9.7 All "bulk" explosive transport vehicles shall have in working order, a metering device to accurately measure the amount of explosives or blasting agents being expelled from the vehicle.

3302.1 Definitions; Fireworks; Permissible Fireworks. Those 1.4G fireworks that have been approved through testing or other means and published as such in an annual list by the Fire Marshal.

3308.2.3 Permits for the display of fireworks or other pyrotechnic effects shall be applied for not less than thirty (30) days prior to the date of the display.

3308.3.1 Fireworks or other pyrotechnic effects shall not be approved for use in an inhabited building.

3308.11 Retail sale**s**. A representative from the store shall monitor the display of the approved ("permissible") fireworks to prevent maliciously tampering, attempting to ignite, or underage accessibility. This store representative may have other duties or assignments in the immediate area of the approved fireworks but may not be a cashier.

A store security video system shall monitor the fireworks display during business hours. In times when the store representative's attention is focused on other duties and cannot monitor the display of fireworks, the store security video system shall be continuously monitored by store personnel. This temporary unattended option shall be utilized no longer than 10 minutes per hour while the store is open to the public. If unable to comply with this procedure the display of fireworks must be constantly supervised by a competent person and safeguarded behind an approved physical barrier that prevents tampering or access by unauthorized persons. In sprinklered buildings, the maximum permitted quantity of fireworks shall not exceed 250 pounds net weight of pyrotechnic composition of the total quantity of fireworks in the building, including retail display samples. Where pyrotechnic composition is not known 25 percent gross weight of the fireworks including packaging shall be used as the maximum permitted quantity.

In non-sprinklered buildings, the maximum permitted quantity of fireworks shall not exceed 125 pounds net weight of pyrotechnic composition of the total quantity of fireworks in the building including retail display samples. Where the net weight of the pyrotechnic composition of the fireworks is not known, 25 percent of the gross weight of the fireworks including packaging shall be used as the maximum permitted quantity.

A minimum of one pressurized water portable fire extinguisher complying with Section 906 shall be located not more than 15 feet (4572 mm) and not less than 10 feet (3048 mm) from the hazard. "No Smoking" signs complying with Section 310 shall be conspicuously posted in areas where fireworks are stored or displayed for retail sale. All structure outlets, whether temporary or permanent, used for the sale or display of fireworks, must be inspected by the Fire Marshal or his/her designated representative prior to the sale or display of fireworks. All necessary business licenses, zoning approvals and other permits must be available at the time of this inspection. Location of a temporary retail sale location shall be approved by the Fire Marshal.

3308.11.1 Dates of sale: Approved permissible fireworks may be sold in Loudoun County from June 15 through July 15 each year, and from December 15 through January 6, provided that the authorized vendor has acquired the appropriate Loudoun County permits, licenses and inspections. Permits for the sale of permissible fireworks shall be applied for not later than 30 days prior to the beginning of each sales period.

3308.11.2 Additional inspections: The owner or his/her designated agent, of any temporary structure used for the sale or display of fireworks, if provided with electricity from any source, shall provide proof of a satisfactory electrical inspection prior to the sale, display or storage of fireworks. This inspection shall be required each time the temporary structure is moved, assembled or reconfigured in any manner.

3308.11.3 Insurance for sale of fireworks. The permit holder shall furnish a certificate of insurance in the amount of $5,000,000 (five million dollars). This certificate of insurance shall further indemnify the County of Loudoun, its agents and employees from any and all actions which may result from the permitted sale.

3308.11.4 Seizure of fireworks: The Fire Marshal shall seize, take, remove or cause to be removed at the expense of the owner, all stocks of fireworks that are offered, exposed or stored for display or sale that are in violation of this Chapter. This seizure shall include any approved fireworks which may be found with those fireworks which are in violation, Seized fireworks shall be held until any criminal charges arising from these violations have been adjudicated.

3308.11.5 Disposal of seized fireworks: If a judgment of conviction be entered, the court shall determine whether fireworks not prohibited by the Loudoun County Fire Prevention Code or otherwise restricted by this Chapter are to be returned to the owner or disposed of in a manner approved by the Fire Marshal upon expiration of the time allowed for an appeal for such conviction. Prohibited or otherwise restricted fireworks shall be disposed of in a manner approved by the Fire Marshal. Where no criminal charges are instituted, seized fireworks shall be disposed of in a manner approved by the code official after a period of thirty (30) days.

3310.1 Unlawful activities: Except as hereinafter provided, it shall be unlawful for any person, firm or corporation to transport, manufacture, store, possess, sell, offer for sale, expose for sale or to buy, use, ignite or explode any firecracker, torpedo, skyrocket, or other substance or thing that contains any explosive or inflammable compound or substance, and which explodes, rises into the air or travels laterally, or fires projectiles into the air, other than sparks or those fireworks excepted under the provision of those listed in 3310.2.

3310.1.1 Enforcement: The Fire Marshal or any law-enforcement officer may enforce the regulations contained herein pertaining to the unlawful transport, manufacture, storage, possession, sale, purchase or use of unlawful fireworks.

3310.1.2 Seizure and destruction of certain fireworks.
Any law-enforcement officer is authorized to seize any article of fireworks as defined by 3310.1 in the possession or under the control of a person.

3310.2 Permissible fireworks: The provisions of 3310.1 shall not apply to fireworks, which have been approved by the Fire Marshal's Office.

3310.3 Approval of permissible fireworks: Persons, firms or corporations engaged in the selling or offering for sale fireworks at retail establishments shall sell only fireworks approved by the Fire Marshal.

3310.4 Approval of fireworks assortments: Pre-packaged fireworks assortments shall bear a label listing the contents of said assortment showing the trade name, manufacturers and individual item number of each item included. Assortments not so labeled or containing individual items that have not been approved shall not be approved for sale.

3310.5 All vehicles transporting fireworks classified by DOT as 1.3 display fireworks, shall comply with 3301.9.

3311.1 Minimum age of sales personnel: No person under the age of eighteen (18) years shall be allowed to sell fireworks.

3311.2 Sales to Minors: It shall be unlawful to sell any firework to any person under the age of eighteen (18) unless accompanied by a parent, legal guardian or other competent adult.

Chapter 38
Liquid Petroleum Gases

3801.2.2 Revocation of Permit. In the event that a valid permit is revoked, the distributor shall within twenty-four (24) hours of notification remove all LP-gas containers from the site. The Fire Marshal is authorized to have such cylinders removed by any distributor and at no cost to the government if proper action is not taken within the prescribed timeframe. Notification for the purpose of this section shall be satisfied by a telephone call to the main business or emergency contact number for the distributor.

3809.12. Location of storage outside of buildings. Storage outside of buildings, for containers awaiting use, resale or part of a cylinder exchange program shall be located not less than 10 feet (3048 mm) from openings into buildings, 20 feet (6096 mm) from any motor vehicle fuel dispenser, 10 feet (3048 mm) from any combustible material, 5 feet from any lot line or public way, and in accordance with Table 3809.12.

TABLE 3809.12
LOCATION OF CONTAINERS AWAITING USE OR RESALE STORED OUTSIDE OF BUILDINGS

Quantity of LP-Gas Stored	Distances to a Building or Group of Buildings (feet)	Distance to a Property Lot Line or Public Way
2500 pounds or less	0	5
2,501 to 6,000 pounds	10	10
6,001 to 10,000 pounds	20	20
Over 10,000 pounds	25	25

For SI: 1 foot: 304.8 mm, 1 pound = 0.454 kg.

3809.16 Quantity limitations. Quantities of nominal 20lb cylinders in cylinder exchange locations shall not exceed 72 cylinders. Used returned cylinders shall be counted and stored in the same manner as full cylinders.

AYES: Mr. Gallaway, Ms. Mallek, Ms. McKeel, and Mr. Randolph.
NAYS: None.
ABSENT: Mr. Dill and Ms. Palmer.

ORDINANCE NO. 19-A(12)

**AN ORDINANCE TO AMEND AND ADOPT
THE ALBEMARLE COUNTY FIRE RESCUE
OFFICE OF THE FIRE MARSHAL FEE SCHEDULE**

WHEREAS, pursuant to Virginia Code § 27-97, the Board has adopted the Virginia Statewide Fire Prevention Code as set forth in § 6-200 of the Albemarle County Code; and

WHEREAS, the Board is authorized by Virginia Code § 27-98 to establish such procedures or requirements, including the imposition of fees to defray costs, as may be necessary for the administration and enforcement of the Virginia Statewide Fire Prevention Code.

NOW, THEREFORE, BE IT ORDAINED THAT the Albemarle County Board of Supervisors hereby adopts the Albemarle County Fire Rescue Office of the Fire Marshal Fee Schedule, as amended, attached hereto and incorporated herein.

This ordinance shall be effective immediately.

*****

FEE SCHEDULE (Effective on May 15, 2015)

DESCRIPTION	PERMIT REQUIRED (Yes or No)	PERMIT FEE	INSPECTION FEE
Aerosol products. An operational permit is required to manufacture, store or handle an aggregate quantity of Level 2 or Level 3 aerosol products in excess of 500 pounds (227 kg) net weight.	Yes (annual/per location)	$200	See inspection fee below
Amusement buildings. An operational permit is required to operate a special amusement building.	Yes (Fixed–Annual/location or mobile–30 days/location)	$200	See inspection fee below
Aviation facilities. An operational permit is required to use a Group H or Group S occupancy for aircraft servicing or repair and aircraft fuel-servicing vehicles. Additional permits required by other sections of this code include, but are not limited to, hot work, hazardous materials and flammable or combustible finishes.	Yes (annual/per location)	$200	See inspection fee below
Carnivals and fairs. An operational permit is required to conduct a carnival or fair.	Yes (30 days/location)	$200	No
Cellulose nitrate film. An operational permit is required to store, handle or use cellulose nitrate film in a Group A occupancy.	Yes (annual/per location)	$200	See inspection fee below
Combustible dust-producing operations. An operational permit is required to operate a grain elevator, flour starch mill, feed mill, or a plant pulverizing aluminum, coal, cocoa, magnesium, spices or sugar, or other operations producing combustible dusts as defined in Chapter 2.	Yes (annual/per location)	$200	See inspection fee below
Combustible fibers. An operational permit is required for the storage and handling of combustible fibers in quantities greater than 100 cubic feet (2.8 m^3). **Exception:** An operational permit is not required for agricultural storage.	Yes (annual/per location)	$200	See inspection fee below

Compressed gas. An operational permit is required for the storage, use or handling at normal temperature and pressure (NTP) of compressed gases in excess of the amounts listed below. **Exception:** Vehicles equipped for and using compressed gas as a fuel for propelling the vehicle. **PERMIT AMOUNTS FOR COMPRESSED GASES** **TYPE OF GAS** — **AMOUNT (cubic feet at NTP)** Corrosive — 200 Flammable (except cryogenic fluids and liquefied petroleum gases) — 200 Highly toxic — Any amount Inert and simple asphyxiant — 6,000 Oxidizing (including oxygen) — 504 Pyrophoric — Any amount Toxic — Any amount For SI: 1 cubic foot = 0.02832 m^3.	Yes (annual/per location)	$200	See inspection fee below
Covered and open mall buildings. An operational permit is required for: 1. The placement of retail fixtures and displays, concession equipment, displays of highly combustible goods and similar items in the mall. 2. The display of liquid-fired or gas-fired equipment in the mall. 3. The use of open-flame or flame-producing equipment in the mall.	Yes (annual/per location)	$200	See inspection fee below
Cryogenic fluids. An operational permit is required to produce, store, transport onsite, use, handle or dispense cryogenic fluids in excess of the amounts listed below. **Exception:** Operational permits are not required for vehicles equipped for and using cryogenic fluids as a fuel for propelling the vehicle or for refrigerating the lading. **PERMIT AMOUNTS FOR CRYOGENIC FLUIDS** **TYPE OF CRYOGENIC FLUID** — **INSIDE BUILDING (gallons)** — **OUTSIDE BUILDING (gallons)** Flammable — More than 1 — 60 Inert — 60 — 500 Oxidizing (includes oxygen) — 10 — 50 Physical or health hazard not indicated above — Any amount — Any amount For SI: 1 gallon = 3.785 L.	Yes (annual/per location)	$200	See inspection fee below
Cutting and welding. An operational permit is required to conduct cutting or welding operations within the jurisdiction.	Yes (per event/location)	$100	No
Dry cleaning plants. An operational permit is required to engage in the business of dry cleaning or to change to a more hazardous cleaning solvent used in existing dry cleaning	Yes (annual/per location)	$200	See inspection fee below
Exhibits and trade shows. An operational permit is required to operate exhibits and trade shows.	Yes (per event/location)	$200	See inspection fee below
Explosives, fireworks, and pyrotechnics. An operational permit is required for the manufacture, storage, handling, sale or use of any quantity of explosive, explosive materials, fireworks, pyrotechnic special effects, or pyrotechnic special effects material within the scope of Chapter 56. **Exception:** Storage in Group R-3 or R-5 occupancies of smokeless propellant, black powder and small arms primers for personal use, not for resale, and in accordance with the quantity limitations and conditions set forth in Section 5601.1, exception numbers four and twelve. **Note: Manufacture, storage, handling, sale of explosives, explosive materials and pyrotechnics requires annual permit and facility inspection with associated fees.** **Use of explosives/blasting requires a use permit every 30 days with associated fees.** **Fireworks and Pyrotechnic special effects require either wholesale (60 days), retail (60 days) or use/display (per event 1 day)**	Fixed Facility: Yes: (annual/location) Site Storage: in addition to use (30 days) Use/ Blasting : Yes (per event – 30 days maximum/location) Wholesale (fireworks): Yes (60 days/location) Retail (fireworks): yes (60 days/location) Display/Use (fireworks): Yes (per event 1 day/location)	$200 --------------------- $200 --------------------- $500 --------------------- $500 --------------------- $600	See inspection fee below --- No --- No --- See inspection fee below --- No

Fire hydrants and valves. An operational permit is required to use or operate fire hydrants or valves intended for fire suppression purposes that are installed on water systems and accessible to a fire apparatus access road that is open to or generally used by the public. **Exception:** An operational permit is not required for authorized employees of the water company that supplies the system or the fire department to use or operate fire hydrants or valves.	Yes (per event/location)	$100	No
Flammable and combustible liquids. An operational permit is required: 1. To use or operate a pipeline for the transportation within facilities of flammable or combustible liquids. This requirement shall not apply to the offsite transportation in pipelines regulated by the Department of Transportation (DOTn) nor does it apply to piping systems. 2. To store, handle or use Class I liquids in excess of 5 gallons (19 L) in a building or in excess of 10 gallons (37.9 L) outside of a building, except that a permit is not required for the following: 2.1. The storage or use of Class I liquids in the fuel tank of a motor vehicle, aircraft, motorboat, mobile power plant or mobile heating plant, unless such storage, in the opinion of the fire official, would cause an unsafe condition. 2.2. The storage or use of paints, oils, varnishes or similar flammable mixtures when such liquids are stored for maintenance, painting or similar purposes for a period of not more than 30 days. 3. To store, handle or use Class II or Class IIIA liquids in excess of 25 gallons (95 L) in a building or in excess of 60 gallons (227 L) outside a building, except for fuel oil used in connection with oil-burning equipment. 4. To remove Class I or Class II liquids from an underground storage tank used for fueling motor vehicles by any means other than the approved, stationary on-site pumps normally used for dispensing purposes. 5. To operate tank vehicles, equipment, tanks, plants, terminals, wells, fuel- dispensing stations, refineries, distilleries and similar facilities where flammable and combustible liquids are produced, processed, transported, stored, dispensed or used. 6. To install, alter, remove, abandon, place temporarily out of service (for more than 90 days) or otherwise dispose of an underground, protected above-ground or above-ground flammable or combustible liquid tank. 7. To change the type of contents stored in a flammable or combustible liquid tank to a material that poses a greater hazard than that for which the tank was designed and constructed. 8. To manufacture, process, blend or refine flammable or combustible liquids.	Yes (annual/per location)	$200	See inspection fee below
Floor finishing. An operational permit is required for floor finishing or surfacing operations exceeding 350 square feet (33 m^2) using Class I or Class II liquids.	Yes (30 days/location)	$75	No
Fruit and crop ripening. An operational permit is required to operate a fruit-ripening or crop-ripening facility or conduct a fruit-ripening process using ethylene gas.	Yes (annual/per location)	$200	See inspection fee below
Fumigation, thermal and insecticidal fogging. An operational permit is required to operate a business of fumigation, thermal or insecticidal fogging and to maintain a room, vault or chamber in which a toxic or flammable fumigant is used.	Yes (annual for facility/ location) (per event/location)	$200 (annual) $75 (event)	Facility: See inspection fee below

Hazardous materials. An operational permit is required to store, transport on site, dispense, use or handle hazardous materials in excess of the amounts listed below. **PERMIT AMOUNTS FOR HAZARDOUS MATERIALS** **TYPE OF MATERIAL — AMOUNT** Combustible liquids — See flammable and combustible liquids Corrosive materials Gases — See compressed gases Liquids — 55 gallons Solids — 1000 pounds Explosive materials — See explosives Flammable materials Gases — See compressed gases Liquids — See flammable and combustible liquids Solids — 100 pounds Highly toxic materials Gases — See compressed gases Liquids — Any amount Solids — Any amount Oxidizing materials Gases — See compressed gases Liquids Class 4 — Any amount Class 3 — 1 gallon[a] Class 2 — 10 gallons Class 1 — 55 gallons Solids Class 4 — Any amount Class 3 — 10 pounds[b] Class 2 — 100 pounds Class 1 — 500 pounds Organic peroxides Liquids Class I — Any amount Class II — Any amount Class III — 1 gallon Class IV — 2 gallons Class V — No permit required Solids Class I — Any amount Class II — Any amount Class III — 10 pounds Class IV — 20 pounds Class V — No permit required Pyrophoric materials Gases — See compressed gases Liquids — Any amount Solids — Any amount Toxic materials Gases — See compressed gases Liquids — 10 gallons Solids — 100 pounds Unstable (reactive) materials Liquids Class 4 — Any amount Class 3 — Any amount Class 2 — 5 gallons Class 1 — 10 gallons Solids Class 4 — Any amount Class 3 — Any amount Class 2 — 50 pounds Class 1 — 100 pounds Water reactive materials Liquids Class 3 — Any amount Class 2 — 5 gallons Class 1 — 55 gallons Solids Class 3 — Any amount Class 2 — 50 pounds Class 1 — 500 pounds See Note on following page	Yes (annual/per location)	$ 200	See inspection fee below
For SI: 1 gallon = 3.785 L, 1 pound = 0.454 kg. a. Twenty gallons when Table 5003.1.1(1) Note k applies and hazard identification signs in accordance with Section 5003.5 are provided for quantities of 20 gallons or less. b. Twenty pounds when Table 5003.1.1(1) Note k applies and hazard identification signs in accordance with Section 5003.5 are provided for quantities of 200 pounds or less.	Yes (annual/per location)	$ 200	See inspection fee below
HPM facilities. An operational permit is required to store, handle or use hazardous production materials.	Yes (annual/per location)	$ 200	See inspection fee below

High piled storage. An operational permit is required to use a building or portion thereof as a high-piled storage area exceeding 500 square feet (46 m^2).	Yes (annual/per location)	$ 200	See inspection fee below
Hot work operations. An operational permit is required for hot work including, but not limited to: 1. Public exhibitions and demonstrations where hot work is conducted. 2. Use of portable hot work equipment inside a structure. **Exception:** Work that is conducted under a construction permit. 3. Fixed-site hot work equipment such as welding booths. 4. Hot work conducted within a hazardous fire area. 5. Application of roof coverings with the use of an open-flame device. **6.** When approved, the fire official shall issue a permit to carry out a Hot Work Program. This program allows approved personnel to regulate their facility's hot work operations. The approved personnel shall be trained in the fire safety aspects denoted in this chapter and shall be responsible for issuing permits requiring compliance with the requirements found in this chapter. These permits shall be issued only to their employees or hot work operations under their supervision.	Facility: Yes (annual/location) ------------------ Fixed Site: Yes (annual/location) ________ Other: per event/location Yes (30 day/location)	$200 ——— $200 ——— $100	See inspection fee below See inspection fee below ——— No
Industrial ovens. An operational permit is required for operation of industrial **ovens regulated by Chapter 30.**	Yes (annual/per location)	$200	See inspection fee below
Lumber yards and woodworking plants. An operational permit is required for the storage or processing of lumber exceeding 100,000 board feet (8,333 ft^3) (236 m^3).	Yes (annual/per location)	$200	See inspection fee below
Liquid-fueled or gas-fueled vehicles or equipment in assembly buildings. An operational permit is required to display, operate or demonstrate liquid-fueled or gas-fueled vehicles or equipment in assembly buildings.	Yes (per event 30 days/location)	$200	See inspection fee below
LP-gas. An operational permit is required for: 1. Storage and use of LP-gas. **Exception:** An operational permit is not required for individual containers with a 500-gallon (1893 L) water capacity or less or multiple container systems having an aggregate quantity not exceeding 500 gallons (1893 L), serving occupancies in Group R-3. Operation of cargo tankers that transport LP-gas.	Yes (annual/per location)	$200	See inspection fee below
Magnesium. An operational permit is required to melt, cast, heat treat or grind more than 10 pounds (4.54 kg) of magnesium.	Yes (annual/per location)	$200	See inspection fee below
Miscellaneous combustible storage. An operational permit is required to store in any building or upon any premises in excess of 2,500 cubic feet (71 m^3) gross volume of combustible empty packing cases, boxes, barrels or similar containers, rubber tires, rubber, cork or similar combustible material.	Yes (annual/per location)	$200	See inspection fee below
Open burning. An operational permit is required for the kindling or maintaining of an open fire or a fire on any public street, alley, road, or other public or private ground. Instructions and stipulations of the permit shall be adhered to. **Exception:** Recreational fires.	Yes (Land Clearing Operations Only – 60 days/location)	$500	See inspection fee below
Open flames and candles. An operational permit is required to use open flames or candles in connection with assembly areas, dining areas of restaurants or drinking establishments.	Yes (annual/per location)	$200 (annual if sole permit) $100 (if ancillary to another permit)	See inspection fee below
Open flames and torches. An operational permit is required to remove paint with a torch; or to use a torch or open-flame device in a wildfire risk area.	Yes (per event-30 days/location)	$100	See inspection fee below
Organic coatings. An operational permit is required for any organic-coating manufacturing operation producing more than 1 gallon (4 L) of an organic coating in one day.	Yes (annual/per location)	$200	See inspection fee below
Places of assembly. An operational permit is required to operate a place of assembly (greater than 50 persons)	Yes (annual/per location)	$200	See inspection fee below
Private fire hydrants. An operational permit is required for the removal from service, use or operation of private fire hydrants. **Exception:** An operational permit is not required for private industry with trained maintenance personnel, private fire brigade or fire departments to maintain, test and use private hydrants.	Yes (annual/per location)	$200	See inspection fee below
Pyrotechnic special effects material. An operational permit is required for use and handling of pyrotechnic special effects material.	Yes (per event–1 day/location)	$200	See inspection fee below
Pyroxylin plastics. An operational permit is required for storage or handling of more than 25 pounds (11 kg) of cellulose nitrate (pyroxylin) plastics and for the assembly or manufacture of articles involving pyroxylin plastics.	Yes (annual/per location)	$200	See inspection fee below
Refrigeration equipment. An operational permit is required to operate a mechanical refrigeration unit or system regulated by Chapter 6.	Yes (annual/per location)	$200	See inspection fee below
Repair garages and service stations. An operational permit is required for operation of repair garages and automotive, marine and fleet service stations. **Note: (If in conjunction with Flammable/Combustible Liquid permit than no fee for this permit)**	Yes (annual/per location)	$200	See inspection fee below
Rooftop heliports. An operational permit is required for the operation of a rooftop heliport.	Yes (annual/per location)	$200	See inspection fee below

Spraying or dipping. An operational permit is required to conduct a spraying or dipping operation utilizing flammable or combustible liquids or the application of combustible powders regulated by Chapter 24.	Yes (annual/location) Yes (per event /30 days /location)	$200 (fixed facility) $100 (per event)	See inspection fee below
Storage of scrap tires and tire byproducts. An operational permit is required to establish, conduct or maintain storage of scrap tires and tire byproducts that exceeds 2,500 cubic feet (71 m^3) of total volume of scrap tires and for indoor storage of tires and tire byproducts.	Yes (annual/per location)	$200	See inspection fee below
Temporary membrane structures and tents. An operational permit is required to operate an air-supported temporary membrane structure or a tent. **Exceptions:** 1. Tents used exclusively for recreational camping purposes. 2. Tents and air-supported structures that cover an area of 900 square feet (84 m^2) or less, including all connecting areas or spaces with a common means of egress or entrance and with an occupant load of 50 or less persons. **Note: (permit good for 30 days with a maximum of 5 renewals (total of 180 days within a 12 month period allowed before tent must come down)**	Yes (per event – good for 30 days/location)	$100 if application received 30 days before event $150 if application received 15-29 days before event $200 if application received 8–15 days before event $300 if application received 7 days or less before event	No
Tire-rebuilding plants. An operational permit is required for the operation and maintenance of a tire-rebuilding plant.	Yes (annual/per location)	$200	See inspection fee below
Waste handling. An operational permit is required for the operation of wrecking yards, junk yards and waste material-handling facilities.	Yes (annual/per location)	$200	See inspection fee below
Wood products. An operational permit is required to store chips, hogged material, lumber or plywood in excess of 200 cubic feet (6 m^3).	Yes (annual/per location)	$200	See inspection fee below

ALBEMARLE COUNTY FIRE RESCUE /OFFICE OF THE FIRE MARSHAL

ADDITIONAL/MISCELLANEOUS FIRE PREVENTION FEE SCHEDULE

PURPOSE	DESCRIPTION	FEE
Facility Inspection Fees (in any fixed facility requiring a permit in Table 107. 2 of the Fire Prevention Code)	Inspection Fee	First two hours no charge $100/hr thereafter
Required Fire Inspection for Social Service License (Ex: Day care/Adult Care etc)	1 – 8 persons 9 – 20 persons 21 – 50 persons 51 – 100 persons 101 – 150 persons 151 – 200 persons 201 or more persons	$25 $50 $100 $200 $300 $400 $500 plus $50 for every 100 persons over 201
Re-inspection Fee	After initial inspection, if all violations are corrected, no charge. If not, then each re-inspection incurs a fee until an agreement on remediation is reached or all violations are corrected.	$0 (violations corrected) $100 (per inspection)
Albemarle Fire Rescue Plan Review Fee	Site Plans Special Use Permit All Other	$100 (per set of plans) $50 (per application) $75 (per event)
Request for Fire Code Variance/ Modification and Albemarle County Fire Code Board of Appeals Request	Similar to the Zoning Variance and Appeals Process to offset Cost of the Fire Board of Appeals Operations	$350 (application fee)

Homestay Registry Inspection Fee	After initial inspection, annual inspections due by the inspection anniversary date	$50

Agenda Item No. 24. From the Board: Committee Reports and Matters Not Listed on the Agenda.

(Note: Ms. Palmer returned at 7:28 p.m.)

Mr. Gallaway commented that the Board took up this item earlier in the meeting, and asked if there were any other reports.

Mr. Gallaway added that the letter crafted by the Board regarding the Zan Road bridge, was part on the MPO's agenda and discussed.

Agenda Item No. 26. Adjourn to August 21, 2019, 1:00 p.m., Lane Auditorium.

At 7:29 p.m., Mr. Gallaway adjourned the Board to August 21, 2019, 1:00 p.m., Lane Auditorium.

____
Chairman

Approved by Board

Date 02/19/2020

Initials CKB

Account #	Account Name	2022 Rate Adopted	Unit	Notes
313225	**Rental Housing Occupancy Inspection**			
	Required inspection and all re-inspections after first re-inspection	$75.00	per unit	Required inspections are: 1. Following application; 2.Every four years, if there has been no intervening inspection; and 3.Inspection resulting from valid complaints.
	Install smoke detector in rental unit where none are present, or at owner's request.	$65.00	per detector	
313226	**Fire Prevention Fees**			
	Aerosol products	$160.00	Flat fee	Manufacture, store or handle an aggregate quantity of Level 2 or Level 3 aerosol products in excess of 500 pounds net weight.
	Amusement buildings or structures	$160.00	Per site	
	Aviation facilities	$160.00	Flat fee	Group H or Group S occupancy for aircraft servicing or
	Care facility	$160.00	Flat fee	Location occupied by persons in the care of others.
	Carnivals, circuses, fairs, festivals, exhibits or tradeshow	$250.00	Per event	Exception: Religious or Educational occupancies.
	Cellulose nitrate (pyroxylin plastic)	$160.00	Flat fee	Assembly or manufacturing of articles involving any amount, storage or handling of more than 25 pounds.
	Cellulose nitrate film	$160.00	Flat fee	Store, handle or use cellulose nitrate film in a Group A occupancy.
	Combustible dust-producing operations	$160.00	Flat fee	
	Combustible fibers	$160.00	Flat fee	Storage and handling of combustible fibers in quantities greater than 100 cubic feet. Exception: Agricultural storage.
	Combustible (miscellaneous) storage	$160.00	Flat fee	Store in any building, structure, or upon any premises in excess of 2,500 cubic feet gross volume of combustible empty packing cases, boxes, barrels or similar containers, rubber tires, rubber, cork or similar combustible material.
	Compressed gas			Storage, use or handling at normal temperature and pressure (NTP) of compressed gases in excess of the amounts listed below. Exception: Vehicles equipped for and using compressed gas as a fuel for propelling the vehicle.
	Type of Gas			**Amount (cubic feet at NTP)**
	Carbon dioxide used in carbon dioxide enrichment systems	$160.00	Flat fee	875 (100 lbs.)
	Carbon dioxide used in insulated liquid carbon dioxide beverage dispensing applications	$160.00	Flat fee	875 (100 lbs.)
	Corrosive	$160.00	Flat fee	200
	Flammable (except cryogenic fluids and liquefied petroleum gases)	$160.00	Flat fee	200
	Highly toxic	$160.00	Flat fee	Any Amount
	Inert and simple asphyxiant	$160.00	Flat fee	6,000
	Oxidizing (including oxygen)	$160.00	Flat fee	504
	Pyrophoric	$160.00	Flat fee	Any Amount
	Toxic	$160.00	Flat fee	Any Amount
	Covered and open mall buildings	$160.00	Flat fee	1. The placement of retail fixtures and displays, concession
	Cryogenic fluids			An operational permit is required to produce, store, transport on site, use, handle or dispense cryogenic fluids in excess of the amounts listed below. Exception: Operational permits are not required for vehicles equipped for and using cryogenic fluids as a fuel for propelling the vehicle or for refrigerating the lading.
	Type of Cryogenic Fluid			**Inside Bldg (gals)** / **Outside Bldg (gals)**
	Flammable	$160.00	Flat fee	More than 1 / 60
	Inert	$160.00	Flat fee	60 / 500
	Oxidizing (includes oxygen)	$160.00	Flat fee	10 / 50
	Physical or health hazard not indicated	$160.00	Flat fee	Any Amount
	Dry cleaning plants	$160.00	Flat fee	Any type of dry cleaning plant and systems using any solvent classification or to change to a more hazardous cleaning solvent used in existing dry cleaning equipment.
	Explosives			
	Use at non-fixed site (6-month permit)	$90.00	Per site with hourly inspection rate	$90.00 per hour / per inspector during normal business hours. $150.00 per hour / per inspector outside of normal business hours and holidays
	Use at fixed site (annual permit)	$300.00	Flat fee	
	Storage	$160.00	Per magazine or control room	Exceptions: 1. Storage in Group R-3 or R-5 occupancies of smokeless propellant, black powder and small arms primers for personal use, not for resale, and in accordance with the quantity limitations and conditions set forth in SFPC Section 5601.1, Exceptions 4 and 12. 2. Portable or mobile magazines not exceeding 120 square feet.

Account #	Account Name	2022 Rate Adopted	Unit	Notes
313226	**Fire Prevention Fees (continued)**			
	Temporary storage, any quantity (24-hour permit)	$250.00	Per magazine or control room	
	Restricted manufacture	$160.00	Per occurrence	
	Unrestricted manufacture	$160.00	Flat fee	
	Fireworks	$90.00	Per site with hourly inspection rate	$90.00 per hour / per inspector during normal business hours. $150.00 per hour / per inspector outside of normal business hours and holidays
	Outdoor Display (NFPA 1123 or 1126) (24-hour permit)	$90.00	Per site with hourly inspection rate	$90.00 per hour / per inspector during normal business hours. $150.00 per hour / per inspector outside of normal business hours and holidays
	Retail sales of Permissible Fireworks (45-day	$750.00	Per site	
	Wholesale (45-day permit)	$750.00	Flat fee	
	Storage	$160.00	Per magazine or control room	Exception: At display sites.
	Fire protection system	$160.00	Per location	Where approved fire protection systems are installed throughout a building or systems protecting an individual occupancy (tenant) within the same building. (Annual permit). Exceptions: Handheld portable fire extinguishers.
	Flame effects before an audience (NFPA 160, 24-hour permit)	$90.00	Per site with hourly inspection rate	$90.00 per hour / per inspector during normal business hours. $150.00 per hour / per inspector outside of normal business hours and holidays
	Flammable or combustible liquids	$160.00	Flat fee	Use or operate a pipeline for the transportation within facilities of flammable or combustible liquids.
	Flammable liquids			Store, handle or use Class I liquids in excess of 5 gallons in a building or in excess of 10 gallons outside of a building. Exceptions: 1. The storage or use of Class I liquids in the fuel tank of a motor vehicle, aircraft, motor boat, mobile power plant or mobile heating plant. 2. The storage or use of paints, oils, varnishes or similar flammable mixtures when such liquids are stored for maintenance, painting or similar purposes for a period of not more than 30 days.
	Combustible liquids			Store, handle or use Class II or Class IIIA liquids in excess of 25 gallons in a building or in excess of 60 gallons outside a building. Exception: Fuel oil used in connection with oil-burning equipment at one- and two-family detached single family dwellings and townhouses.
	Flammable or combustible above or underground	$160.00	Per tank	
	Up to 10,000 gallons	$160.00	Per tank	
	10,001 gallons to 30,000 gallons	$250.00	Per tank	
	30,001 gallons to 100,000 gallons	$300.00	Per tank	
	Greater than 100,001 gallons	$0.003	Per gallon	
	Installation	$160.00	Per tank	
	Removal of Class I or Class II liquids from an above-ground or underground storage tank used for fueling motor vehicles by any means other than the *approved* , stationary on-site pumps normally used for dispensing	$160.00	Per tank	
	Alter, abandon, place temporarily out of service (for more than 90 days) or otherwise dispose of an underground, protected above-ground or above-ground	$160.00	Per tank	
	Change the type of contents stored in a tank to a material that poses a greater	$160.00	Per tank	
	Flammable or combustible above ground bulk tank	$160.00	Per tank	
	Up to 49,000 gallons	$160.00	Per tank	
	49,001 gallons to 425,000 gallons	$250.00	Per tank	
	Greater than 425,001 gallons	$0.0007	Per gallon	
	Add or replace roof / floating roof or	$325.00	Per tank	
	Removal or abandonment	$160.00	Per tank	
	Flammable or combustible liquids	$160.00	Flat fee	
	Where flammable and/or combustible liquids are produced, processed, stored,	$160.00	Flat fee	
	Manufacture, process, blend or refine flammable or combustible liquids.	$160.00	Flat fee	
	The storage, handling or use of flammable liquids in an operation other than motor vehicle dispensing, for greater than 30 days. Exception: Where exempted in this	$160.00	Flat fee	

Account #	Account Name	2022 Rate Adopted	Unit	Notes
313226	**Fire Prevention Fees (continued)**			
	Floor finishing (30-day per site permit)	$160.00	Flat fee	Floor finishing or surface operations exceeding 350 square feet using Flammable or Combustible liquids.
	Fruit and crop ripening	$160.00	Flat fee	Fruit- or crop-ripening facility or conduct a fruit-ripening process using ethylene gas.
	Fumigation, thermal, and insecticidal fogging	$16.00	Per site	Fumigation, thermal, or insecticidal fogging and to maintain a room, vault or chamber in which a toxic or flammable fumigant is used.
	Hazardous materials			Store, transport on site, dispense, use or handle hazardous materials in excess of the amounts listed below.
	Type of Material			**Amount**
	Corrosive materials			
	Liquids	$160.00	Flat fee	55 gallons
	Solids	$160.00	Flat fee	1000 pounds
	Flammable solids	$160.00	Flat fee	100 pounds
	Highly toxic materials	$160.00	Flat fee	
	Liquids	$160.00	Flat fee	Any amount
	Solids	$160.00	Flat fee	Any amount
	Oxidizing materials			
	Liquids			
	Class 4	$160.00	Flat fee	Any amount
	Class 3	$160.00	Flat fee	1 gallon
	Class 2	$160.00	Flat fee	10 gallons
	Class 1	$160.00	Flat fee	55 gallons
	Solids			
	Class 4	$160.00	Flat fee	Any amount
	Class 3	$160.00	Flat fee	10 pounds
	Class 2	$160.00	Flat fee	100 pounds
	Class 1	$160.00	Flat fee	500 pounds
	Organic peroxides			
	Liquids			
	Class I	$160.00	Flat fee	Any amount
	Class II	$160.00	Flat fee	Any amount
	Class III	$160.00	Flat fee	1 gallon
	Class IV	$160.00	Flat fee	2 gallons
	Solids			
	Class I	$160.00	Flat fee	Any amount
	Class II	$160.00	Flat fee	Any amount
	Class III	$160.00	Flat fee	10 pounds
	Class IV	$160.00	Flat fee	20 pounds
	Pyrophoric materials			
	Liquids	$160.00	Flat fee	Any amount
	Solids	$160.00	Flat fee	Any amount
	Toxic materials			
	Liquids	$160.00	Flat fee	10 gallons
	Solids	$160.00	Flat fee	100 pounds
	Unstable (reactive) materials			
	Liquids			
	Class 4	$160.00	Flat fee	Any amount
	Class 3	$160.00	Flat fee	Any amount
	Class 2	$160.00	Flat fee	5 gallons
	Class 1	$160.00	Flat fee	10 gallons
	Solids			
	Class 4	$160.00	Flat fee	Any amount
	Class 3	$160.00	Flat fee	Any amount
	Class 2	$160.00	Flat fee	50 pounds
	Class 1	$160.00	Flat fee	100 pounds
	Water reactive materials	$160.00	Flat fee	
	Liquids			
	Class 3	$160.00	Flat fee	Any amount
	Class 2	$160.00	Flat fee	5 gallons
	Class 1	$160.00	Flat fee	55 gallons
	Solids			
	Class 3	$160.00	Flat fee	Any amount
	Class 2	$160.00	Flat fee	50 pounds
	Class 1	$160.00	Flat fee	500 pounds
	HPM facilities	$160.00	Flat fee	Store, handle or use hazardous production materials.
	High piled storage	$160.00	Flat fee	Use a building, structure or portion thereof as a high-piled storage area exceeding 500 square feet.

Account #	Account Name	2022 Rate Adopted	Unit	Notes
313226	**Fire Prevention Fees (continued)**			
	Hot work operations, including, but not limited to:			
	Public exhibitions and demonstrations where hot work is conducted	$160.00	Per occurrence or Per Location	
	Use of portable hot work equipment inside a structure Exception: Work that is conducted under a construction permit	$160.00	Per occurrence or Per Location	
	Fixed-site hot work equipment, such as welding	$160.00	Per occurrence or Per Location	
	Hot work conducted within a hazardous fire area	$160.00	Per occurrence or Per Location	
	Application of roof coverings with the use of an open-flame device	$160.00	Per occurrence or Per Location	
	Hot Work Program (annual permit)	$160.00	Per occurrence or Per Location	
	Industrial ovens	$160.00	Flat fee	
	Lumber yards and woodworking plants	$160.00	Flat fee	Storage or processing of lumber exceeding 100,000 board feet.
	Liquid-fueled or gas-fueled vehicles or equipment in buildings	$160.00	Flat fee	Display, operate or demonstrate liquid-fueled or gas-fueled vehicles or equipment in buildings or structures.
	LP-gas	$160.00	Flat fee	Exception: One- and two-family detached single family dwellings and townhouses.
	Storage and/or use inside any building or structure	$160.00	Flat fee	Exception: One- and two-family detached single family dwellings and townhouses.
	Storage and/or use outside, portable installation, per event more than 10 gallons aggregate (30-day	$160.00	Flat fee	
	Storage and/or use outside, more than 10 gallons aggregate (annual permit). Exception: One- and two-family detached single family dwellings and	$160.00	Flat fee	
	Dispensing and/or cylinder refill operation	$160.00	Flat fee	
	Retail cylinder exchange location	$160.00	Flat fee	
	Install above or underground tank of more than 100 gallons aggregate	$160.00	Per tank	
	Magnesium	$160.00	Flat fee	Melt, cast, heat treat or grind more than 10 pounds of magnesium.
	Mobile food preparation vehicles	$160.00	Per vehicle	Mobile food preparation vehicles equipped with appliances that produce smoke or grease laden vapors (annual permit). Exception: Recreational vehicles used for private recreation.
	Open burning	$100.00	Per site	Kindling or maintaining of an open fire or a fire on any public street, alley, road, or other public or private ground. Exception: Recreational fires.
	Open burning: Bonfire (10-day permit)	$100.00	Per site	
	Open flames and candles	$75.00	Per event	In connection with a meeting, gathering or assembly.
	Organic coatings	$160.00	Flat fee	Manufacturing operation producing more than1 gallon of an organic coating in one day.
	Places of assembly or education	$160.00	Flat fee	Assembly (occupant load 50 or greater) or educational occupancy.
	Pyrotechnic and/or special effects material. Indoor or outdoor display (24-hour permit)	$90.00	Per site with hourly inspection rate	$90.00 per hour / per inspector during normal business hours. $150.00 per hour / per inspector outside of normal business hours and holidays
	Repair garages and service station	$160.00	Flat fee	Motor vehicle repair or service operations inside a building or structure.
	Repair garages or service station and motor vehicle fuel dispensing	$320.00	Flat fee	Motor vehicle repair or service combined with the storage and dispensing of flammable / combustible liquids (up to four storage tanks that are above- / under-ground or combination thereof, and up to 100,000 gallons aggregate).
	Temporary membrane structures and tents	$160.00	Per tent	Exceptions: 1. Tents used exclusively for recreational camping purposes. 2. Tents and air-supported structures that cover an area of 900 square feet or less, including all connecting areas or spaces with a common means of egress or entrance and with an occupant load of 50 or less persons.
	Tent cooking	$50.00	Per tent	Any size or configuration tent where cooking is performed for the purpose of retail.
	Tire-rebuilding plants	$160.00	Flat fee	
	Waste handling	$160.00	Flat fee	Wrecking yards, junk yards and waste material-handling facilities.
	Water recreation facility	$160.00	Flat fee	Dispensing, storage, and use of common swimming pool chemicals.
	Wood products	$160.00	Flat fee	To store chips, hogged material, lumber or plywood in excess of 200 cubic feet.
	Administrative fee for issuance of Stop Work order due to failure to obtain required permit	200.00%	permit fee	$250 Maximum

Account #	Account Name	2022 Rate Adopted	Unit	Notes
313227	**Fire Protection Systems**			
	Fire Alarm Systems			
	Main Panel including branch circuit	$90.00	each	
	First five initiating, detecting or indicating devices	$90.00	first five	
	Each indicating or initiating device over five	$3.00	each	
	Dialers and expansion panels	$90.00	each	
	Sprinkler or Other Fixed Fire Suppression Systems- New			
	Dry-pipe, alarm or deluge valve	$90.00	each	
	Piping and sprinkler heads	$2.50	per head	Minimum $90
	Fire Service Line, each 100 feet or fraction	$90.00	each 100 ft	
	Fire Service Line, repair	$90.00	each	
	Standpipe Systems			
	Not part of a sprinkler system	$90.00	each	
	Fire Pump	$175.00	each	
	Halon, Carbon Dioxide and Fixed Chemical Agent Systems	$100.00	each	
	Minimum permit fee	$90.00		
	Amendments involving additional work	$90.00	each	or fee as listed for work involved on amendment, whichever is higher
	Amendments not including additional work (homeowners are exempt)	$90.00	each	plus hourly review fee
313231	**Fire Marshal Development Fees**			
	Group Home	$ 90.00	each	
	Non-Residential Use Permit Inspections			
	Business – Tenant			
	Gross Floor Area			
	New building, shell only	$90.00	each	
	0 – 500 sq. ft.	$90.00	each	
	501 – 5,000 sq. ft.	$125.00	each	
	5001 – 15,000 sq. ft.	$150.00	each	
	15,001 – 50,000 sq. ft.	$175.00	each	
	50,001 + sq. ft.	$225.00	each	
	Major Home Occupation	$90.00	each	
313233	**Public Safety Fee**			
	Bulk storage handling or use of flammable liquids over 425,000 gallons	$0.0007	gallon	
313234	**Inspections**			
	Stop Work Order-SWO	$90.00	each occurance	
	For more than one inspection after a Stop Work Order or deficiency	$90.00	each	Re-inspection
	Inspections outside regular hours	$90.00	hour	4 hour minimum
313308	**Sign Permits**			
	Signs:			
	Under 100 sq. ft. in total sign area	$115.00	flat fee	
	100 sq. ft. and greater in total sign area	$7.75	square foot	
	Temporary signs:			
	Construction Signs	$26.00	each	
	Special Events Signs	$26.00	each	
	Business Openings and Sales	$26.00	each	
	Real Estate/Leasing Signs	$26.00	each	
	Political sign 10 sq. ft. or less in area	$26.00	per 100	
	Political sign larger than 10 sq. ft.	$26.00	each	
	Signs Removed from Public ROW:			
	10 days or less	$5.25	each	
	greater than 10 days	$10.50	each	
313309	**Zoning Permits**			
	Commercial Building Construction	$60.00	each	
	Commercial Use and Occupancy	$60.00	each	
	Residential Building Construction	$30.00	each	
	Residential Use and Occupancy	$30.00	each	
	Temporary Use Permit (Nonresidential)	$210.00	each	
	Temporary Use Permit (Residential)	$20.00	each	
	Small Cell Facility	$100.00	each	each facility up to 5 small cell facilities on an application plus $50 for each additional small cell facility above 5 up to 35 facilities on an application

Chapter 15.25
FIRE PREVENTION CODE*

Sections:

15.25.010 Adopted – Purpose – Etc.

(1) The Virginia Statewide Fire Prevention Code, as amended and adopted by the Commonwealth of Virginia Board of Housing and Community Development, of which copies are filed and maintained and required by law is hereby adopted and incorporated herein by reference as fully as if set forth and the provisions thereof shall be controlling in the local enforcement for the protection of life and property from the hazards of fire or explosion arising from the improper maintenance of life safety and fire prevention and protection materials, devices, systems and structures, and the unsafe handling and use of material and devices, including explosives and blasting agents, wherever located. .

(2) The Fire Code Official and any Assistant Fire Code Official shall be appointed by the city manager and shall have all powers set forth in the Virginia Statewide Fire Prevention Code. In the absence of such appointment, the Fire Chief of the City shall be Fire Code Official. Any Assistant Fire Code Official may perform the duties of the Fire Code Official in the Fire Code Official's absence or when otherwise designated by the Fire Code Official or City Manager.

State law reference – Authority of city to adopt fire prevention code, Code of Virginia, §27-97.

15.25.015 Amendments and Additions.

(1) The City is empowered to adopt fire prevention regulations that are more restrictive or more extensive

in scope than the Statewide Fire Prevention Code provided such regulations do not affect the manner of construction, or materials to be used in the erection, alteration, repair, or use of a building or structure, including the voluntary installation of smoke alarms and regulation and inspections thereof in commercial buildings where such smoke alarms are not required under the provisions of the Code. The following provisions are in addition to the Virginia Statewide Fire Prevention Code: Appendix B through J.

15.25.020 Availability of copies.

Copies of the fire prevention code adopted by this chapter are available for viewing at the office of the Fire Code Official during normal business hours. (Code 1964, § 12-6; Code 1985, § 13-32).

15.25.030 Administration and enforcement.

Repealed by Ord. 12-13-01. (Code 1985, § 13-33).

15.25.031 Appointment and authority of the Fire Marshal and Deputy or Assistant Fire Marshal.

City Council shall appoint a Fire Marshal and Deputy or Assistant Fire Marshal for the City of Staunton. The Deputy or Assistant Fire Marshal shall have the authority to perform the duties of the Fire Marshal in the Fire Marshal's absence or when otherwise designated by the Fire Marshal or City Manager.

State Law Reference--Authority to appoint Fire Marshal and assistants, Code of Virginia, §27-30, §27-36.

15.25.032 Enforcement.

The Fire Marshal, Deputy and Assistant Fire Marshals and Fire Code Official(s) shall have the authority to enforce the Virginia Statewide Fire Prevention Code, the Code of Virginia and any sections of the Staunton City Code related to fire prevention and protection to the extent authorized under this Chapter and under the Code of Virginia.

15.25.033 Authority to order immediate compliance with law, etc., or prohibit use of building or equipment.

The Fire Marshal and Deputy and Assistant Fire Marshal and Fire Code Official(s) shall have the authority as prescribed under this Chapter to exercise in the same manner and subject to the same conditions, the powers conferred upon other authorities by the Code of Virginia, subject to the limitations prescribed by the Code of Virginia, including the prohibition on the use of a building or equipment.

15.25.034 Right of entry to investigate releases of hazardous material, hazardous waste or regulated substances.

The Fire Marshal, Deputy and Assistant Fire Marshals and Fire Code Official(s) shall have the right to enter upon any property from which a release of any hazardous materials, hazardous waste, or regulated substance, as defined by state law, has occurred or is reasonably suspected to have occurred and which has entered into the groundwater or soils of the city, in order to investigate the extent and cause of any such release.

15.25.035 Summoning a Fire Marshal.

The fire and rescue department officer in charge of any fire, explosion or environmental crimes incident scene shall contact the Fire Marshal, Deputy Fire Marshal, or Assistant Fire Marshall to investigate the circumstances involved when such circumstances require investigation.

15.25.040 Violations.

(1) Any person who shall violate any of the provisions of the fire prevention code adopted by this chapter, or fail to comply therewith, or who shall violate or fail to comply with any order made thereunder, or who shall build in violation of any detailed statement of specifications or plans submitted and approved thereunder, or any certificate or permit issued thereunder, and from which no appeal has been taken, or who shall fail to comply with such an order as affirmed or modified by the Local Board of Fire Prevention Code Appeals or by a court of competent jurisdiction, within the time fixed therein, shall severally, for each and every such violation and noncompliance, respectively, be guilty of a Class 1 misdemeanor . The imposition of one penalty for any violation shall not excuse the violation or permit it to continue; and all such persons shall be required to correct or remedy such violations or defects within a reasonable time; and when not otherwise specified, each 10 days that prohibited conditions are maintained shall constitute a separate offense.

(2) The application of the above penalty shall not be held to prevent the enforced removal of prohibited conditions.

15.25.050 Liability insurance as prerequisite to issuance of blasting permit.

(1) As a condition to issuance of a blasting permit, the applicant for such permit shall comply with the financial responsibility provisions of the Explosives and Fireworks chapter of the Virginia Statewide Fire Prevention Code.

(2) Where blasting is to be conducted in an area where there is a high density of persons or where there are a number of nearby structures of two stories or more, the fire code official may require liability insurance coverage greater than that specified in subsection (1) of this section, in order to adequately make available protection commensurate with the risk to persons and property.

(3) This section shall not apply to blasting operations undertaken by city forces. (Code 1964, § 12-29; Code 1985, § 13-35; Ord. 3-24-88; Ord. 1-9-92; Ord. 12-14-01).

15.25.055 Permit fees.

(1) Payment Prerequisite to Issuance or Amendment of Permit. No permit required by the Virginia Statewide Fire Prevention Code to begin work shall be issued until the fees prescribed in this section have been paid to the department of building inspection or other authorized municipal agency, nor shall an amendment be made to such a permit necessitating an additional fee, because of an increase in the estimated cost of the work involved, be approved until the additional fee has been paid.

(2) Fees. The fees for fire code permits shall be as follows:

Description	Permit Required	Fee	Time
Amusement buildings. An operational permit is required to operate a special amusement building.	Yes	$25.00	Event
Carnivals and Fairs. An operational permit is required to conduct a carnival or fair.	Yes	$100.00	Event
Explosives. An operational permit is required:			
To store explosives, fireworks or pyrotechnic special effects – per site.	Yes	$200.00	Annual
To use explosives – per site.	Yes	$150.00	90 days
To conduct a fireworks display (public or private).	Yes	$200.00	Event
Sale of fireworks – per site. (Allowed June 1st through July 15th per calendar year.)	Yes	$150.00	45 Days
Flammable and Combustible Liquids. An operational permit is required:			
To remove Class I or Class II liquids from an underground storage tank used for fueling motor vehicles by any means other than the approved, stationary on-site pumps normally used for dispensing purposes – per site.	Yes	$50.00	90 Days
To remove, abandon, place temporarily out of service (for more than 90 days) or otherwise dispose of an underground, protected above-ground or above-ground flammable or combustible liquid tank – per site.	Yes	$100.00	90 Days
To change the type of contents stored in a flammable or combustible liquid tank to a material which poses greater hazard than that for which the tank was designed and constructed – per site.	Yes	$50.00	90 Days
To store, handle or use Class II or Class IIIA liquids in excess of 25 gallons (95 L) in a building or in excess of 60 gallons (227 L) outside a building, except for fuel oil used in connection with oil-burning equipment.	Yes	$50.00	Annual
Hazardous materials. An operational permit is required to store, transport on site, dispense, use or handle hazardous materials in excess of the amounts listed below. **PERMIT AMOUNTS FOR HAZARDOUS MATERIALS** **TYPE OF MATERIAL** — **AMOUNT** Combustible Liquids liquids — See flammable and combustible Corrosive materials	Yes	$50.00	Annual

Gases	200 cubic ft (at NTP)			
Liquids	55 gallons			
Solids	100 pounds			
Explosive materials	See explosives			
Flammable materials				
Gases	200 cubic ft (at NTP)			
Liquids	See flammable and combustible liquids			
Solids	100 pounds			
Highly toxic materials				
Gases	Any Amount			
Liquids	Any Amount			
Solids	Any Amount			
Oxidizing materials				
Gases (including oxygen)	504 cubic ft. (at NTP)			
Liquids				
Class 4	Any Amount			
Class 3	1 gallon			
Class 2	10 gallons			
Class 1	55 gallons			
Solids				
Class 4	Any Amount			
Class 3	10 pounds			
Class 2	100 pounds			
Class 1	500 pounds			
Organic Peroxides				
Liquids				
Class I	Any Amount			
Class II	Any Amount			
Class III	1 gallon			
Class IV	2 gallons			
Class V	No permit required			
Solids				
Class I	Any Amount			
Class II	Any Amount			
Class III	10 pounds			
Class IV	20 pounds			
Class V	No permit required			
Pyrophoric materials				
Gases	200 cubic ft (at NTP)			
Liquids	Any Amount			
Solids	Any Amount			
Toxic materials				
Gases	Any Amount			

Liquids 10 gallons Solids 100 pounds Unstable (reactive) materials Liquids Class 4 Any Amount Class 3 Any Amount Class 2 5 gallons Class 1 10 gallons Solids Class 4 Any Amount Class 3 Any Amount Class 2 50 pounds Class 1 100 pounds Water-reactive materials Liquids Class 3 Any Amount Class 2 5 gallons Class 1 55 gallons Solids Class 3 Any Amount Class 2 50 pounds Class 1 500 pounds For SI: 1 gallon=3.785L, 1 pound=0.454kg			
LP-gas. An operational permit is required for: Storage and use of LP-gas. **Exception:** An operational permit is not required for individual containers with a 500-gallon (1893 L) water capacity or less serving occupancies in Group R-3; and Operation of cargo tankers that transport LP-gas.	Yes	$50.00	Annual
Pyrotechnic Special Effects Material or Flame Effects Material. An operational permit is required for the use and handling of pyrotechnic special effects material or flame effect material.	Yes	$100.00	Event
Storage of scrap tires and tire byproducts. An operational permit is required to establish, conduct or maintain storage of scrap tires and tire byproducts that exceed 2,500 cubic feet (71 m3) of total volume of scrap tires and for indoor storage of tires and tire byproducts.	Yes	$50.00	Annual
Temporary membrane structures, tents and canopies. An operational permit is required to operate an air-supported temporary structure or a tent that covers an area in excess 400 square feet ($37m^2$) and less than 900 square feet ($84m^2$). **Exceptions:**	Yes	$25.00	Event

Tents used exclusively for recreational camping purposes; Tents and air-supported structures that cover an area of 400 square feet or less, including all connecting areas or spaces with a common means of egress or entrance and with an occupant load of 50 or less persons; Fabric canopies and awnings open on all sides which comply with the following; Individual canopies shall have a maximum size of 700 square feet ($65m^2$); The aggregate area of multiple canopies placed side by side without a fire break clearance of 12 feet (3658 mm) shall not exceed 700 square feet ($65m^2$) total; and A minimum clearance of 12 feet (3658 mm) to structures and other tents shall be provided.			

(3) Refunds. Refunds shall be issued at the discretion of the fire code official or their designee. Refunds shall be based on the amount of staff work completed at the time of the request for permit withdrawal, with the refund not to exceed 50 percent of the permit cost. (Ord. 2005-11).

15.25.057 Miscellaneous Fire Prevention Inspection and Review Schedule

The fee schedule for inspections and/or reviews is as follows for the indicated purposes:

PURPOSE	DESCRIPTION	FEE
Required Fire Inspection for Social Service Licensure or Behavioral Health Licensure (Ex.: Day Care/Adult Care, etc.)	1-8 persons 9-20 persons 21-50 persons 51-100 persons 101-150 persons 151-200 persons 201 or more persons	\$50 \$75 \$100 \$200 \$300 \$400 \$500
Re-inspection Fees	Initial inspection and first re-inspection, if all violations are corrected, no charge. Upon 3rd inspection and each subsequent inspection incurs an increased fee until remediation is reached or all violations are corrected.	\$0 (violations corrected) \$50 (3rd inspection) \$100 (per inspection for 4 or more)
Staunton Fire and Rescue Plan Review Fee	Special Event Permit All Other	\$50 (per application) \$50

15.25.060 Modifications.

Repealed.

15.25.070 Appeals.

The Board of Building Code Appeals (BBCA) shall act as the board to hear all fire code related appeals. An appeal case of applied appendixes decided by the BBCA shall constitute an appeal in accordance with this section and shall be final. Appeals regarding the Virginia Statewide Fire Prevention Code shall also be heard by the BBCA and in accordance with the provisions set forth in Chapter 1 of the Virginia Statewide Fire Prevention Code.

15.25.080 New materials, processes or occupancies requiring permits.

Repealed.

FP111.2-21

VFC: 111.2

Proponents: Steven Sites (steven.sites@fairfaxva.gov)

2018 Virginia Statewide Fire Prevention Code

Revise as follows:

111.2 Service. The written notice of violation of this code shall be served upon the *owner*, a duly authorized *agent* or upon the occupant or other person responsible for the conditions under violation. Such notice shall be served either by delivering a copy of same to such persons by mail to the last known post office address, by delivering in person or by delivering it to and leaving it in the possession of any person in charge of the premises, or, in the case such person is not found upon the premises, by affixing a copy thereof in a conspicuous place at the entrance door or avenue of ~~access.~~ access, or by transmitting to a valid electronic mailbox. Such procedure shall be deemed the equivalent of personal notice. 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* or *owner's agent*.

Reason Statement: Fire Officials that utilize fire inspection software have the ability to send a copy of the notice of violation directly to email address(s). This software retains the official original notice.

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

Cost Impact: The code change proposal will not increase or decrease the cost of construction
There is no cost impact to citizens or or those doing business with the Commonwealth of Virginia. This method of service delivery can reduce the operating costs to the Fire Official - state and local government. The costs of paper, printing, U.S. Postal Service mailing, vehicle maintenance, fuel, and employee time per-inspection is reduced.

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*.

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/1169/1645/files/download/686/
- **NFPA Sprinkler Report 2017.pdf**
  https://va.cdpaccess.com/proposal/1169/1645/files/download/685/
- **Life Cycle Cost Analysis of Portable extinguishers - Copy.pdf**
  https://va.cdpaccess.com/proposal/1169/1645/files/download/684/
- **Ordinary People and Fire Extinguisher Effectiveness.pdf FINAL.pdf**
  https://va.cdpaccess.com/proposal/1169/1645/files/download/683/
- **UnreportedResidentialFires.pdf**
  https://va.cdpaccess.com/proposal/1169/1645/files/download/682/
- **An evaluation of the role of fire extinguishers (3).pdf**
  https://va.cdpaccess.com/proposal/1169/1645/files/download/681/

Workgroup Recommendation

Proposal # 1169

AN EVALUATION OF THE ROLE OF FIRE EXTINGUISHERS

TABLE OF CONTENTS

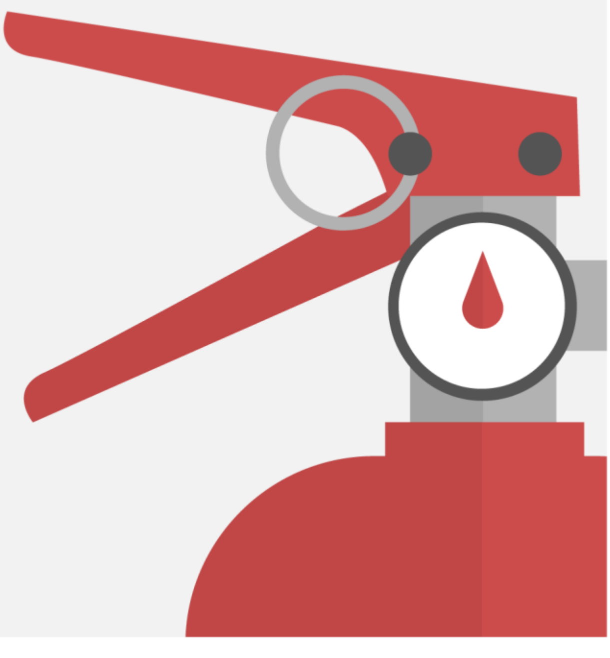
7. Research and data

8. Key findings, discussion, recommendations

11. Bibliography

12. About the author

13. Acknowledgements



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

Findings

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.

Discussion

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.

Recommendation 1

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

Findings

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.

Discussion

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.

<u>Recommendations 9 and 10</u>

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.

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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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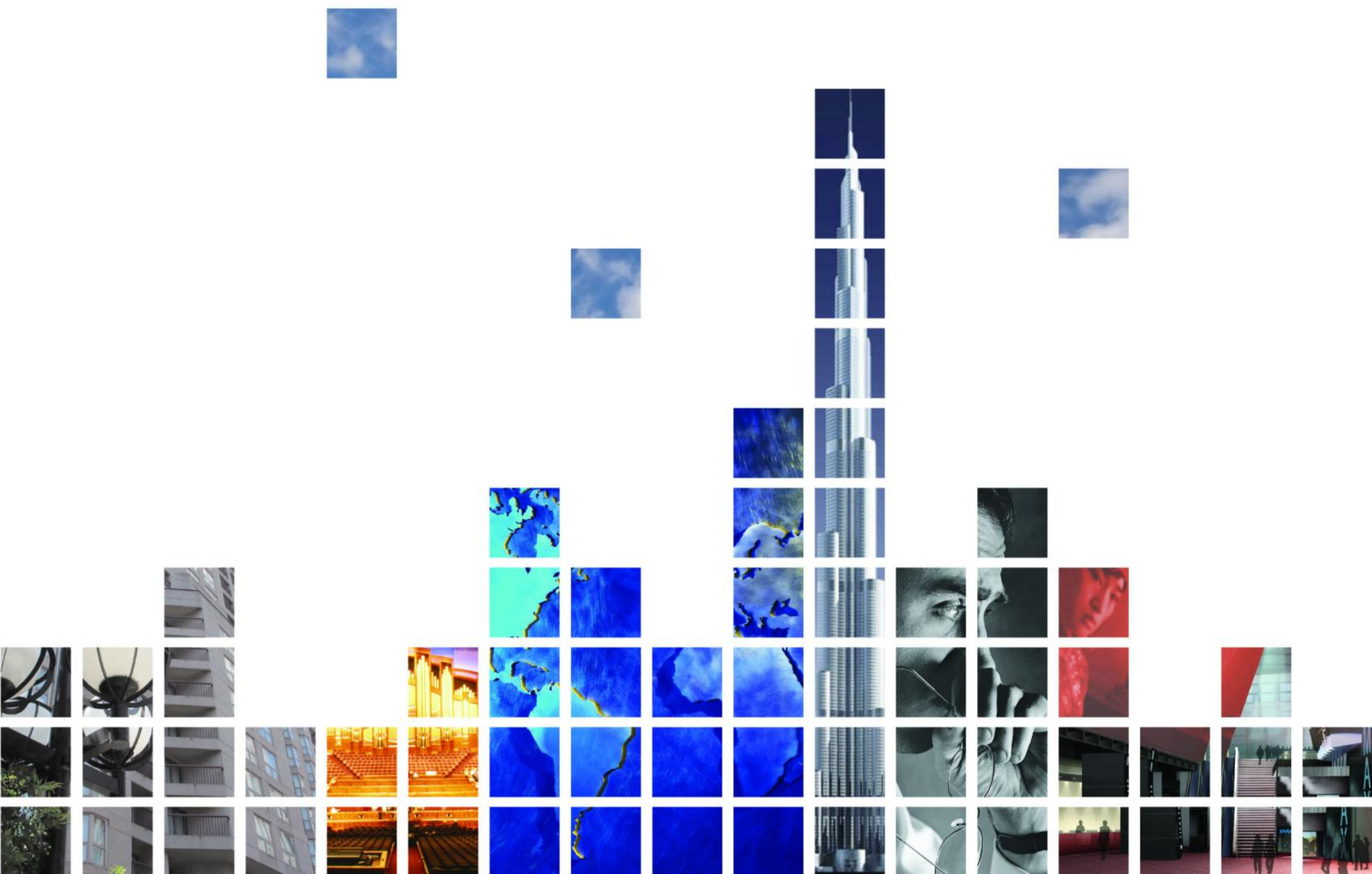
STUDY ON THE LIFE CYCLE COST OF PORTABLE FIRE EXTINGUISHERS



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STUDY ON THE LIFE CYCLE COST OF PORTABLE FIRE EXTINGUISHERS

Richard W. Bukowski, P.E., FSFPE

Prepared for:

Fire Equipment Manufacturers' Association
Cleveland, Ohio

January 8, 2014

RJA Project No. C58655

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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)	

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U.S. Experience with Sprinklers

July 2017

Marty Ahrens

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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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NFPA No. USS14

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.

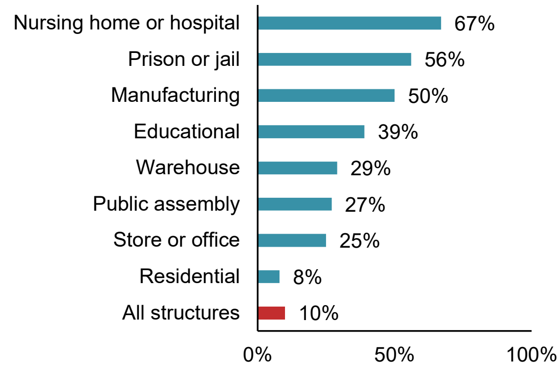
Sprinkler Presence

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.

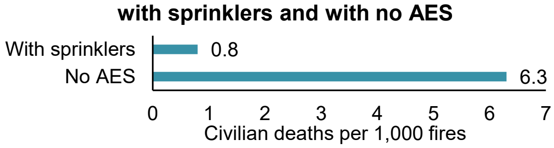
Wet pipe sprinklers accounted for 87% of the sprinklers in reported structure fires, dry pipe systems accounted for 10%, and other types of sprinklers accounted for 3%.

Presence of sprinklers in reported fires by occupancy



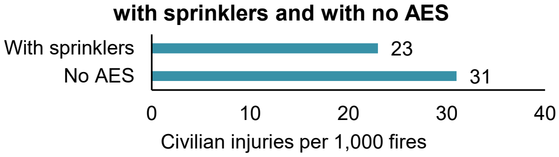
Impact of Sprinklers

Civilian death rates per 1,000 fires in properties with sprinklers and with no AES



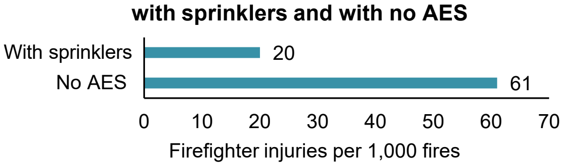
The civilian fire death rate of 0.8 per 1,000 reported fires was 87% lower in properties with sprinklers than in properties with no AES.

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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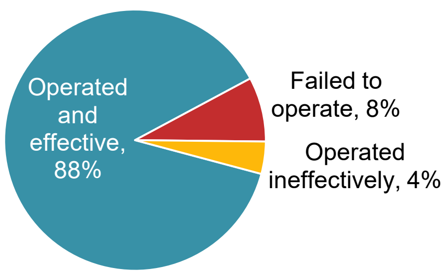
FACT SHEET » RESEARCH *(continued)*

Sprinkler Operation and Effectiveness

Sprinkler operation and effectiveness

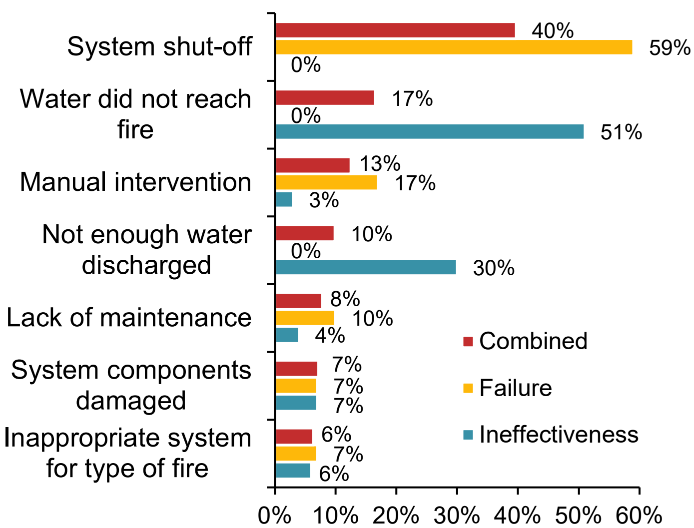


Sprinklers operated in 92% of the fires in which sprinklers were present and the fire was large enough to activate them.

- 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
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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

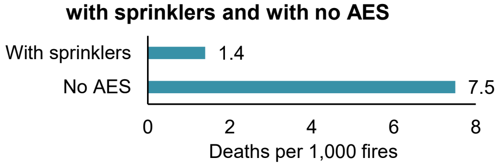
Automatic extinguishing systems (AES) are designed to control fires until the fire department arrives. Sprinklers are a type of AES that uses water to control fires. Other types of AES use something other than water.

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%.

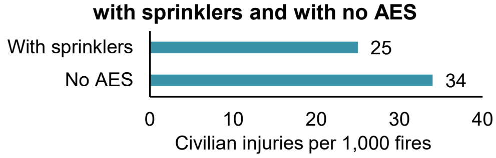
Impact of Sprinklers

Death rates per 1,000 fires in homes with sprinklers and with no AES



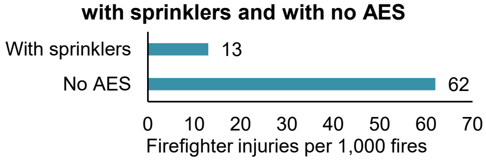
The civilian death rate of 1.4 per 1,000 reported fires was 81% lower in homes with sprinklers than in homes with no AES.

Civilian injury rates per 1,000 fires in homes with sprinklers and with no AES



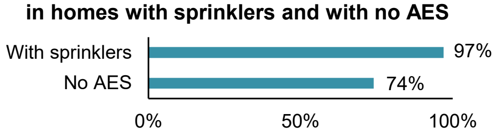
The civilian injury rate of 25 per 1,000 reported fires was 31% lower in homes with sprinklers than in homes with no AES. Many of the injuries occurred in fires that were too small to activate the sprinkler or in the first moments of a fire before the sprinkler operated.

Firefighter injury rates per 1,000 fires in homes with sprinklers and with no AES



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.

Percent of fires confined to room of origin in homes with sprinklers and 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.

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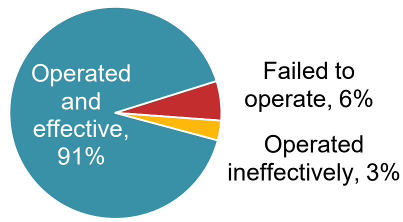
FACT SHEET » RESEARCH *(continued)*

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.

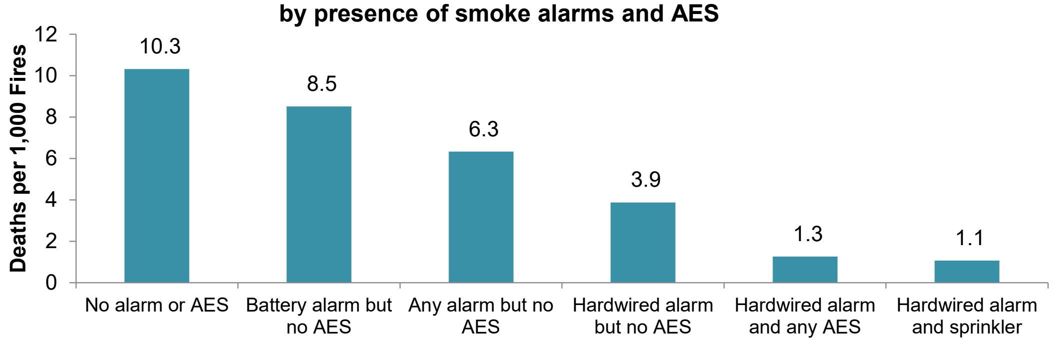
In three out of five (62%) of fires in which sprinklers failed to operate, the system was shut off.

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.

Source: NFPA Research: www.nfpa.org/research
Contact information: 617-984-7451 or research@nfpa.org

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Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

List of Figures and Tables

List of Figures and Tables (Continued)

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

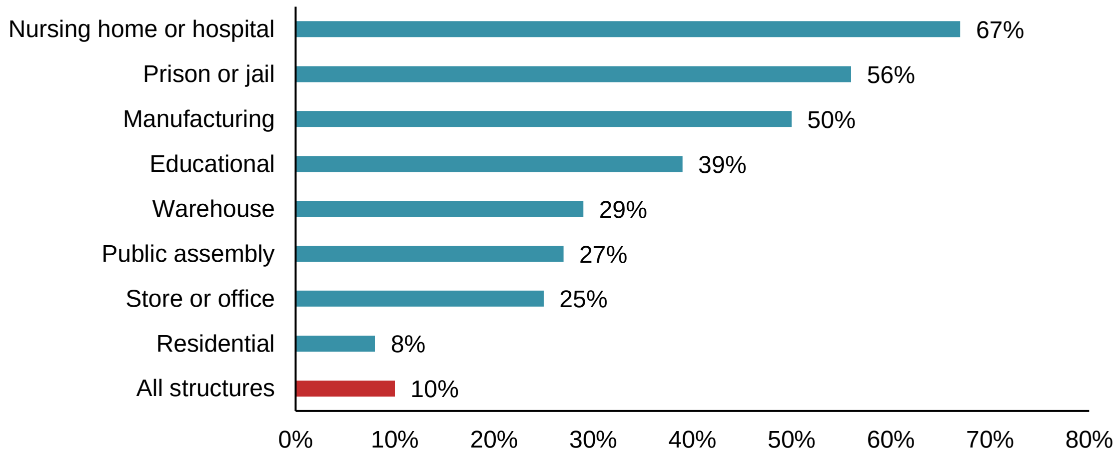


Table 1 provides information about more occupancies and shows estimates of automatic extinguishing system (AES) presence in 1980-1984 and 1994-1998 for historical context.[1] Table A summarizes information about AES in all reported structure fires *except those under construction*.

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

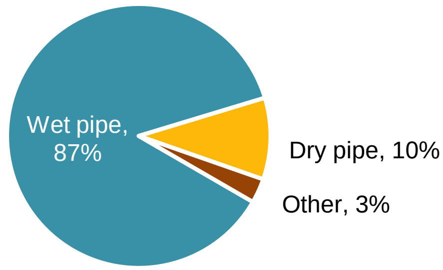
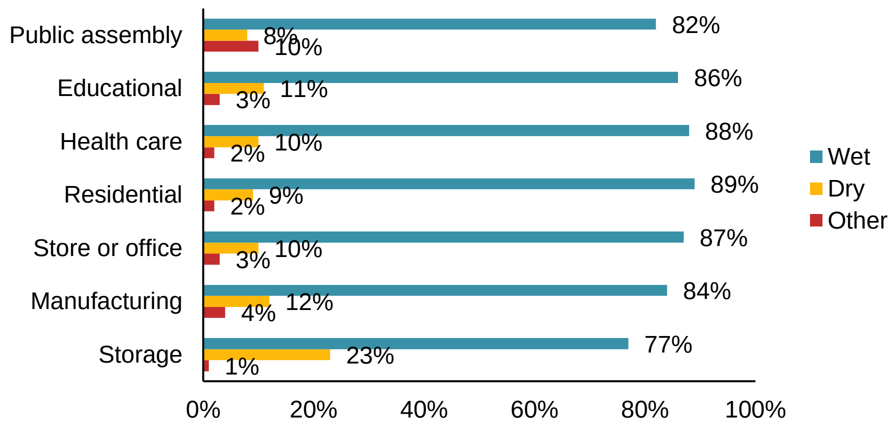


Figure 3 and Table 2 show that dry pipe sprinklers were more common in storage occupancies. "Other" sprinklers were seen most frequently in eating and drinking establishments. It is possible that some of these other sprinklers were actually miscodes of systems designed specifically for cooking equipment.

Figure 3. Sprinkler type by occupancy: 2010-2014

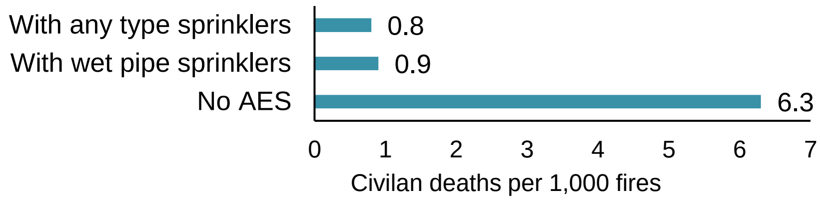


FIRES IN PROPERTIES WITH SPRINKLERS VS. NO AES

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.

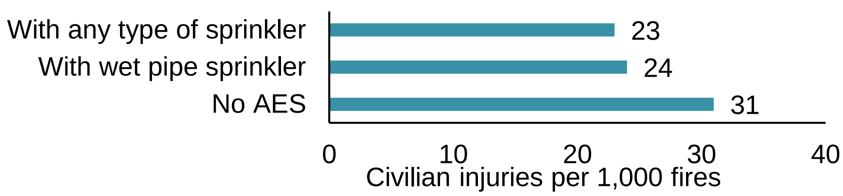
While the reduction in deaths was greater in some occupancies with wet pipe sprinklers than total sprinklers, the differences were small. With so few deaths in sprinklered properties, the differences are not meaningful.

Figure 4. Civilian death rates per 1,000 fires in properties with sprinklers and with no AES: 2010-2014



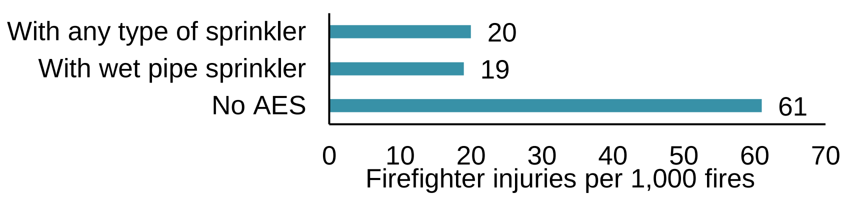
The civilian injury rate per 1,000 reported fires was 27% lower in properties with sprinklers than in properties with no AES. Figure 5 shows that when sprinklers of any type were present, reported civilian injuries averaged 23 per year, compared to 31 per year in which no AES was present. The injury 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.

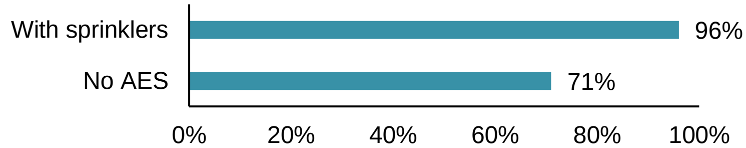
Figure 6. Firefighter injury rates per 1,000 fires in properties with sprinklers and with no AES 2010-2014



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.

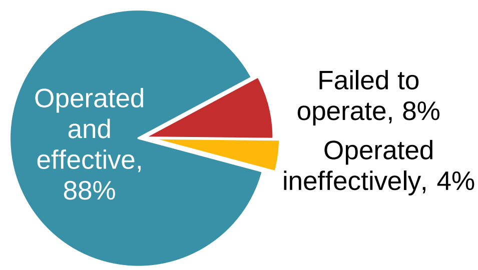
Figure 7. Percent of fires confined to room of origin in properties with sprinklers and with no AES 2010-2014



SPRINKLER OPERATION, EFFECTIVENESS AND PROBLEMS

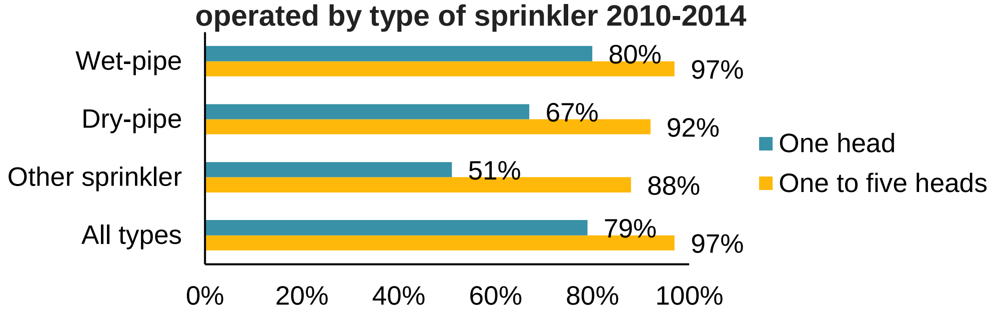
Sprinklers operated in 92% of the fires in which sprinklers were present and the fire was considered large enough to activate them.[2] They were effective at controlling the fire in 96% of fires in which they operated. Figure 8 shows that sprinklers operated effectively in 88% of the fires large enough 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.

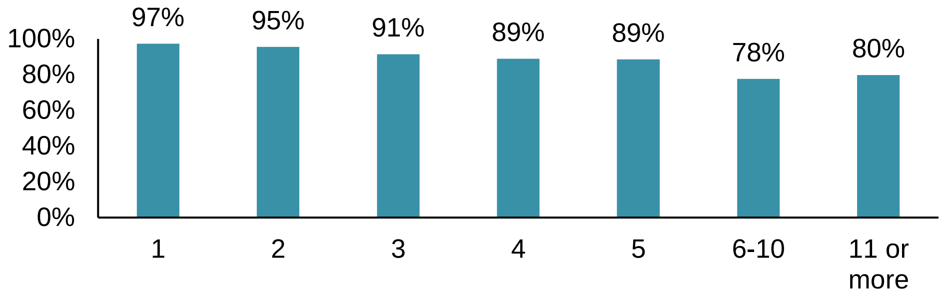
Figure 9. When sprinklers operated, percentage of fires in which one or one to five heads operated by type of sprinkler 2010-2014



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.

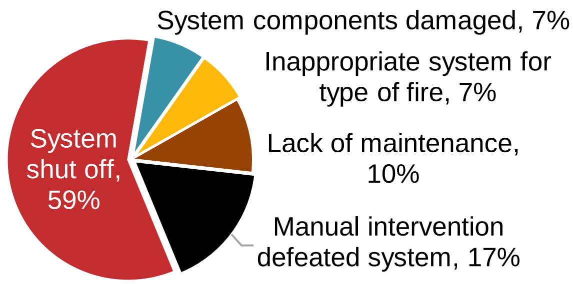
[2] These calculations exclude fires with confined structure fire incident types (NFIRS incident types 113-118). Among confined fires with sprinklers present, the fire was too small to operate 76% of the time, sprinklers operated and were effective 19% of the time and failed to operate 4% of the time. 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.

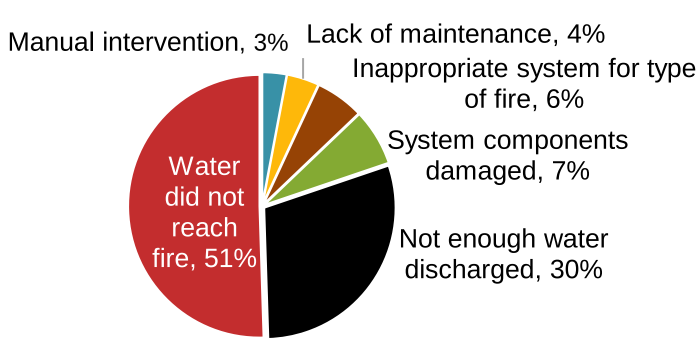


The system was inappropriate for the type of fire in 7% of the incidents in which sprinklers failed to operate. Throughout a building's life cycle, the use and occupancy type may change. A system that was designed for the original purpose may not be sufficient to meet the requirements of the changed 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.

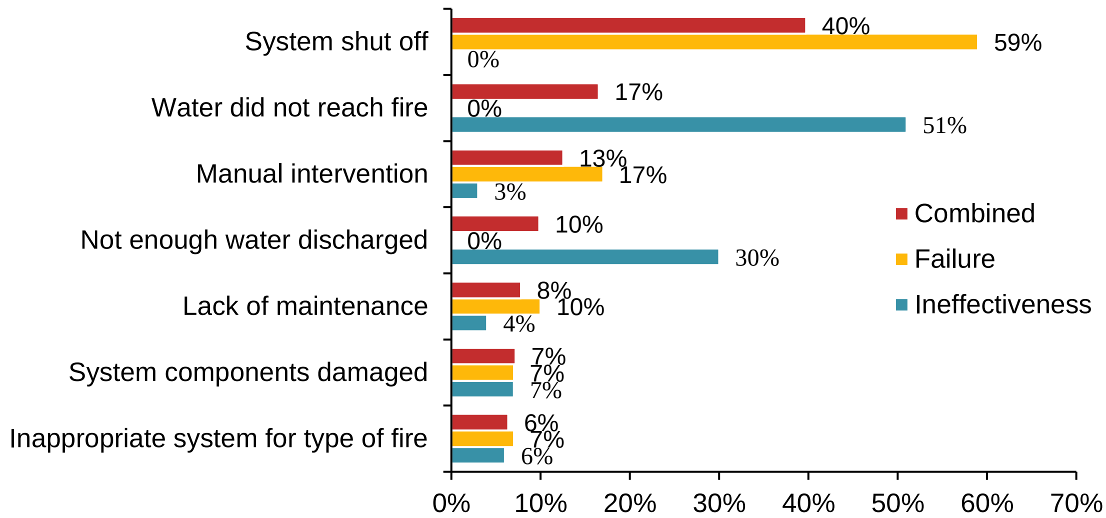
In half (51%) of the fires in which sprinklers were ineffective. the water did not reach the fire. Figure 12 shows that in 30% of the incidents, not enough water was discharged. In 7%, system components were damaged. The system was inappropriate for the type of fire in 6%. Lack of maintenance was identified 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

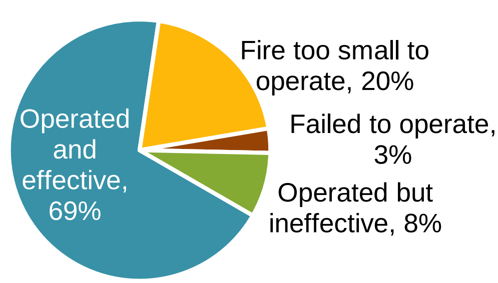


Civilian deaths in sprinklered properties

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.

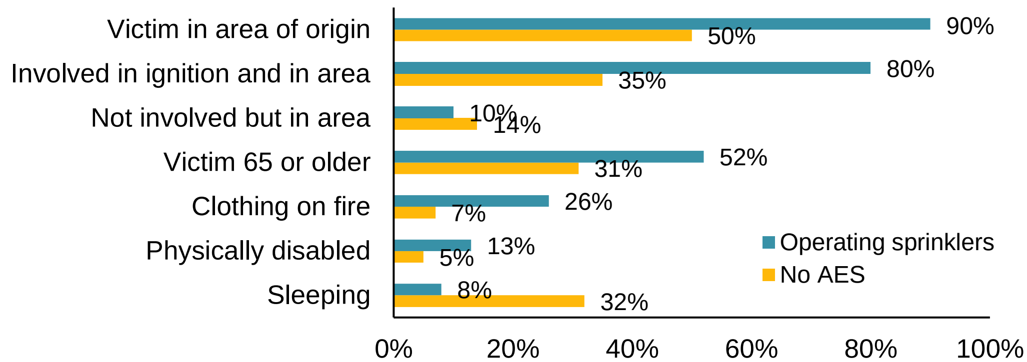
Figure 14 shows that 69% of the deaths in properties with sprinklers were caused by fires in which the sprinklers operated and were effective in controlling the fire. In some of these cases, the sprinklers actually extinguished the fire. The victims were typically fatally injured before the sprinklers 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.

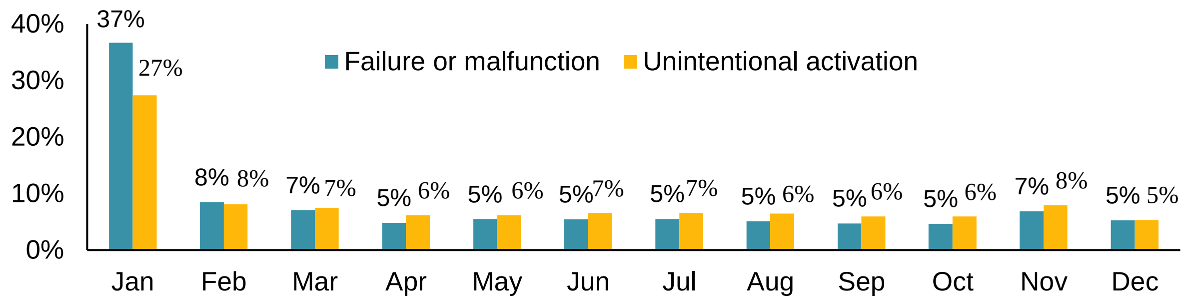
Figure 15. Victim characteristics in fires with effectively operating sprinklers and with no AES 2010-2014



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.

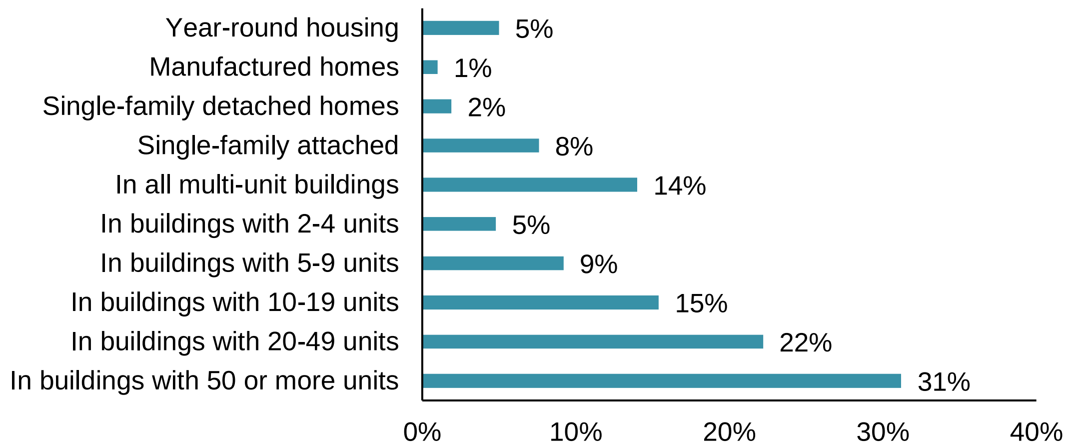
Table B summarizes information about AES in all reported home structure fires except those under construction.

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]

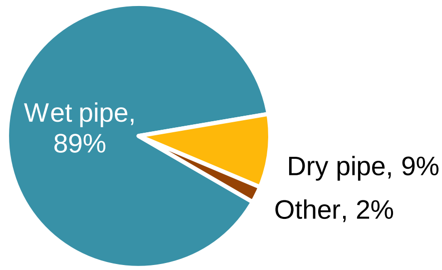
Figure 17. Percentage of occupied units with sprinklers in 2011 American Housing Survey



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.

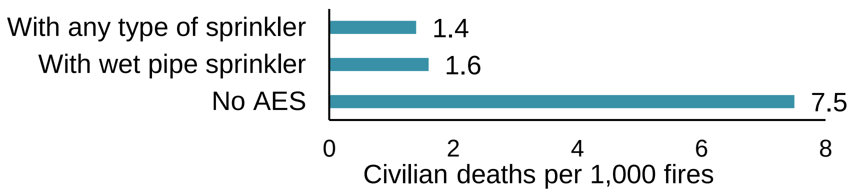
Figure 18. Types of sprinklers found in home structure fires: 2010-2014



FIRES IN HOMES WITH SPRINKLERS VS. NO AES

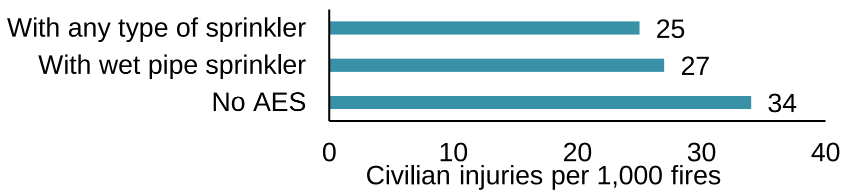
The death rate per 1,000 reported fires was 81% lower in homes with sprinklers than in homes with no AES. These rates are based strictly on reported presence or absence. Operation is not considered. Figure 19 shows that in reported structure fires with no automatic extinguishing systems (AES) present, 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.

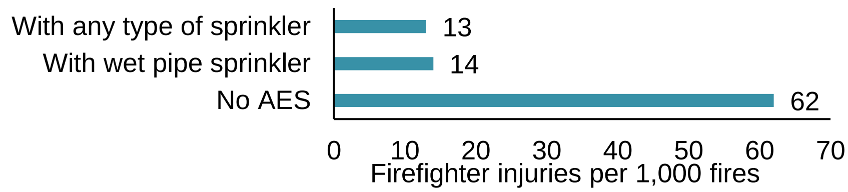
Figure 20. Civilian injury rates per 1,000 fires in homes with sprinklers and with no AES 2010-2014



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]

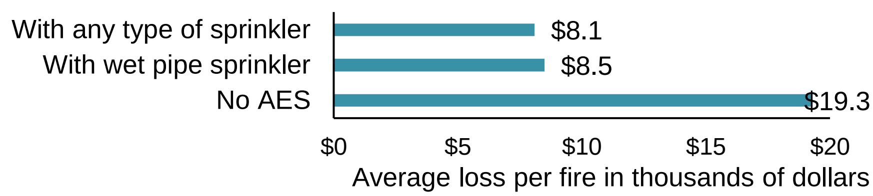
The average firefighter fireground injury rate per 1000 reported home fires was 79% lower when sprinklers were present than in fires with no AES. Figure 21 shows that when sprinklers were present, 13 firefighters were injured per 1000 fires, compared to 62 firefighter injuries per 1,000 fires in properties without AES protection.

Figure 21. Firefighter injury rates per 1,000 fires in homes with sprinklers and with no AES 2010-2014



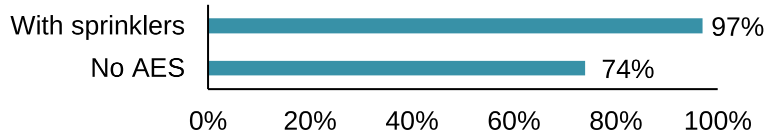
When sprinklers were present in reported home fires, the average property loss per fire was less than half the average in homes with no AES. Figure 22 shows that when any type of fire sprinkler was present in reported fires, the average loss was $8,100 per fire. This was 58% lower than the $19,300 average 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.

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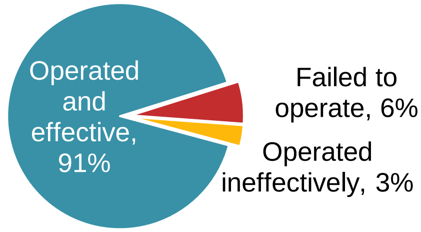
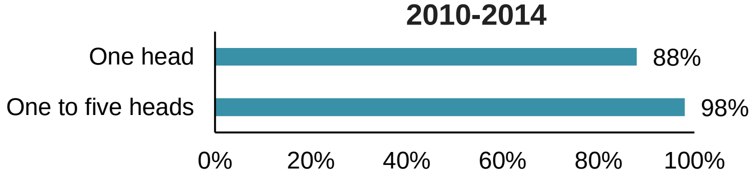
[3] These calculation exclude fires with confined structure fire incident types (NFIRS incident types 113-118). Among confined fires with sprinklers present, the fire was too small to operate 74% of the time, sprinklers operated and were effective 22% of the time and failed to operate 4% of the time. 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



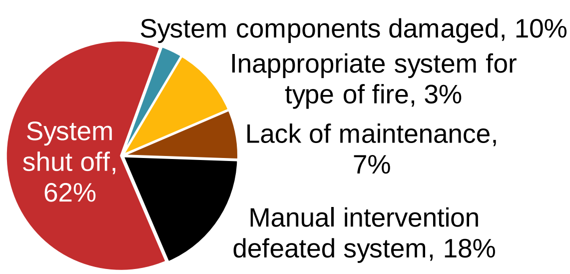
In 98% of home fires with operating sprinklers, five or fewer heads operated. Figure 25 shows that only one sprinkler operated in 88% of fires with operating sprinklers of all types. The percentage of fires in which only one head operated is higher in this report than in previous editions because fires 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



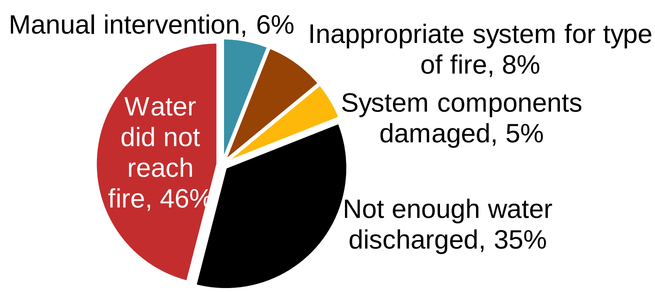
In three of every five (62%) home fires in which sprinklers failed to operate, the system had been shut off. Figure 26 shows that manual intervention defeated the system in 18% of the incidents. System components were damaged in 10% of these fires, lack of maintenance caused 7% of the failures, and 3% 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

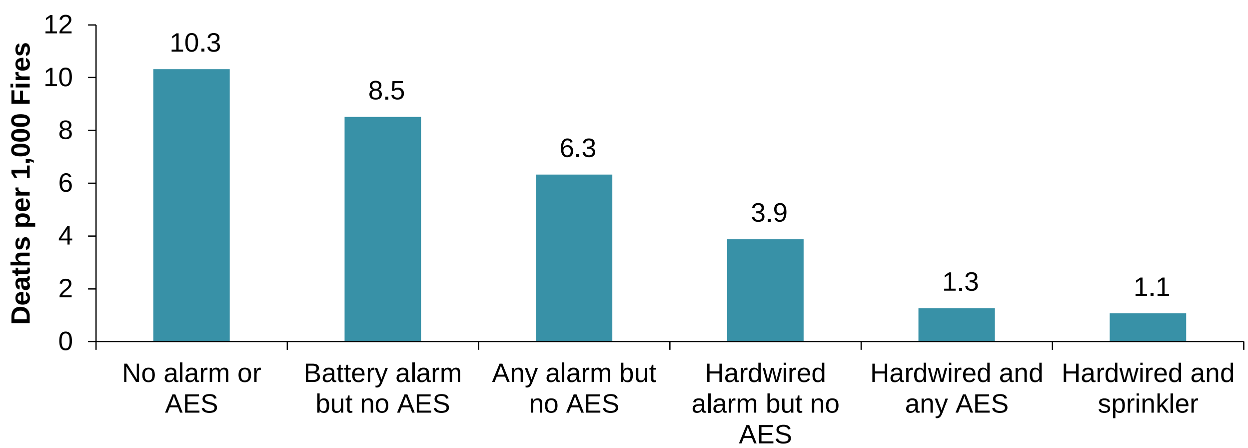


IMPACT OF SMOKE ALARMS AND SPRINKLERS IN DEATHS PER 1,000 HOME FIRES

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

	Percentage of fires confined to room of origin excluding structures under construction and sprinklers not in fire area		
Property Use	**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.

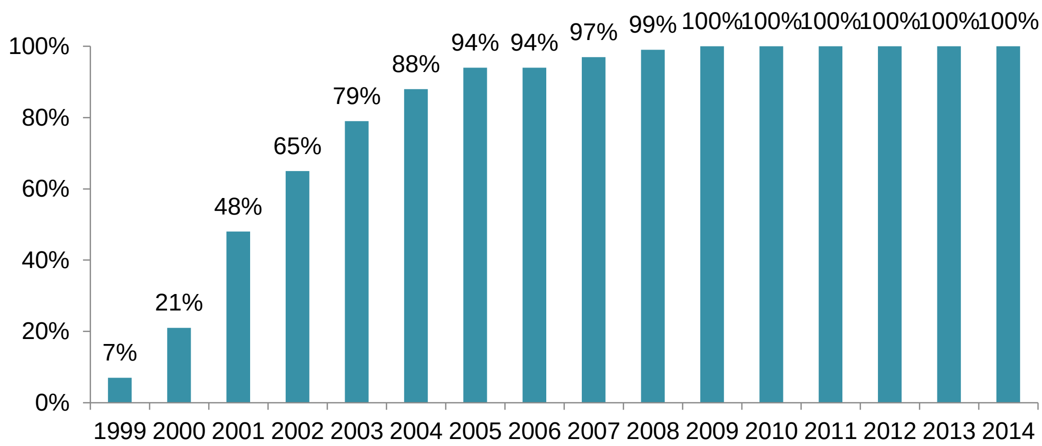
Figure A.1 shows the percentage of fires originally collected in the NFIRS 5.0 system. Each year's release version of NFIRS data also includes data collected in older versions of NFIRS that were converted to NFIRS 5.0 codes.

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

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[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

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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.

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Table of Contents

List of Tables

List of Figures

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

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[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%

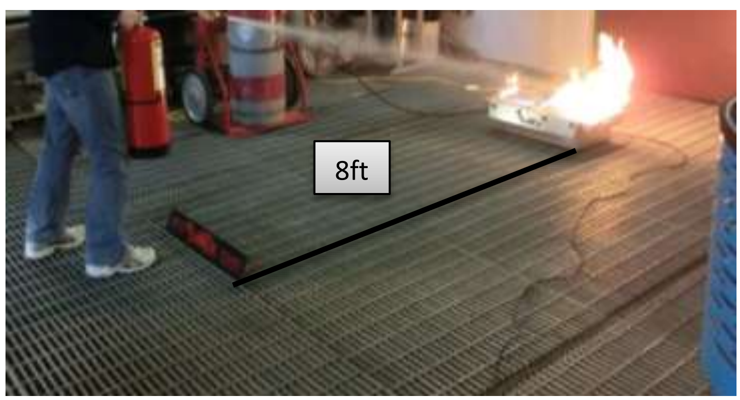

Figure 16: Participant standing just over 8ft away from the BullEx ITS

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.

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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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___ WITH PORTIONS REMOVED: ______

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.

[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.

Table of Contents

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.

[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 Responses	Projected Percent	Actual Responses	Actual 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

	Projected		Actual	
Demographic Factor	Number	Percent	Number	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

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[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

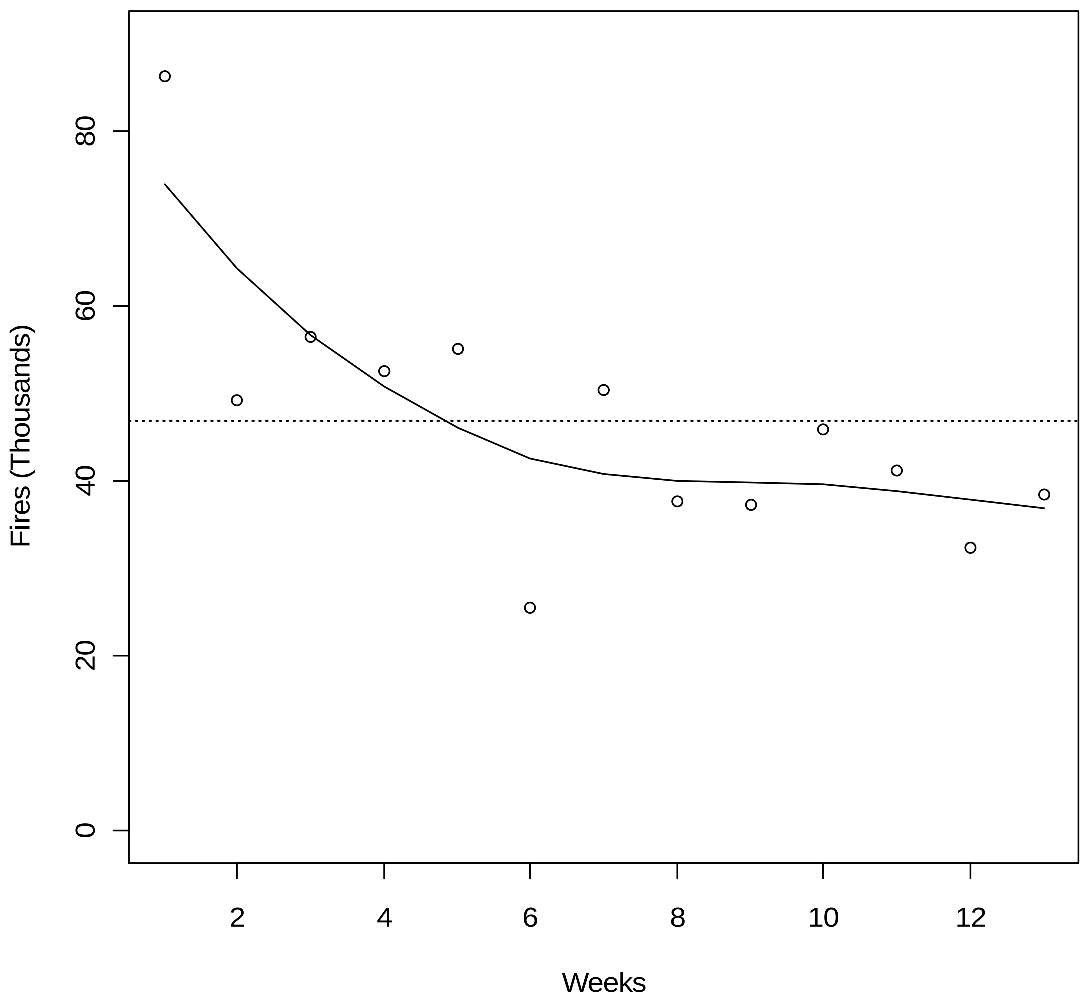
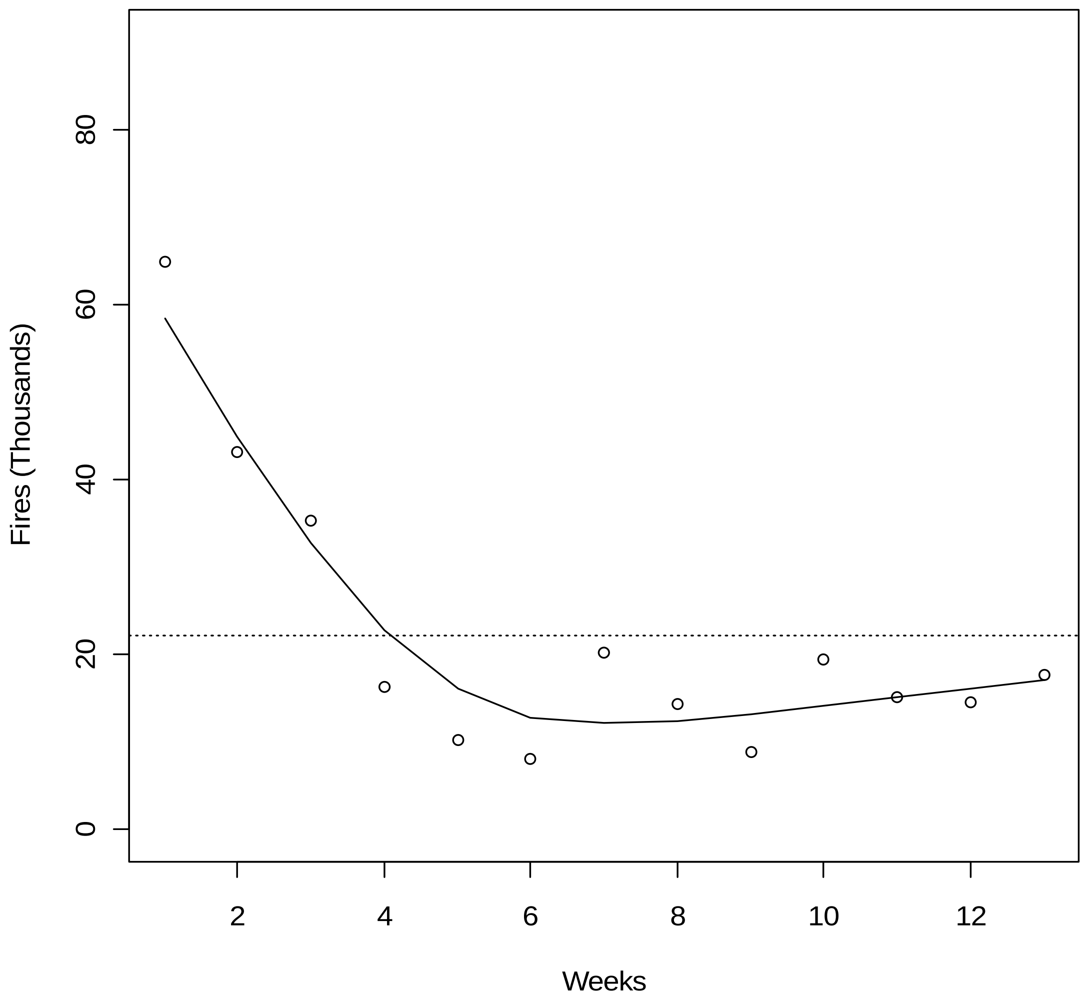


Figure 3-2 shows the same plot for the low severity fires. The estimated weighted average number of fires was 22,150, about 47 percent of the average of the high severity fires (Standard Deviation = 16,290, Range 8,143 – 64,774, Coefficient of Variation = 73.5 percent). Like Figure 3-1, the largest number 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 Weeks from Interview	Fire Incidents			Reference Period: 1 week		Reference Period: 1-2 weeks		Reference Period: 1-3 weeks	
	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		Reference Period 1-2 weeks		Reference Period 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

[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

[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.

[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.

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[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.

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[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.

[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.

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[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.

[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.

[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.

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[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.

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[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.

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[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.

[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.

[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.

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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

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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 <u>in starting the fire</u>? **(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
Don't know 3
Refused 4

→**SKIP TO INSTRUCTION BEFORE Q31**

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.

FP912.2-21

VFC: 912.2

Proponents: Deidra Peterson (drkpeter@vbgov.com)

2018 Virginia Statewide Fire Prevention Code

Revise as follows:

912.2 Location. With respect to hydrants, driveways, buildings and landscaping, fire department connections shall ~~remain located in accordance with the *applicable building code* so that fire apparatus and hose connected to supply the system will not obstruct *access to* the *buildings* for other fire apparatus~~ be so located that fire apparatus and hose connected to supply the system will not obstruct access to the buildings for other fire apparatus. The location of the fire department connections shall be approved by the fire chief.

Reason Statement: This code as written in the IFC must remain as is and be located in the SFPC to be enforcbile. It can't only be written in the VCC. The fire chief is the department leader approving department wide policy. [Excerpt from the IFC Commentary "...fireground operations are based on local operational procedures, it is only reasonable that he fire chief of the jurisdiction has approval authority over the location of and access to the FDC.] Furthermore, the FDC location approval may be delegated to the fire code official.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposed code change would put the authority of approval where it belongs, to the fire chief of the local fire department.

Cost Impact: The code change proposal will not increase or decrease the cost of construction
There should be no change in construction cost.

FP5601.2.2.1-21

VFC: 5601.2.2.1 (New)

Proponents: Steven Sites (steven.sites@fairfaxva.gov)

2018 Virginia Statewide Fire Prevention Code

Add new text as follows:

5601.2.2.1 Permissible fireworks. Where the sale or retail display of *permissible fireworks* is allowed by Section 5601.1.3, Exception 4, such sales or retail display shall comply with the applicable requirements of NFPA 1124 - 13 edition.

Reason Statement: There is no provisions to regulate the sales and retail display of permissible fireworks. Newer versions of NFPA 1124 (after the 2013) edition removed sales provisions. Fire Officials need the ability to ensure safe practices for the placement within a approved (by local building official - when applicable) building, structure, or tent. The prevention of ignition sources and security of the products while at the sales or retail display location is important for public safety. NFPA 1124 - 13 contains sound and safe practices for the safety of permissible fireworks at sales or retail display sites.

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

Cost Impact: The code change proposal will not increase or decrease the cost of construction
The building, structure, or tent will be governed by the building official and applicable building code. The sales or retail display of permissible fireworks is a seasonal commodity. In general the building, structure, or tent will be accommodating the sales or retail display for a defined period of time. The cost impact to the business owner should be minimal, and will not be impacted by the applicable regulations contained in NFPA 1124 - 13.

FP5705.5-21

VFC: 5705.5, 5705.5.1

Proponents: Perry Weller (wellerpw@ci.staunton.va.us)

2018 Virginia Statewide Fire Prevention Code

Revise as follows:

5705.5 Alcohol-based hand rubs classified as Class I or II liquids. The use of ~~wall-mounted~~ approved dispensers containing *alcohol-based hand rubs* classified as Class I or II *liquids* shall be in accordance with all of the following:

1. The maximum capacity of each dispenser shall be 68 ounces (2 L).
2. The minimum separation between dispensers shall be 48 inches (1219 mm).
3. The dispensers shall not be installed above, below, or closer than 1 inch (25 mm) to an electrical receptacle, switch, appliance, device or other ignition source. The wall space between the dispenser and the floor or intervening countertop shall be free of electrical receptacles, switches, appliances, devices or other ignition sources.
4. Dispensers shall be mounted or located so that the bottom of the dispenser is not less than 42 inches (1067 mm) and not more than 48 inches (1219 mm) above the finished floor.
5. Dispensers shall not release their contents except when the dispenser is manually activated. Facilities shall be permitted to install and use automatically activated "touch free" *alcohol-based hand-rub* dispensing devices with the following requirements:

    5.1. The facility or persons responsible for the dispensers shall test the dispensers each time a new refill is installed in accordance with the manufacturer's care and use instructions.

    5.2. Dispensers shall be designed and must operate in a manner that ensures accidental or malicious activations of the dispensing device are minimized. At a minimum, all devices subject to or used in accordance with this section shall have the following safety features:

        5.2.1. Any activations of the dispenser shall only occur when an object is placed within 4 inches (98 mm) of the sensing device.

        5.2.2. The dispenser shall not dispense more than the amount required for hand hygiene consistent with label instructions as regulated by the US Food and Drug Administration (USFDA).

        5.2.3. An object placed within the activation zone and left in place will cause only one activation.

6. Storage and use of *alcohol-based hand rubs* shall be in accordance with the applicable provisions of Sections 5704 and 5705.
7. Dispensers installed or located in occupancies with carpeted floors shall only be allowed in *smoke compartments* or *fire areas* equipped throughout with an *approved automatic sprinkler system* in accordance with NFPA 13 or NFPA 13R or the *applicable building code*.

5705.5.1 Corridor installations. Where ~~wall-mounted~~ approved dispensers containing *alcohol-based hand rubs* are installed or located in *corridors*, they shall be in accordance with all of the following:

1. Level 2 and 3 *aerosol containers* shall not be allowed in *corridors*.
2. The maximum capacity of each Class I or II *liquid* dispenser shall be 41 ounces (1.21 L) and the maximum capacity of each Level 1 aerosol dispenser shall be 18 ounces (0.51 kg).
3. The maximum quantity allowed in a *corridor* within a *control area* shall be 10 gallons (37.85 L) of Class I or II *liquids* or 1,135 ounces (32.2 kg) of Level 1 aerosols, or a combination of Class I or II *liquids* and Level 1 aerosols not to exceed, in total, the equivalent of 10 gallons (37.85 L) or 1,135 ounces (32.2 kg) such that the sum of the ratios of the *liquid* and aerosol quantities divided by the allowable quantity of *liquids* and aerosols, respectively, shall not exceed one.
4. The minimum *corridor* width shall be 72 inches (1829 mm).
5. Projections into a *corridor* shall be in accordance with the *applicable building code*.

Reason Statement: Since the last code update cycle, the pandemic has created a multitude of issues surrounding alcohol-based hand rub dispensers. There many variations to alcohol-based dispensers in use nowadays, not just wall-mounted dispensers. The fire code currently only addresses "wall-mounted" dispensers. Many occupancies are using stand-alone dispensers with amounts greater than 68 ounces (2L). The fire code should reflect the current changes in dispenser types available to society and adjust accordingly. Many dispensers in use contain up to 128 ounces and are located in a hallways and multiple dispensers are located in the same corridor. Fire code officials should have the ability to address the various types of dispensers to ensure the safety of the building occupants and protect the egress corridors.
There have been numerous fires reported across the Commonwealth from alcohol-based hand rubs being ignited, more so in educational

occupancies. These fires have great potential to cause a severe life safety hazard due to the fuel being used to ignite the fires. Allowing all dispensers to be approved by the fire code official may assist in lowering the availability of this flammable liquid has an ignition source.

Resiliency Impact Statement: This proposal will increase Resiliency
This proposal will increase Resiliency This proposal will increase resiliency since it will provide that all alcohol-base hand rub dispensers will safety provisions. This will increase safety regarding the use and handling of these dispensers and the facilities and occupants they are used in.

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 This proposal relates only to maintenance and inspection of alcohol-based hand rub dispensers, not construction.