CSI - Ohio

The Common Sense Initiative

Business Impact Analysis

Agency Name: Ohio Board of Building Standards

Regulation/Package Title: Ohio Building Code Amendments

Rule Number(s): 4101:1-1-01, 4101:1-2-01, 4101:1-3-01, 4101:1-7-01, 4101:1-9-01, 4101:1-10-01, 4101:1-16-01, 4101:1-22-01, 4101:1-23-01, 4101:1-25-01, 4101:1-26-01, 4101:1-34-01, 4101:1-35-01

Date: March 14, 2018

Rule Type:

New

X Amended

☐ 5-Year Review

Rescinded

The Common Sense Initiative was established by Executive Order 2011-01K and placed within the Office of the Lieutenant Governor. Under the CSI Initiative, agencies should balance the critical objectives of all regulations with the costs of compliance by the regulated parties. Agencies should promote transparency, consistency, predictability, and flexibility in regulatory activities. Agencies should prioritize compliance over punishment, and to that end, should utilize plain language in the development of regulations.

Regulatory Intent

1. **Please briefly describe the draft regulation in plain language.**
   Please include the key provisions of the regulation as well as any proposed amendments.

   The Ohio Board of Building Standards (Board) proposes to amend Ohio Administrative Code (OAC) Rules as follows:

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4101:1-1-01 to clarify intent of exemption for signs, retaining walls, bridges, walkways or site stairs; add an exception for primitive transient lodging structures that are 400 sq. ft. or less in area; and modify charging paragraph to clarify intent of "Work exempt from approval."

4101:1-2-01 to modify definitions to incorporate ICC errata and adds definitions for primitive transient lodging structure, semi-primitive lodging structure, and transient lodging structure.

4101:1-3-01 to incorporate ICC Errata; clarify that certain Boarding Houses and Congregate Living facilities with transient occupants would not be classified as Group R-1; add requirements for transient lodging structures; add pointer to SFM licensing requirements; add requirements for semi-primitive transient lodging structures that are 400 sq. ft. or smaller; add requirements for primitive or semi-primitive transient lodging structures that are greater than 400 sq. ft. in area; clarify the classification of Boarding Houses and Congregate Living facilities with 10 or fewer occupants; clarify the classification of Boarding Houses and Congregate Living facilities; clarify the classification of Boarding Houses and Congregate Living facilities with 16 or fewer occupants; clarify the classification of Boarding Houses and Congregate Living facilities; clarify that an owner-occupied lodging house with 5 or fewer guest rooms is Group R-3; clarify that some Group R-3 occupancies may use the RCO; and clarify the classification of Boarding Houses and Congregate Living facilities with more than 16 occupants.

4101:1-7-01 to incorporate ICC Errata; bring back the reference to NFPA 221 which recognizes cantilevered fire walls and tied fire walls; incorporate language from approved petition 17-01 prescribing damper access door requirements; and delete ICC Exception #2 as a result of broader new Ohio Exception #6 for smoke dampers.

4101:1-9-01 to incorporate provisions to promote fire/building official coordination; incorporate ICC Errata; and add language from approved petition 17-05 removing fire extinguisher exception 1.1 for Groups A, B and E and adds another option for Group E (exception 1.2 from 2018 IBC).

4101:1-10-01 to incorporate ICC Errata; and brings back the "Luminous Egress Path Markings" section, including the subsections, but clarifies that the markings are not mandatory.

4101:1-16-01 to incorporate ICC Errata and bring back reference to AWC WFCM.

4101:1-22-01 to delete requirement for certificate of compliance; and to bring back reference to AISI S230 for townhouses.

4101:1-23-01 to bring back reference to AWC WFCM.

4101:1-25-01 to incorporate ICC Errata.

4101:1-26-01 to incorporate ICC Errata.

4101:1-34-01 to correct code references; renumber sections 3401.4 - 3401.6 to 3401.3 - 3401.5 and corrects the internal references to those sections due to incorrect section numbering in the original rule (missing Section 3401.3); add a new section which references ACI 562 for the design of concrete repairs and rehabilitation; clarify that newer existing buildings undergoing a proposed change of occupancy can be evaluated using the methodology found in Section 3412; bring in 2015 IEBC text for I-2 smoke compartments; add Group I-2 and category f from 2015 IEBC in Table 3412.6.8; add Category f from 2015 IEBC in Section 3412.6.8.1; bring in 2015 IEBC text for Group I-2 in Table 3412.6.9; bring in 2015 IEBC text for Group I-2 in Tables 3412.6.10 and 3412.6.11

4101:1-35-01 to update references to ACI, AWC, NFPA, and TMS standards.

A detailed summary of the proposed amendments is attached as Exhibit A.

2. **Please list the Ohio statute authorizing the Agency to adopt this regulation.**

   Revised Code § 3781.10: http://codes.ohio.gov/orc/3781.10
   Revised Code § 3781.11: http://codes.ohio.gov/orc/3781.11

3. **Does the regulation implement a federal requirement? Is the proposed regulation being adopted or amended to enable the state to obtain or maintain approval to administer and enforce a federal law or to participate in a federal program?**
   If yes, please briefly explain the source and substance of the federal requirement.

   No.

4. **If the regulation includes provisions not specifically required by the federal government, please explain the rationale for exceeding the federal requirement.**

   NA

5. **What is the public purpose for this regulation (i.e., why does the Agency feel that there needs to be any regulation in this area at all)?**

   Revised Code § 3781.10 directs the Board to "formulate and adopt rules governing the erection, construction, repair, alteration and maintenance of all buildings specified in section 3781.06 of the Revised Code…" It further requires that the Board's rules also "relate to the conservation of energy and the safety and sanitation of those buildings."

6. **How will the Agency measure the success of this regulation in terms of outputs and/or outcomes?**

   The enforcement of these rules will be implemented by certified township, city, and county building departments. Rule 4101:1-1-01 lays out the administrative procedures certified building departments must follow to implement the substantive requirements of these rules to determine compliance. These provisions require a builder or owner to make application to a building department to obtain an approval to build (permit). As part of this application the owner must submit sufficient information and/or construction documents for the building official/plans examiner to determine whether the proposed work complies with the code. After the builder or owner obtains the approval (permit), construction may commence and the building department inspectors will inspect the construction to ensure that the work conforms with the original approval. Rule 4101:1-1-01 § 105.2 provides that in the absence of fraud or a serious safety or sanitation hazard, any non-residential structure built in accordance with approved plans shall be conclusively presumed to comply with these rules. The Board requires that certified nonresidential building departments submit an annual yearly operational report which lists the following information: current employees and their certifications, total number of permits issued during the year for each type of occupancy, total number of inspections made, the total value of construction, and the total number of appeals of the code requested by a builder or owner during the year.

Development of the Regulation

7. **Please list the stakeholders included by the Agency in the development or initial review of the draft regulation.**
   If applicable, please include the date and medium by which the stakeholders were initially contacted.

   The Board maintains a stakeholder distribution including building department personnel, contractors, designers and professional associations. The stakeholder list is available upon request. On December 5, 2017, the Board sent an email to all agency stakeholders informing them of a scheduled stakeholder meeting on January 5, 2018 to hear comments and respond to questions on these rules. The notice summarized the proposed amendments and also informed stakeholders that if they could not attend the stakeholder meeting, they could submit questions or comments via email or regular mail by January 12, 2018. On January 5, 2018, the Board conducted a stakeholder meeting on the proposed rules between 10:00 AM and 12:00 PM and the following individuals attended: Derek Spurling, MVBOC, Rick Helsinger, OBOA, Mike Spry, City of Cincinnati, Jene Gaver, City of Springfield, James Smith, American Wood Council, Michael Boso, City of Grove City, Jason Baughman, Mid East Ohio Building Department, Scott Young, MVBOC, and Don Phillips, City of Worthington.

8. **What input was provided by the stakeholders, and how did that input affect the draft regulation being proposed by the Agency?**

A copy of the correspondence the Board received in response to December 5, 2017 email and a summary of the January 5, 2018 stakeholder meeting are attached as Exhibit B This information was reviewed by the Board's Code Committee at its meeting on March 1, 2018.

At the January 5, 2018 stakeholder meeting several code officials in attendance requested modification to the new exemptions for signs and retaining walls. These exemptions were new to the OBC effective November 1, 2017 and during the rule development process the Board received no comments regarding the new exemptions. In addition to the comments presented at the stakeholder meeting, the Board received written comments from building officials requesting the exemptions be modified. The Board has made no changes as result of these comments as it is our understanding the representatives from the Ohio Building Officials Association are developing proposed language to clarify which signs/retaining should be regulated and which should be exempt. The Board expects to receive these comments during eNotification review and will be considered at that time. In general, the Board's Code Committee is supportive of modifying the exemptions but requests more information from stakeholders in specifying which signs pose little risk and therefore should be exempt vs those that pose risk of injury or damage to other structures and should be regulated.

Email comments received from Greg Lauterbach, Ned Heminger and Timothy Meyer regarding editorial corrections were reviewed the Board's Code Committee and accepted. Additionally, comments submitted by Gerald Burg were also addressed by the Code Committee by incorporating new paragraph to § 3412 to clarify that the risk analysis of § 3412 may be used when evaluating existing structures approved on or after July 1, 1979.

Board Staff has been working with Hocking Hills vacation rental owners since its April 14, 2017 Public Hearing on the OBC effective November 1, 2017. At the public hearing, the Board heard comments from vacation rental owners regarding amendments included in the new OBC for transient lodging structures clarifying that they are R-1 transient structures and regulated by the commercial building code. However, the Board responded to the comments submitted with a commitment to work with Hocking Hills owners to allow vacation rental to comply with the Residential Code of Ohio for construction requirements under certain conditions. The proposed changes were presented to the Hocking Hills short term rental association members at a forum on September 21, 2017. However, after the presentation the Board proposed additional changes to the vacation rental provisions for accessibility. Kevin Claus from Cedar Grove Lodging and the Board's contact with Hocking Hills association members submitted an email comment regarding the addition of the accessibility requirements. The comment was reviewed by the Board's Code Committee and accepted by adding an exception to the accessibility requirements if the owner demonstrates to the building department that the structure would not be a place of public accommodation under

ADA. Mr. Claus also expressed concern regarding an additional provision for hotel licensure requirements. This provision was added at the request of the State Fire Marshal and is only a pointer to hotel licensing requirements. The Board's Code Committee did accept Mr. Claus' request to remove or move the provision and retained the pointer. Finally, Don Philips commented during the January 5, 2018 stakeholder meeting that the descriptive language for vacation rentals (cabins, cottages, bungalows, etc) may make the provisions more difficult to enforce as an owner may think that the list was exhaustive. As a result, the Board's Code Committee removed the descriptive terms.

Email comments from Ken Fogle regarding sprinkler requirements for certain care facilities and changes adopted in the State of Oregon were reviewed by the Board's Code Committee and were not accepted. During the development of the new OBC effective November 1, 2017, Board Staff worked extensively with representatives from the Department of Developmental Disabilities and the care provider industry for the new regulatory structure proposed in the code for residential care facilities for 5 or few occupants. The Mr. Fogle's comment would require sprinkler in these facilities and the Board's Code Committee determined that the owner/care provider should evaluate the capabilities of their residents and make a determination of whether sprinklers should be installed rather than an across the board requirement which would significantly increase cost to operate facilities that there is already limited funding for.

Included in the rule package are changes as a result of approved Petition # 17-01 submitted by Joseph Sandman requesting amendment to rule 4101:1-7-01 damper access door to coordinate with changes also proposed in the Ohio Mechanical Code in separate rule package. A copy of Petition 17-01 is attached Exhibit C. also, included in the rule package are changes as result of approved Petition # 17-05 submitted by the Fire Extinguisher Manufacturers Association requesting amendment to OBC § 906.1 requesting the elimination of an exception for fire extinguishers for certain occupancies, including education occupancies, if equipped with quick response sprinklers. A copy of Petition #17-05 is attached as Exhibit D. The elimination of the exception is consistent with the 2018 IBC, but will result in requiring placement of more extinguishers in the affected occupancies including schools.

9. What scientific data was used to develop the rule or the measurable outcomes of the rule? How does this data support the regulation being proposed?

Continuing law is based on is the 2015 International Building Code (IBC) promulgated and amended by the International Code Council (ICC). The model codes developed by ICC are updated every three years through a process that incorporates petitioning, public hearings and voting by ICC members. The ICC Committees that oversaw the development of the different provisions 2015 IBC included building and fire code officials, architects, engineers, contractors, and representatives from the National Association of Home Builders, Underwriters Laboratories, .and other professional organizations.

When a petition to amend the model code is submitted, the proponent of the change must submit the proposed language of the amendment, the reason for the amendment including scientific data when applicable, and the cost impact of the amendment. All submitted petitions are then published prior to initial code development hearings on the petitions. Interested persons may review the proposed changes and attend the code development hearing and provide comments. A report then is published on the public hearings for review and then final action is taken on the proposed changes at final action hearings. All successful changes are incorporated into the next edition of the model code.

Upon publication the Board's code committee reviews each substantive change included in the newest edition of the code and determines whether to recommend the change to the Board for adoption. The Board last fully updated the Ohio Building Code on November 1, 2017.

10. What alternative regulations (or specific provisions within the regulation) did the Agency consider, and why did it determine that these alternatives were not appropriate? If none, why didn't the Agency consider regulatory alternatives?

See response to Question 9.

11. Did the Agency specifically consider a performance-based regulation? Please explain. *Performance-based regulations define the required outcome, but don't dictate the process the regulated stakeholders must use to achieve compliance.*

Continuing law permits a registered design professional's alternative engineered design to be a compliance alternative method to the prescriptive requirements of the code. Section 106.5 of the OBC permits a registered design professional to submit sufficient technical data to substantiate that performance of the proposed alternative engineered design meets the intent of the code. Additionally, section 107.4.3 provides that when construction documents have been prepared by an Ohio registered design professional conforming to the requirements of the rules of the Board pertaining to design loads, stresses, strength, and stability and other requirements involving technical analysis, the documents need only be examined to the extent necessary to determine conformity with other requirements of the rules of the Board.

12. What measures did the Agency take to ensure that this regulation does not duplicate an existing Ohio regulation?

Editorial changes are routinely made to the rules to provide consistency with the Ohio Revised Code and other Board and agencies' rules. Additionally, RC § 3781.10 gives the Board sole authority to adopt rules which regulate the erection, construction, repair, alteration, and maintenance of all buildings or classes of buildings specified RC 3781.06 including residential and non-residential buildings.

13. Please describe the Agency's plan for implementation of the regulation, including any measures to ensure that the regulation is applied consistently and predictably for the regulated community.

For these rules to be enforced by a local government, its building department must be certified by the Board. The Board also certifies the personnel who work within these departments to ensure only qualified personnel are enforcing the Board's rules. Certified personnel must complete continuing education to maintain their certifications and continue to be authorized to enforce these rules. The Board has authority to suspend or revoke certifications for failure to properly enforce the rules. Also, the Board has a staff member dedicated to responding to complaints by persons affected by the Board rules. This program helps promote consistent and predictable application of the Board rules.

Adverse Impact to Business

14. Provide a summary of the estimated cost of compliance with the rule. Specifically, please do the following:

a. Identify the scope of the impacted business community;

The amendments included in this package primarily incorporate ICC Errata for the 2015 IBC. There may be an increase in material cost to comply with the new requirement for damper door access as a result of approved Petition 17-01. Additionally, there will be an increase cost to affected occupancies, including schools, to comply with changes made as a result of approved Petition 17-05 eliminating the exemption for fire extinguishers if equipped with quick response sprinklers.

b. Identify the nature of the adverse impact (e.g., license fees, fines, employer time for compliance); and

See above.

c. Quantify the expected adverse impact from the regulation.

The adverse impact can be quantified in terms of dollars, hours to comply, or other factors; and may be estimated for the entire regulated population or for a

"representative business." Please include the source for your information/estimated impact.

See Petitions 17-01 and 17-05 attached as Exhibits C and D.

15. Why did the Agency determine that the regulatory intent justifies the adverse impact to the regulated business community?

See Petitions 17-01 and 17-05 attached as Exhibits C and D for justification.

Regulatory Flexibility

16. Does the regulation provide any exemptions or alternative means of compliance for small businesses? Please explain.

The rules do not have special exemptions or alternative means of compliance specifically for small business. The OBC requires a building official to issue an adjudication order to an owner when the design or construction of a building does not comply with the OBC. The adjudication order must comply with Revised Code Chapter 119 and give the owner an opportunity to appeal. This mechanism is often utilized by an owner voluntarily to obtain a variance from the requirements. Variance requests are heard by either the Ohio Board of Building Appeals or a certified local board of building appeals.

Also, the OBC permits alternative engineered designs prepared by a registered design professional to not strictly comply with the prescriptive requirements of the rules. To obtain approvals based on alternative engineered designs, the design professional must submit sufficient technical information to demonstrate that the performance meets the intent of the rules.

17. How will the agency apply Ohio Revised Code section 119.14 (waiver of fines and penalties for paperwork violations and first-time offenders) into implementation of the regulation?

Revised Code § 3781.102 does not authorize the Board to set the fees and/or penalties assessed by local certified building departments in connection with the enforcement of these rules. Compliance with the rules is accomplished through construction conforming to the certificate of plan approval (permit). Therefore, there are no potential paperwork violations of these rules.

18. What resources are available to assist small businesses with compliance of the regulation?

The Board's technical staff spends approximately 25% of their time responding to questions on the building codes and educating design professionals, contractors, the public, and code officials of the intent of the Board's rules assisting all parties in compliance.

Ohio Department of Commerce
Division of Industrial Compliance
John R. Kasich, Governor
Jacqueline T. Williams, Director

Exhibit A

E-NOTIFICATION
AMENDMENTS GROUP 95 - OHIO BUILDING CODE PROPOSED CHANGES

Ohio Administrative Code Rule Number	Paragraph/Section	Reason for Proposed Change
4101:1-1-01	101.2, Exception #19	Clarifies intent of exemption for signs
	101.2, Exception #22	Clarifies intent of exemption for retaining walls, bridges, walkways or site stairs
	101.2, Exception #23	Adds an exception for primitive transient lodging structures that are 400 sq. ft. or less in area.
	102.10	Modifies charging paragraph to clarify intent of "Work exempt from approval"
4101:1-2-01	AMBULATORY CARE FACILITY	ICC Errata modifies the definition
	AUTOMATIC WATER MIST SYSTEM	ICC Errata adds the definition
	COMMON PATH OF EGRESS TRAVEL40	ICC Errata modifies the definition
	FIRE PROTECTION RATING	ICC Errata modifies the definition
	FLOOD HAZARD AREA SUBJECT TO HIGH-VELOCITY WAVE ACTION	ICC Errata deletes the definition
	GRADE FLOOR OPENING	ICC Errata deletes the definition
	HURRICANE-PRONE REGIONS	ICC Errata modifies the definition
	INCAPABLE OF SELF-PRESERVATION	Modifies/clarifies intent of definition
	LOWEST FLOOR	ICC Errata modifies the definition
	PORCELAIN TILE	ICC Errata modifies the definition
	PRIMITIVE TRANSIENT LODGING STRUCTURE	Adds a definition
	SEMI-PRIMITIVE TRANSIENT LODGING STRUCTURE	Adds a definition
	SMOKEPROOF	ICC Errata modifies the definition

	ENCLOSURE	
	SPECIAL INSPECTION	ICC Errata modifies definition of Continuous special inspection
	STEEL MEMBER, STRUCTURAL	ICC Errata deletes the definition
	TRANSIENT LODGING STRUCTURE	Adds definitions
	VEHICLE BARRIER	ICC Errata modifies the definition
	WILDLAND URBAN INTERFACE AREA	ICC Errata deletes the definition
	WIND-BORNE DEBRIS REGION	ICC Errata modifies the definition
4101:1-3-01	Table 307.1(2)	ICC Errata corrects the application of footnotes “e” and “f”
	307.7	ICC Errata corrects a code reference
	310.3	Clarifies that certain Boarding Houses and Congregate Living facilities with transient occupants would not be classified as Group R-1
	310.3.2	Adds requirements for transient lodging structures
		Adds pointer to SFM licensing requirements
	310.3.2.1	Adds requirements for semi-primitive transient lodging structures that are 400 sq. ft. or smaller
	310.3.2.2	Adds requirements for primitive or semi-primitive transient lodging structures that are greater than 400 sq. ft. in area
	310.3.3	Clarifies the classification of Boarding Houses and Congregate Living facilities with 10 or fewer occupants
	310.4	Clarifies the classification of Boarding Houses and Congregate Living facilities
	310.4.4	Clarifies the classification of Boarding Houses and Congregate Living facilities with 16 or fewer occupants
	310.5	Clarifies the classification of Boarding Houses and Congregate Living facilities
	310.5.4	Clarifies that an owner-occupied lodging house with 5 or fewer guest rooms is Group R-3
	310.5.5	Clarifies that some Group R-3 occupancies may use the RCO
	310.5.6	Clarifies the classification of Boarding Houses and Congregate Living facilities with more than 16 occupants

4101:1-7-01	703.3, Item #5	Corrects code reference
	Table 705., footnote j	ICC Errata to add superscript j to five rows and to modify the text of footnote j
	706.2	Brings back the reference to NFPA 221 which recognizes cantilevered fire walls and tied fire walls.
	716.6.7.1	ICC Errata to correct code references
	717.4	Petition 17-01 prescribes damper access door requirements
	717.5.3 exception #2	Deletes ICC Exception #2 as a result of broader new Ohio Exception #6 for smoke dampers
	722.1	ICC Errata corrects reference to ANSI/AWC NDS
	722.5.1.2	ICC Errata to move 0.75 from inside the bracket to outside the bracket
4101:1-9-01	901.2.1.1	Suggestions for fire/building official coordination
	901.2.1.2	Suggestions for fire/building official coordination
	901.3	Suggestions for fire/building official coordination
	901.4	Suggestions for fire/building official coordination
	901.5	Suggestions for fire/building official coordination
	903.1.1	Suggestions for fire/building official coordination
	903.3.1.1.1	Suggestions for fire/building official coordination
	903.2.11.1	ICC Errata corrects code references
	903.3.6	Suggestions for fire/building official coordination
	903.4.1	Suggestions for fire/building official coordination
	904.2	Suggestions for fire/building official coordination
	904.14	Suggestion to adopt 2018 text recognizing aerosol fire-extinguishing systems
	905.4	Suggestions for fire/building official coordination
	905.5.3	Suggestions for fire/building official coordination
	906.1	Petition 17-05 removes fire extinguisher exception 1.1 for Groups A, B and E and adds another option for Group E (exception 1.2 from 2018 IBC)
	906.1	Suggestions for fire/building official coordination
	906.5	Suggestions for fire/building official

		coordination
	907.1.1	Suggestions for fire/building official coordination
	907.2	Suggestions for fire/building official coordination
	907.2.6	Suggestions for fire/building official coordination
	907.2.13.2	Suggestions for fire/building official coordination
	907.5.1	Suggestions for fire/building official coordination
	907.6.6.1	Suggestions for fire/building official coordination
	907.7	Suggestions for fire/building official coordination
	909.5	ICC Errata deleted sentence
	909.15	Suggestions for fire/building official coordination
	909.18.8.3.1	Suggestions for fire/building official coordination
	911.1.1	Suggestions for fire/building official coordination
	912.2.1	Suggestions for fire/building official coordination
	912.2.2	Suggestions for fire/building official coordination
	912.3	Suggestions for fire/building official coordination
	912.4	Suggestions for fire/building official coordination
	912.4.1	Suggestions for fire/building official coordination
	912.4.2	Suggestions for fire/building official coordination
4101:1-10-01	1006.3	ICC Errata deletes second paragraph and exceptions
	1006.3.1	ICC Errata adds the word “independent”
	1006.3.2	ICC Errata modifies condition #1 to change “exit access” to “common path of egress”
	1006.3.2.2	ICC Errata deletes the section
	1010.1.4.1 #5	ICC Errata modifies/clarifies type of revolving doors requiring emergency stop switch
	Table 1010.1.4(2)	ICC Errata corrects Table number
	1010.1.4.3 #3	ICC Errata modifies text to limit opening force to 15 pounds to max width.
	1011.14.1	ICC Errata corrects code reference
	1015.1	ICC Errata corrects code references
	Table 1020.2	ICC Errata modifies text to reflect

		description of care facility
	1025	Brings back the “Luminous Egress Path Markings” section, including the subsections, but clarifies that the markings are not mandatory
	1029.9.1 #2 Exception	ICC Errata modifies text to clarify type of handrail
	1029.9.7	ICC Errata corrects code reference
	1029.9.8	ICC Errata corrects code reference
	1029.10.1	ICC Errata corrects code reference
	1029.10.2	ICC Errata adds the word “through” between code references
	1029.13.1.3	ICC Errata corrects code references
	1029.14, Exception #2	ICC Errata clarifies that exception applies to seating at tables
4101:1-16-01	1612.5(1.2)	ICC Errata corrects ASCE 24 code references
	1604.6	ICC Errata corrects code reference
	1604.7	ICC Errata corrects code reference
	1607.10.1, Eq. 16-23	Corrects typo in Equation 16-23
	1609.1.1 #2	Brings back reference to AWC WFCM
	1609.1.1 #3	Brings back reference to AISI S230
	1609.1.1.1	Brings back references to AWC WFCM & AISI S230
	1609.1.2.1	ICC Errata corrects referenced standard
	1612.2	ICC Errata deletes reference to “Existing construction” definition
4101:1-22-01	2207.5	Deletes requirement for certificate of compliance
	2211.7	Brings back reference to AISI S230 for townhouses
4101:1-23-01	2301.2 #4	Brings back reference to AWC WFCM
	Table 2304.8(1) footnote b	ICC Errata corrects code reference
	Table 2306.2(1) notes a and f	ICC Errata corrects references to ANSI/ AWC NDS
	Table 2306.2(2) notes a and h	ICC Errata corrects references to ANSI/ AWC NDS
	Table 2306.3(1) notes a and i	ICC Errata corrects references to ANSI/ AWC NDS
	Table 2306.3(1) note g	ICC Errata corrects references to AWC SDPWS
	Table 2306.3(2) note b	ICC Errata corrects references to ANSI/ AWC NDS

	Table 2306.3(3) note a	ICC Errata corrects references to AWC SDPWS
	2308.2.6	ICC Errata corrects seismic design category reference
4101:1-25-01	Table 2506.2	ICC Errata adds 2 rows to the gypsum table
	Table 2507.2	ICC Errata adds 3 rows to the lath and plaster table
	2508.3.1	ICC Errata adds a section for “Floating angles”
4101:1-26-01	2603.9	ICC Errata corrects code reference
4101:1-34-01	3401.3- 3401.5	Renumbers sections 3401.4 - 3401.6 to 3401.3 - 3401.5 and corrects the internal references to those sections due to incorrect section numbering in the original rule (missing Section 3401.3)
	3401.6	Adds a new section which references ACI 562 for the design of concrete repairs and rehabilitation
	3403.1.2	Corrects code references
	3403.2	Corrects references to definitions now found in Chapter 2
	3403.4	Corrects code references
	3404.2	Corrects references to definitions now found in Chapter 2
	3404.4	Corrects code references
	3404.6.2	Editorial fix
	3405.2.1	Corrects code references
	3406.1	Corrects code reference
	3411.1 Exception	Deletes exception
	3411.4.2	Corrects code reference
	3411.7.1	Editorial fixes
	3411.8.5	Corrects code reference
	3412.1	Corrects code reference
	3412.2	Clarifies that newer existing buildings undergoing a proposed change of occupancy can be evaluated using the methodology found in Section 3412
	3412.2.3.2	Corrects code references
	3412.6	Brings in 2015 IEBC text for I-2 smoke compartments
	3412.6.1	Brings in 2015 IEBC text for number of stories
	3412.6.1.1, Eq. 34-2	Editorial fix
	3412.6.2.1	Editorial fix
	3412.6.3.1	Corrects code reference
	3412.6.3.2	Corrects code reference
	3412.6.4	Editorial fix
	3412.6.4.1	Editorial fix and corrects code references

	3412.6.5	Corrects code reference
	3412.6.5.1	Brings in 2015 IEBC text for Group I-2
	3412.6.6	Editorial fix and brings in 2015 IEBC text
	3412.6.6.1	Editorial fix and bring in 2018 IEBC text
	3412.6.7.1	Editorial fix and corrects code references
	3412.6.8	Brings in 2015 IEBC text for Group I-2
	Table 3412.6.8	Adds Group I-2 and category f from 2015 IEBC
	3412.6.8.1	Adds Category f from 2015 IEBC
	Table 3412.6.9	Brings in 2015 IEBC text for Group I-2
	3412.6.9.1	Corrects code references
	Table 3412.6.10	Brings in 2015 IEBC text for Group I-2
	3412.6.10.1	Corrects code reference
	3412.6.11	Corrects code references
	Table 3412.6.11	Editorial fix and brings in 2015 IEBC text for Group I-2
	3412.6.11.1	Corrects code references
	Table 3412.6.12	Editorial fixes and brings in 2015 IEBC text for Group I-2 and Category d
	3412.6.12.1	Corrects code reference and brings in 2015 IEBC text for Category d
	3412.6.13	Corrects code reference
	3412.6.14	Editorial fixes
	3412.6.14.1	Editorial fixes
	Table 3412.6.15	Editorial fixes
	3412.6.15.1	Editorial fixes
	3412.6.16	Corrects a code reference and brings in 2015 IEBC text for Group I-2
	Table 3412.6.16	Brings in 2015 IEBC text for Group I-2
	3412.6.16.1	Corrects code reference
	3412.6.17	Corrects code references and brings in 2015 IEBC text for high-rise and Group I-2
	Table 3412.6.17	Brings in 2015 IEBC text for Group I-2
	3412.6.18	Editorial fixes
	Table 3412.6.18	Brings in 2015 IEBC text for Group I-2
	3412.6.19	Corrects code references and editorial fixes
	Table 3412.6.19	Brings in 2015 IEBC text
	3412.6.20	Brings in 2015 IEBC text for Group I-2
	Table 3412.6.20	Brings in 2015 IEBC text for Group I-2
	3412.6.20.1	Brings in 2015 IEBC text for Group I-2
	3412.6.21	Brings in 2015 IEBC text for Group I-2
	3412.6.21.1	Brings in 2015 IEBC text for Group I-2
	Table 3412.6.21.1	Brings in 2015 IEBC text for Group I-2
	3412.6.21.1.1	Brings in 2015 IEBC text for Group I-2
	3412.6.21.2	Brings in 2015 IEBC text for Group I-2
	Table 3412.6.21.2	Brings in 2015 IEBC text for Group I-2
	3412.6.21.2.1	Brings in 2018 IEBC text for Group I-2
	3412.6.21.3	Brings in 2015 IEBC text for Group I-2
	Table 3412.6.21.3	Brings in 2015 IEBC text for Group I-2

	3412.6.21.3.1	Brings in 2015 IEBC text for Group I-2
	Table 3412.7	Brings in 2015 IEBC text for Group I-2
	3412.8	Editorial fixes
	Table 3412.8	Brings in 2015 IEBC text for Group I-2
4101:1-35-01	ACI	Adds standard 562
	AWC	Fixes reference to NDS Supplement
	NFPA	Updates/coordinates standards 37, 58, 85 with the OMC editions and adds standard 2010
	TMS	Adds standard

Exhibit B

January 5, 2018 Stakeholder Meeting
OBC, OPC & OMC Proposed Rules

Attendees:

Derek Spurling, MVBOC
Rick Helsinger, OBOA
Mike Spry, City of Cincinnati
Jene Gaver, City of Springfield
James Smith, American Wood Council
Michael Boso, City of Grove City
Jason Baughman, Mid East Ohio Building Department
Scott Young, MVBOC
Don Phillips, City of Worthington

Staff Present:

Regina Hanshaw
Steve Regoli
Debbie Ohler
Jay Richards
Rob Johnson

Board Staff presented overview of proposed changes to the OBC, OMC & OPC (attached).

Comments Submitted:

Ohio Building Code Rules
Mr. Spry asked about whether the term structure is specified in the law regarding the list of exemption in Section 101.2 (#19). Staff responded that the definition of building in RC 3781.06 is very broad and includes any structure. Staff provided some historical evidence from older Ohio building codes that previous boards had narrowed the definition in rule. Mr. Boso asked about cell towers since they are not occupied structures. Staff responded that while cell towers were considered to be added to the list of exemptions but at this point Staff did not recommend they be added to the list of exemptions. Mr. Gaver stated that when his jurisdiction heard about the new exemption for signs, it plans to adopt a local ordinance. He stated that he is not concerned about monument signs, but pole signs should be regulated. Mr. Baughman stated that he is concerned with the exemption for signs and retaining walls and asked how that can be addressed. Staff responded that the comments from today's meeting and other written comments submitted by OBOA will be reviewed and considered by the Board's Code Committee. Staff encouraged stakeholders to submit comments on which signs should be within the scope and which should not. Mr. Phillips stated that in his jurisdiction he tried by apply common sense and that consistent with fences, he required approvals for signs over 6 feet.

Mr. Phillips asked that the descriptive language in Section 310.3.2 for cabins, cottages, bungalows, and chalets be removed as it gives owners an impression that only those structures are regulated by the provision.

Ohio Mechanical Code Rules
No comments submitted.

Ohio Plumbing Code Rules
No comments submitted.

Hanshaw, Regina

From: Greg Lauterbach <greg@gllarchitect.com>
Sent: Monday, December 11, 2017 3:43 PM
To: Ohler, Debbie
Cc: 'Schoener, Steve'
Subject: OBC 2017

Follow Up Flag: Follow up
Flag Status: Flagged

Dear Ms. Ohler,

I received your email address from the City of Dayton's plan reviewer.

I have found what I believe to be mistakes in OBC 2017.

3412.6.4.1 Categories – references Sections 709 and 712 ... I think it should reference Section 708 and 711

3412.6.11.1 Categories – references Section 1021 ... not sure what this should reference, maybe Section 1006

Table 3412.6.15 has a Category "c" column, yet there is no Category "c."

3412.6.19 Incidental accessory occupancy references Section and Table 508.2.5 ... I think it should reference 509.

Table 3412.7; the bottom of the table references 1401.6.20 smoke compartmentation, 1401.6.21.1 patient ability for self-preservation, 1401.6.21.2 patient concentration, and 1401.6.21.3 attendant to patient ratio. Not sure what these (4) rows are referencing?

If you are not the person who should be made aware of these potential mistakes, providing me the correct contact person would be appreciated.

Thanks.

Greg Lauterbach

greg l. lauterbach, architect, llc
200 Brown Street
Dayton, Ohio 45402
937.222.0719/phone
937.313.7151/ cell

Hanshaw, Regina

From: Ned B. Heminger <nbheminger@hawainc.com>
Sent: Thursday, December 28, 2017 3:17 PM
To: Ohler, Debbie
Subject: RE: OBC, OPC and OMC

Follow Up Flag: Follow up
Flag Status: Flagged

Thank you Debbie.

Yesterday I was in Chapter 34 (which I believe is all Ohio language). Section 3412.6.7.1, items 2 and 4 referenced 1018.5 and I think is supposed to be 1020.5

Then in 3412.6.3.1 it refers to Section 1025 which I think should be 1026

Section 3412.6.5 refers to 1018, but believe this should be 1020.

This is just some I noticed. May be worth looking thru this chapter.

Ned

From: debbie.ohler@com.state.oh.us [mailto:debbie.ohler@com.state.oh.us]
Sent: Wednesday, December 27, 2017 4:36 PM
To: Ned B. Heminger <nbheminger@hawainc.com>
Subject: RE: OBC, OPC and OMC

Good afternoon, Ned.
We do not have an errata sheet published. However, we are aware of some ICC publishing errors (see attached) and, in addition, we do have a list of rule corrections that we are planning to make. There is a stakeholder meeting scheduled for January 5th to describe these changes: http://www.com.ohio.gov/dico/bbs/ProposedRules.aspx

Debbie

Deborah D. Ohler, P.E., Staff Engineer
Ohio Board of Building Standards
PO Box 4009, 6606 Tussing Rd
Reynoldsburg, OH 43068-9009
Office Phone: 614-644-2613 Fax:614-222-2147
dohler@com.state.oh.us
http://www.com.ohio.gov/dico/BBS/

From: Ned B. Heminger [mailto:nbheminger@hawainc.com]
Sent: Wednesday, December 27, 2017 4:21 PM
To: Ohler, Debbie <debbie.ohler@com.state.oh.us>
Subject: OBC, OPC and OMC

Debbie

As I'm using the building code, I've notice incorrect paragraph references. Is there an errata sheet that has been developed?

Ned B. Heminger, PE, LEED AP, HBDP
Vice President

HAWA INCORPORATED
HAWA Incorporated
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Columbus, Ohio 43220

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****
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****

Hanshaw, Regina

From: Kevin Claus <kevin@cedargrovelodging.com>
Sent: Thursday, January 04, 2018 9:55 AM
To: Hanshaw, Regina
Cc: kevweaver80@gmail.com; braeloch2@gmail.com; doug@ikarensell.com; whannahchd@gmail.com; v.freda1@yahoo.com; larlar43149@hotmail.com; Ladaklug@sbcglobal.net; David Youse
Subject: Re: FW: Board of Building Standards Proposed Rules Changes/Stakeholder Meeting Notification

The ADA line item was not included in the PPT that was presented. Vacation rentals are generally exempt from these requirements since they are considered private property unless your structure includes common areas that are open to the general public (such as a rental office, public restrooms, public parking lots, etc...). This section of code is referring to a single free-standing structure that is rented as a single unit (like inside your private hotel room with no public areas). We have not been subject to these federal requirements in the past and I've owned in other states where they haven't as well. These units must still comply with the ADA requirements for service animals but not accessibility.

I also see that Hotel Licensure language was added to this section since our presentation. Licensure applies to structures that have more than 5 guest rooms. Current enforcement has interpreted this to mean rentable units. Since this section of code is only referring to standalone single rentable units licensure would not apply. Adding such language to this section just makes things all the more confusing.

Including references to other requirements that don't apply is one of the reasons why a summary document of intentions would really be helpful.

Thank you,
Kevin Claus, Owner

www.CedarGroveLodging.com
740-380-2209

On Thu, Jan 4, 2018 at 8:45 AM, Regina.Hanshaw@com.state.oh.us <Regina.Hanshaw@com.state.oh.us> wrote:

> I thought the accessibility issue was discussed by Steve and Jay at the meeting in September. Federal accessibility for transient occupancies are not something we can exempt from these structures. I understand the document is large, which is why I referenced the particular pages the vacation rental/transient lodging appears. Hopefully some of you can attend tomorrow, if not please let me know if you have any comments. And if you or others from the group want to better understand the accessibility requirements, you can call and talk with Steve or Jay. Our number is 614-644-2613.

Hanshaw, Regina

From: Ken Fogle <ken.fsa@sbcglobal.net>
Sent: Monday, January 08, 2018 10:04 AM
To: Ohler, Debbie; Regoli, Steve
Subject: Appendix SR_Special Residence (Assisted Self-Preservation) Occupancies.pdf
Attachments: Appendix SR_Special Residence (Assisted Self-Preservation) Occupancies.pdf; House 3 Fire Ext.JPG; House 3 Fire Int.JPG

Follow Up Flag: Follow up
Flag Status: Flagged

Debbie, Steve;

One of our clients had a fire in their R-4, 6 person home over the holiday started by staff smoking on the back deck (not a permitted activity). They were able to get all 6 residents out even though one required assistance to transfer to a wheelchair.
The building maintenance director commented on the sprinkler system as having saved this from being much worse as the fire almost found the attic but was suppressed enough for the fire department to get control before that happened.

I am still very uncomfortable with the ICC commentary language for "self-preservation". Allowing "Self-preservation" to be anything short of wheeling someone out in a gurney does not reflect the reality of transfer time to a wheel chair. If we have 4 or 5 people requiring assistance to transfer to a wheel chair (a single portable hoyer lift in the home?) without a sprinkler system, we are going to lose somebody. A single awake staff person cannot achieve the transfer in a reasonable time if a lift is required to move a large person or persons from bed to chair. I attached Oregon's designation of Assisted Self-preservation as a middle ground. If physical transfer of more than one person is required I think we should still require 13D sprinkler systems. Please consider this in your Ohio approach to the definition of self-preservation.

Ken
Fogle/Stenzel Architects, Inc.
216-861-5151

Hanshaw, Regina

From: Ohler, Debbie
Sent: Tuesday, January 09, 2018 10:33 AM
To: Burg, Gerald; Eaton, Geoffrey; Jiang, Yeong-Tarng
Subject: RE: Use of Section 3412 OBC

FYI... I just discussed this issue with Steve. He is of the opinion, that it wasn't the intent to allow the 3412 risk analysis, when used as referenced in Section 3408, to be performed only on buildings older than 1979. We will discuss clarifying language next week with the BBS Code Committee.

Deborah D. Ohler, P.E., Staff Engineer
Ohio Board of Building Standards
PO Box 4009, 6606 Tussing Rd
Reynoldsburg, OH 43068-9009
Office Phone: 614-644-2613 Fax:614-222-2147
dohler@com.state.oh.us
http://www.com.ohio.gov/dico/BBS/

From: Burg, Gerald
Sent: Tuesday, January 09, 2018 10:29 AM
To: Eaton, Geoffrey <geoff.eaton@com.state.oh.us>; Jiang, Yeong-Tarng <Yeong-Tarng.Jiang@com.state.oh.us>
Cc: Ohler, Debbie <debbie.ohler@com.state.oh.us>
Subject: Use of Section 3412 OBC

After discussion today with Deb Ohler, the current state of affairs seems to be that Section 3412 ONLY applies to buildings built before 7/1/1979, per 3412.2 OBC, even if an analysis of an existing building is desired per 3408.1 OBC.

Other types of analysis may be submitted per 3408.1 OBC, but it is up to the Building Official to decide if those other types of analysis adequately evaluate life safety, fire safety, and (in the case of storm shelters in schools) structural safety in comparing a previous Use to a proposed Use.

Hanshaw, Regina

From: Meyer, Timothy <tmeyer@city.cleveland.oh.us>
Sent: Wednesday, February 28, 2018 3:10 PM
To: Ohler, Debbie
Subject: another OBC correction, not in Ch. 34

Ms. Ohler,

Since we were discussing OBC errors/corrections a few weeks back, here's another one I just spotted:

703.3, item 5. Alternative protection methods as allowed by Section104.11.

Section 104.11 appears to be an IBC Chapter 1 reference, and there is no such section in Ohio's Chapter 1. The 2011 code changed this to "...Section*s 106.5 or 114.3*," which would still seem to work with Ohio Chapter 1.

(Sorry, I have not yet had a break in the work flow to allow me to look through the proposed revisions to Chapter 34.)

Timothy A. Meyer
Chief Architect / Master Plans Examiner
The City of Cleveland
601 Lakeside Avenue, Room 505
Cleveland, Ohio 44114
(216) 664-3759 tmeyer@city.cleveland.oh.us

Hanshaw, Regina

From: Wyckoff, Maury <WyckoffM@mcohio.org>
Sent: Wednesday, December 13, 2017 10:29 AM
To: Spry, Michael; Amit Ghosh (abghosh@columbus.gov); Carl Lamping (Clamping@clermontcountyohio.gov); Crase, Bruce; Dahlberg, Art; Dave Golis (Dave.golis@toledo.oh.gov); Jeffery Uroseva (Juroseva@mahoningcountyoh.gov); Keith Wagenknecht (kepwags@yahoo.com); Ken Arthur (Karthur@richlandcountyoh.us); mrudey@co.wood.oh.us; Hanshaw, Regina; Schriewer, Richard; Scott Adams (Scott.adams@daytonohio.gov); Thomas (TVanover@city.cleveland.oh.us)
Cc: Boso, Mike; Charles Huber; croblee@iccsafe.org; cwilson@wcgov.org; Dan Sammon; Eifert, Bob; Gerry Wasserman (gwasserman@ci.oregon.oh.us); Gregory Fort (gregoryfort@mayfieldheights.org); Jeff Rettberg (Jrettberg@massillonohio.com) (Jrettberg@massillonohio.com); 'jgaver@springfieldohio.gov' (jgaver@springfieldohio.gov); Jim Stocksdale (jestocksdale@columbus.gov); John Cheatham; Johnson, Robert; Joseph A. Meyers (joseph.meyers@lakewoodoh.net); Lackey, Eugene; mike mihalisin (mmihalisin@co.geauga.oh.us); NMontan@ecohba.com; Paul Myers (bdp@cityofstbernard.org); Phil Seyboldt (pseyboldt@sbcglobal.net); Phillips, Don; rick1@one.net; rsack@cityofwickliffe.com; Snodgrass, Renee; Regoli, Steve; Stephen Risser (srisser@ci.mansfield.oh.us); Terry Welker; Moeller, Walter (St. Bernard)
Subject: RE: Proposed elimination of free standing sign permitting requirements

During our last teleconference we discussed proposed OBC code changes that would clarify the new exemption of ground signs to exempt all freestanding signs from the requirements of the building code. This would include ground signs, pole signs, billboards, etc. If we felt that was giving away more than we should with regards to inspecting such construction for compliance with applicable codes, we were challenged by Regina Hanshaw to propose where we would "draw a line in the sand" (my words, not hers) and testify at the BBS's January stakeholders' meeting.

I asked around in my department and came up with two different responses:

1) My inspection supervisor said, fine, let's not waste time inspecting any of them for structural adequacy, but we should still inspect any electrical work associated with them, such as trenches, grounding, listing of sign cabinets, provisions for disconnecting means, etc.
2) I have expressed that we should exempt signs under one story high, which could be either 12 or 16 feet. I agree that we should still inspect any electrical work associated with them, whether internal or external illumination.

It was also suggested that we should converse with sign companies, which I haven't done yet, but if any of you do, it would be interesting to hear their thoughts. Since companies doing high rise signs often have special inspection agencies evaluating deep drilled footings and welded and bolted connections up in the stratosphere, it would also be interesting to know if their services would still be sought if building departments didn't require them.

Lastly, Steve Regoli suggested that if the state exempted these signs, local jurisdictions could adopt enforcement provisions at the local level. I think that would be a big mistake. We have worked successfully to create common standards statewide and nationally, so dividing up the requirements would be a big step backwards, in my opinion.

So let's put our heads together now and come up with a consensus of what should or shouldn't be enforced, and offer that unified testimony to the Board at their January stakeholders' meeting. What say you? Chime in at the next teleconference on December 20, 2:00 PM.

Maury Wyckoff
Chief Building Official

Montgomery County Building Regulations
937-225-4586

From: Spry, Michael [mailto:Michael.Spry@cincinnati-oh.gov]
Sent: Wednesday, December 06, 2017 9:54 AM
To: Amit Ghosh (abghosh@columbus.gov) <abghosh@columbus.gov>; Carl Lamping (Clamping@clermontcountyohio.gov) <Clamping@clermontcountyohio.gov>; Crase, Bruce <bruce.crase@hamilton-co.org>; Dahlberg, Art <art.dahlberg@cincinnati-oh.gov>; Dave Golis (Dave.golis@toledo.oh.gov) <Dave.golis@toledo.oh.gov>; Jeffery Uroseva (Juroseva@mahoningcountyoh.gov) <Juroseva@mahoningcountyoh.gov>; Keith Wagenknecht (kepwags@yahoo.com) <kepwags@yahoo.com>; Ken Arthur (Karthur@richlandcountyoh.us) <Karthur@richlandcountyoh.us>; mrudey@co.wood.oh.us; Regina.Hanshaw@com.state.oh.us; Schriewer, Richard <Richard.Schriewer@cincinnati-oh.gov>; Scott Adams (Scott.adams@daytonohio.gov) <Scott.adams@daytonohio.gov>; Thomas (TVanover@city.cleveland.oh.us) <TVanover@city.cleveland.oh.us>; Wyckoff, Maury <WyckoffM@mcohio.org>
Cc: Boso, Mike <mboso@grovecityohio.gov>; Charles Huber <chuber@medinaco.org>; croblee@iccsafe.org; cwilson@wcgov.org; Dan Sammon <dan@mvboc.org>; Eifert, Bob <Bob.Eifert@hamilton-co.org>; Gerry Wasserman (gwasserman@ci.oregon.oh.us) <gwasserman@ci.oregon.oh.us>; Gregory Fort (gregoryfort@mayfieldheights.org) <gregoryfort@mayfieldheights.org>; Jeff Rettberg (Jrettberg@massillonohio.com) (Jrettberg@massillonohio.com) <Jrettberg@massillonohio.com>; 'jgaver@springfieldohio.gov' (jgaver@springfieldohio.gov) <jgaver@springfieldohio.gov>; Jim Stocksdale (jestocksdale@columbus.gov) <jestocksdale@columbus.gov>; John Cheatham <jcheatham@safebuilt.com>; Johnson, Robert <Robert.Johnson@com.state.oh.us>; Joseph A. Meyers (joseph.meyers@lakewoodoh.net) <joseph.meyers@lakewoodoh.net>; Lackey, Eugene <Eugene.Lackey@cincinnati-oh.gov>; mike mihalisin (mmihalisin@co.geauga.oh.us) <mmihalisin@co.geauga.oh.us>; NMontan@ecohba.com; Paul Myers (bdp@cityofstbernard.org) <bdp@cityofstbernard.org>; Phil Seyboldt (pseyboldt@sbcglobal.net) <pseyboldt@sbcglobal.net>; Phillips, Don <DPhillips@ci.worthington.oh.us>; rick1@one.net; rsack@cityofwickliffe.com; Snodgrass, Renee <Renee.Snodgrass@daytonohio.gov>; spregoli@com.state.oh.us; Spry, Michael <Michael.Spry@cincinnati-oh.gov>; Stephen Risser (srisser@ci.mansfield.oh.us) <srisser@ci.mansfield.oh.us>; Terry Welker <Terry.Welker@ketteringoh.org>; Moeller, Walter (St. Bernard) <wmoeller@cityofstbernard.org>
Subject: Todays Agenda Tele-Conference

Please find attached the agenda for todays meeting……….

Thanks,

Michael Spry
Assistant Supervisor of Inspections
805 Central Avenue Suite 500
Cincinnati, Ohio 45202
(513) 352-1551

Montgomery County Building Regulations
Maurice D. Wyckoff
3/12/2018

Comments on proposed change in OBC Section 101.2 Exception 19, exempting ground signs

Here are comments received from various building departments around the state:

HAMILTON COUNTY

Maury
We are looking at these as exempt ground supported signs 6' h or less only, akin to a fence or dumpster enclosure (meaning literally the ground footing supports the sign continuous). Yes, electric service from the building should be approved & inspected.

Pole signs are not ground signs and require engineering to withstand the lateral wind loads, they are potentially more hazardous and can cause more collateral damage in the event of a failure.

Thank you for your voice on these matters.

Sincerely,

Bruce Crase, Architect
Chief Building Official, Senior Plans Examiner
Hamilton County Planning & Development
Building Inspections Division
138 E. Court Street, Suite 801
Cincinnati, Ohio 45202
513-946-4516

SOUTHEAST OHIO

Maury,

I personally have no feeling either way. I feel that both reason are acceptable and will do the inspection according to what the BBS decides.
Does a billboard sign have inherent dangers of collapse and electrical shock, yes; however we are in the business of protecting building with occupants not falling debris.

Just my thoughts.

Southeast Ohio
Building Department
Christopher T Wilson
Chief Building Official
RBO,ESI,BI,MHI
205 Putnam Street
Marietta, Ohio 45750
740.374.4185

CLEVELAND

I apologize that I haven't been as active on the calls as I'd like to be.

I want to begin by clarifying that we are talking about OBC plan approval requirements not Permitting. Because of Zoning and Planning requirements all signs, at least in CLE, will continue to be permitted.

Also, I have already began discussions with my plans examiners on what our local ordinance will look like. From a City with thousands of Billboards, pole signs and substantial free standing digital signs I believe it is irresponsible to not regulate these possibly dangerous structures.

This exemption along with several others in this code cycle seems to steer away from the mission that we were trained to believe in that the Code's purpose is to create uniformity across the State. Being that Cleveland wrote our local building code in 1896 we already have many ordinances that will take over for situations like this.

That being said I don't quite understand why there was a need to remove ground signs from review for structural components. We review 73" tall fences and 49" retaining walls. Furthermore, I don't understand why ground signs aren't clearly defined.

As I read it currently the exception only covers ground signs. Our approach is that if the sign is supported directly on grade it is a ground sign. If the sign is mounted to a pole, concrete, block, brick or steel we would consider them structures of an accessory character and review them a U structures.

Finally, as with other new exclusions in the code we will continue to review and regulate all electrical installations that are not governed by PUCO. It is my opinion that allowing these installations without approval is the definition of irresponsible.

Thank you for allowing this input.

Regards

Thomas Vanover
Chief Building Official
Department of Building and Housing
City of Cleveland
216-420-8416

MANSFIELD

Hi Maury,

It is the position of the City of Mansfield Building Department and also that of the Richland County Building Department that signs and associated electrical systems should ***NOT*** be exempted from regulation under the OBC. I'm a little frustrated that the proposed rules changed the language in 101.2 but did nothing to address sign requirements in 3107. I'm not sure of the petition language or research performed but it's frustrating from an enforcement standpoint when a certain section of the code is changed and other referenced sections are not updated. This is not only confusing to enforcement staff but also Owners, Contractors, and Design Professionals.

With regard to the importance of signs, sign assemblies, sign structures, and associated electrical systems.....

The electrical systems should be inspected. Often times, signs are adjacent to parking lots, sidewalks, buildings, walkways, drive-thru's, etc. and are installed in wet locations. The signs are in close proximity to where people congregate or traverse....it is essential that the electrical systems and services are inspected .

Structurally....our biggest influence is the wind load. Signs of meaningful height (I don't know that I can necessarily define meaningful here) need to resist a wind load. This often requires embedment in a foundation that extends below the frost line to development an embedment length to resist an overturning moment due to the wind pressure. Frost protection can be a factor but typically signs/ sign foundations are embedded below the frost line more so to resist an over-turning moment due to applied wind pressure. We would be concerned that sign structures that are not inspected have a greater potential to become wind borne and pose a high risk for damage and serious injury.

Billboards and Pylon Type Signs We have many traffic routes (state routes, interstates, typically classified as a utility structure which results in the lowest factors of safety being applied when proper structural design principles and standards are used. It is critical that these structures are inspected as many of our roadway engineers rely on our enforcement to ensure that these structures are safe. An argument could be made that the highway or traffic jurisdiction regulates overhead sign structures. That's because ODOT already has standards in their L&D Manual Volume that are used in the design of those sign structures. There are no other standards for billboards and pylon structures; thus the OBC is an important tool in ensuring safe sign structures.

A quick check of surrounding states.......

- Pennsylvania UCC Section 403.62. Signs and electric are inspected.
- Michigan...2015 IBC. MI does have an amendment (R 408.30497) that allows local ordinance to supersede with regard to placement of signs but structural and electrical are still enforced under the IBC.
- Indiana (still under 2012 IBC). 675 IAC 12-6-4 Sec 4. (a) (1) (H). They exempt signs that are not occupied or used by the public. Thus most signs and electric are inspected.

In summary, signs, sign assemblies, sign structures ***should not*** be considered as incidental work or assemblies that are exempt from approval and ***should*** be left within the scope of the OBC. The OBC (and the RCO) was created to be a uniform standard enforced by all jurisdictions. Removing sign requirements would create an inequality in standards among jurisdictions.

On behalf of the City and the County,

Stephen M. Risser, PE
Chief Deputy City Engineer
City of Mansfield
Bureau of Buildings, Inspections, Licenses and Permits
30 N. Diamond Street
Mansfield, Ohio 44902

Phone (419) 755-9688
Fax: (419) 755-9453
srisser@ci.mansfield.oh.us

DAYTON

Maury,

I agree that small ground signs are not a big issue but the larger billboard type should still fall under some sort of regulation. I also feel that any electrical installations for the signs need to be inspected as well. BBS has good intentions but they have missed the boat on thinking this through. I think your thoughts expressed in your email are an accurate start for further dialogue with the BBS.

Thank you,

Scott Adams
Chief Building Official
Department I City of Dayton
371 West Second Street I Dayton, Ohio 45402
Office 937.333.3911

Hanshaw, Regina

From: Stephen Moore <SMoore@groveport.org>
Sent: Monday, February 05, 2018 5:31 PM
To: Hanshaw, Regina
Subject: OBC section 101.2 (exceptions)

Regina,

I have been made aware that some Building Officials are not in favor of the exception #19 - Ground signs. I just wanted to state that I am in favor of this exception. I do believe the definition for ground signs needs worked out so it is clear what signs are considered ground signs.

Thank you,

Stephen Moore, BO, CFM
Building Official
614-830-2045
smoore@groveport.org

Ohler, Debbie

From: Uroseva, Jeff <JUroseva@mahoningcountyoh.gov>
Sent: Thursday, February 22, 2018 9:31 AM
To: Ohler, Debbie
Subject: RE: Sign exemption

Hi Debbie,
Sorry for the delay, just got back from Florida this week and have been playing catch up.
OK-so I read the proposed change in 101.2(19). This amendment reads to me like "regulation of ground signs" with the few exceptions in 31, Right?
As for my opinion on regulation:

1. Anything connected to the building or building services equipment should be regulated, i.e., electrical.
2. Ground signs that include an occupied structure within the fall radius of the sign should be regulated. (we have some large billboard signs that cantilever over structures)
3. I would exempt ground signs under 6 ft. in height without electric.

So to answer, I support exemption of the small signage that does not affect the building occupants. The larger structures that can impact the safety of the building occupants should be regulated, by who, I'll leave that up to the Board to decide.

Jeffrey S. Uroseva
Chief Building Official
Mahoning County Building Department
330.270.2894x259

From: debbie.ohler@com.state.oh.us [mailto:debbie.ohler@com.state.oh.us]
Sent: Tuesday, February 20, 2018 4:25 PM
To: Uroseva, Jeff <JUroseva@mahoningcountyoh.gov>
Subject: Sign exemption

Good afternoon, Jeff.
I hope you are enjoying this warm weather.
You and I have talked in the past about the scoping provisions of the OBC Chapter 1.

The BBS has been trying to address many of the questions that have been asked of us over the years by discussing the issue and having the board make a decision (yes or no) that the issue should be in the scope of the OBC. Some of the issues that have been addressed in recent versions of the OBC Chapter 1, Section 101.2 were bridges, flagpoles, site lighting, and wind turbines and pumps not connected to building services equipment. As you may know, in Amendments Group 95, the BBS is proposing to further clarify the exemption for ground signs (Section 101.2, #19) in response to many questions and concerns from building officials around the state. You can see the proposed amendment here: https://www.com.ohio.gov/documents/dico_ProposedOBCodeRules.pdf

I am curious of your opinion on this issue. Are you in support of a sign exemption or do you think they need to be regulated?
Debbie

Exhibit C

APPLICATION
FOR
RULE CHANGE

Pursuant to section 3781.12 of the Revised Code and rules adopted by the Board of Building Standards, application is herewith submitted to adopt, amend, or annul a rule adopted by the Board pursuant to section 3718.10 of the Revised Code.

BOARD OF BUILDING STANDARDS
6606 Tussing Road, P.O. Box 4009
Reynoldsburg, Ohio 43068-9009
(614) 644-2613
bbs@ohio.gov
www.com.state.oh.us/dico/bbs/default.aspx

For BBS use:	
Petition #:	17-01
Date Recv'd:	8/16/17

Submitter: Joseph P. Sandman
(Contact Name) (Organization/Company)

Address: 1976 Ford Road
(Include Room Number, Suite, etc.)

Morrow (City) Ohio (State) 45152 (Zip)

Telephone Number: (513) 899-9743 **Fax Number:**

Date: 08/09/2017 **E-mail Address:** josephs@fioptics.com

Code Section: 607.4 Access and Identification (Ohio Mechanical Code)

General Explanation of Proposed Change (attach additional sheets if necessary):

Saving lives and countless dollars in property damage by providing a realistic approach to the maintenance and inspection of smaller fire dampers.

Explanation of Cost Impact of Proposed Code Change*: My proposed change will reduce the time it takes to inspect and service smaller fire dampers by 50%

***Attach additional cost information as necessary to justify any statement of cost increase or cost decrease.**

Information on Submittal (attach additional sheets if necessary):	
1. Sponsor:	Organization sponsoring or requesting the rule change (if any)
2. Rule Title:	Access and Identification Title of rule change
3. Purpose/ Objective:	By providing a removable section of ductwork this will allow adequate access for inspection and maintenance of the fire damper and it's operating parts. Technical justification for the proposed rule change
4. Formatted Rule Language **(Using Strike-out for Deleted Text and Underline for Added Text)** (OMC)	**607.4 Access and identification.** Fire and smoke dampers shall be provided with an approved means of access, ~~large enough~~ to permit inspection and maintenance of the damper and it's operating parts. <u>Dampers equipped with fusible links, internal operators, or both shall be provided with an access door that is not less than 12 in. (305mm) square or provided with a removable duct section.</u> The access openings shall not reduce the fire-resistance-rated assemblies. The access openings shall not reduce the fire-resistance rating of the assembly. Access points shall be permanently identified on the exterior label having letters not less than .05 inch (12.7 mm) in height reading: FIRE/SMOKE DAMPER, SMOKE DAMPER or FIRE DAMPER. Access doors in ducts shall be tight fitting and suitable for the required duct construction. Use strike-out for deleted text and underline for added text
5. Notes:	1. To encourage uniformity among states using model codes, it is recommended that the submitter first submit any code change directly to ICC and participate in the national model code development process. 2. Please provide a copy of application and documentation. 3. Use a separate form for each code change proposal.

Date: July 27, 2017

Ohio Board Of Building Standards
6606 Tussing Road
Reynoldsburg Ohio 43068

ATTN: BOARD MEMBERS

I would like to bring to your attention a recurring problem we have in the HVAC industry with the intention that there is something your organization can help us fix or refer this letter to a department that can help rectify this problem.

Fire and smoke dampers are an important part of a HVAC ductwork system, in the event of a fire they are designed to close and prevent the spread of fire and smoke throughout the buildings ductwork system, giving the building occupants enough time to evacuate and also providing the fire department sufficient time to enter the building and extinguish the fire safely.

The NFPA requires all fire and smoke dampers be periodically inspected, maintained and tested per their guidelines to assure these dampers function properly in the event of a fire.

The NFPA requires that fire and smoke dampers are inspected and maintained through an access door that provides full unobstructed access to these dampers. These access doors are mounted on the ductwork as close as possible to the damper it serves. Access doors work well for large fire and smoke dampers because the ductwork size is large enough to except an adequate sized access door, the problem is with the smaller fire and smoke dampers, the ductwork size is too small to mount an adequate size access door to. NFPA 80 addresses this problem by mandating the minimum size access door shall be no smaller than 12 inch square or you must supply a removable ductwork section, this removable section provides the maintenance technician with the unobstructed room needed to properly inspect and maintain the smaller fire and smoke dampers.

Our concerns are with the smaller fire and smoke dampers, because in many cases the removable ductwork sections for these dampers are not being provided as mandated by the NFPA 80, rather inadequate small access doors are being installed in the ductwork system next to the fire and smoke damper it serves, these smaller access doors don't provide the sufficient room needed to properly inspect and maintain the smaller fire and smoke dampers. The inadequacies of these access doors is nothing new in the HVAC industry, in many cases when it becomes time for the periodic damper inspections the maintenance technician will ignore and pass over the smaller fire and smoke dampers knowing that it's virtually impossible to perform the inspection through the small access doors. We are asking for your help in addressing this problem, these fire and smoke dampers are much to important to be ignored, they save lives and countless dollars in property damage, the solutions are known they are just not being implemented.

Thank you for your time and if I can be of any assistance please don't hesitate to contact me.

Sincerely,

Joseph P. Sandman
1976 Ford Road
Morrow, Ohio 45152
Home (513) 899-9743
Mobile (513) 678-6825

August 1, 2017

I have been testing fire and smoke dampers to assure their operation is at the same standard as when they were installed. Today round and rectangular dampers 4" to 12" are extremely difficult to test due to the fact that the access openings are limited in size. In order to test a fire damper the mechanic must remove the fire damper link and watch the damper close then clean out the tracks of the damper blade for corrosion build up over the years, install the blade back to the original position and secure the fire link.

I would estimate it takes 45 minutes to check a small damper, if a removable ductwork section was in front of the fire damper I believe it would reduce this time by 50%. The installation of a removable ductwork section in front of an existing small fire damper most likely would not be feasible due to other mechanical devices directly beneath it, however it could be implemented in new construction and save considerable time in testing and the removal of a damper that is not working properly.

Matt Haarmeyer

DEBRA - KUEMPEL

MATT HAARMEYER

CRITERIA FOR SUBMITTING RULE CHANGES TO THE BOARD OF BUILDING STANDARDS

The Ohio Board of Building Standards processes all petitions for changes to the rules of the Board of Building Standards (Building, Mechanical, Plumbing, Boiler, Elevator, or Residential Codes) pursuant to ORC Chapter 119.

When anyone desires to petition the Board of Building Standards to adopt, amend, or annul a provision of rules of the Board, they must complete an application and provide supporting information submitted to the Secretary of the Board of Building Standards.

The application must include the following:

(1) The date the application is prepared;
(2) The rule number or section that is proposed for amendment, adoption, or annulment;
(3) The rule numbers of all other rules that will be affected by the matter proposed;
(4) The name, address, contact information, affiliation of the applicant, and of any representative;
(5) The provisions that are proposed for adoption, amendment, or annulment;
(6) The reason and technical justification for the proposed change;
(7) All text to be eliminated shall be shown deleted by means of strikethrough, e.g., ~~matter to be eliminated~~;
(8) All proposed new text to be inserted into a rule shall be shown as underlined, e.g., <u>proposed new matter</u>; and
(9) One copy of the completed application and attachments.
(10) An estimate of the increase or decrease in cost that would occur with the adoption of the proposed code change.

When the Secretary of the Board of Building Standards receives a completed application for an adoption, amendment, or annulment of rules of the Board, the Secretary will promptly deliver or mail a copy of the application to each member of the Board.

After receiving an application for the adoption, amendment, or annulment of rules of the Board, the Board of Building Standards shall proceed under sections 3781.101 and 3781.12 of the Revised Code.

APPLICATION

FOR

RULE CHANGE

Pursuant to section 3781.12 of the Revised Code and rules adopted by the Board of Building Standards, application is herewith submitted to adopt, amend, or annul a rule adopted by the Board pursuant to section 3718.10 of the Revised Code.

BOARD OF BUILDING STANDARDS

6606 Tussing Road, P.O. Box 4009
Reynoldsburg, Ohio 43068-9009
(614) 644-2613
bbs@ohio.gov
www.com.state.oh.us/dico/bbs/default.aspx

For BBS use:	
Petition #:	
Date Recv'd:	

Submitter: Jim Tidwell and Jeff Terrey (Contact Name) Fire Equipment Manufacturers' Assocation (Organization/Company)

Address: 1300 Sumner Avenue (Include Room Number, Suite, etc.)

Cleveland (City) OH (State) 44115 (Zip)

Telephone Number: 817-715-8881 **Fax Number:** 216-241-0105

Date: November 15, 2017 **E-mail Address:** jimtidwell@tccfire.com; jterrey@rasky.com

Code Section: Section 906.1

General Explanation of Proposed Change (attach additional sheets if necessary):

Please see attached documents.

Explanation of Cost Impact of Proposed Code Change*:

See attached RJA Report: "Study on the Life Cycle Cost of Portable Fire Extinguishers"

***Attach additional cost information as necessary to justify any statement of cost increase or cost decrease.**

Information on Submittal (attach additional sheets if necessary):	
1. Sponsor:	Fire Equipment Manufacturers' Association Organization sponsoring or requesting the rule change (if any)
2. Rule Title:	Portable Fire Extinguishers Section 906.1 Title of rule change
3. Purpose/ Objective:	Please see attached documents. Technical justification for the proposed rule change
4. Formatted Rule Language **(Using Strike-out for Deleted Text and Underline for Added Text)**	Please see attached documents. Use strike-out for deleted text and underline for added text
5. Notes:	1. To encourage uniformity among states using model codes, it is recommended that the submitter first submit any code change directly to ICC and participate in the national model code development process. 2. Please provide a copy of application and documentation. 3. Use a separate form for each code change proposal.

Reason for Addition: In keeping with the Ohio suggestion that code changes be first submitted to ICC to secure consensus through that national code body, this change was submitted and approved for the 2018 International Fire Code. Because the new language provides additional options for the designers and owners, it's widely viewed as an improvement in the code. The reasons for the change include the fact that schools are now required to develop lock down plans to protect students and faculty from intruders. The plans effectively prevent access to portable extinguishers normally located in hallways during lockdown situations. Locating extinguishers in classrooms provides accessibility during normal conditions as well as when a school is forced into lockdown. This change provides an option for schools implementing lockdown plans to relocate extinguishers from hallways to classrooms. This is an option, not a requirement.

Cost Impact: Will not increase the cost of construction. This change will provide an option to schools, and is not a requirement; as such, the school management is empowered to make the best decision based upon their individual needs.

Reason for Removal: Our proposed change will provide consistency between the Ohio Building Code and the International Building Code. This is in conformance with Ohio's stated desire to vet code changes through the national consensus process. The current inclusion of the "line 1 exception" is counter to that stated desire, and inconsistent with the national consensus.

Portable extinguishers are a critical layer of fire protection, and are used throughout the United States to reduce property damage, injuries and fatalities from fire. The Line 1 Exception in Section 906.1 significantly reduces the number of portable fire extinguishers required in most public buildings, thereby weakening fire safety requirements.

The Consumer Product Safety Commission conducted a survey and analyzed the data from survey participants, the results of which were published in 2009. According to this report, five percent of fires were put out using a portable fire extinguisher. This means that 371,000 residential fires were suppressed using portable fire extinguishers annually at the time of the survey. It's clear that thousands of fires are extinguished annually by people using portable fire extinguishers, both in commercial and residential occupancies. While there is no corresponding data for commercial occupancies, the information from the CPSC survey can be extrapolated to give us an idea about unreported fires and fire extinguisher use in occupancies beyond residences. Using the same ratios – that is, the number of unreported fires to reported fires; the percentage of fires extinguished with fire extinguishers, etc., fire extinguishers were being used on about 190,000 commercial fires in 2008. Based upon this information, it's clear that thousands of fires are extinguished annually by people using portable fire extinguishers, both in commercial and residential occupancies throughout the United States. Citizens of Ohio should not be denied this important layer of safety. *(Ref: 2004-2005 National Sample Survey of Unreported Residential Fires, U. S. Consumer Product Safety Commission, Michael A. Greene, Division of Hazard Analysis, Directorate for Epidemiology, page 159, Table 8-4 https://www.cpsc.gov/PageFiles/105297/UnreportedResidentialFires.pdf)*

According to the 2013 NFPA report "U.S. Experience With Sprinklers", citing fires from 2007-2011, there were a total of 48,460 reported structure fires annually in buildings equipped with sprinkler systems. Of these fires, a total of 40,440 never grew large enough to activate the sprinkler system (confined and unconfined fires). This means that some 83 percent of the fires reported in sprinklered buildings didn't grow large enough to operate the sprinkler system. The systems were operational and unimpaired; the fire simply didn't grow large enough to activate them. One conclusion that can be drawn from this statistic is that many fires are being suppressed by building occupants. Because people are extinguishing fires in their buildings, it's critical that the correct tools for doing so – portable fire extinguishers - are provided; otherwise, the risk to the public is increased substantially.*(Ref: Table 3-1, page 19 of 2013 NFPA report titled "U.S. Experience With Sprinklers by John Hall http://www.tvsfpe.org/_images/us_experience_with_sprinklers.pdf)*

Occasionally, the cost of this layer of fire protection is questioned. The cost/benefit analysis of portable extinguishers proves that their value is indisputable. According to a study conducted by Richard Bukowski at RJA (formerly of NIST), the total life cycle cost per square foot for a portable extinguisher ranges from a low of one half of one cent to a high of just under four cents per year. This includes acquisition costs and all inspection, maintenance, and upkeep for the life of the extinguisher. This is likely the lowest cost fire protection available, and has shown to be very effective. (*Reference: Study on the Life Cycle Cost of Portable Fire Extinguishers, Richard W. Bukowski, P.E., FSPE, Rolf Jensen and Associates, Inc. http://www.femalifesafety.org/docs/006GRCAtt01RJAFinalReport011714.pdf)*

Portable extinguishers can be used safely and effectively by persons with little or no training in their use. According to a study conducted by Worcester Polytechnic Institute and the Eastern Kentucky University, of 276 subjects, 98 percent were able to successfully use an extinguisher by pulling the pin, squeezing the trigger, and discharging the extinguisher. 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. After minimal training, the subjects showed a measurable increase in effectiveness. *(Reference: "Ordinary People and Effective Operation of Fire Extinguishers", (April 27, 2012 by Brandon Poole, Undergraduate Student, WPI; Kathy Ann Notarianni, Professor and Head of Department, Fire Protection Engineering, WPI; Randy Harris, Lab Coordinator, Fire Protection Engineering Department, WPI; William D. Hicks, Assistant Professor, Fire and Safety Engineering Technology Program, EKU; Corey Hanks, Lab Coordinator, Fire and Safety Engineering Technology Program, EKU; Gregory E. Gorbett, Program coordinator, Fire and Safety Engineering Technology Program, EKU. http://www.femalifesafety.org/docs/WPIStudyFinal.pdf)*

Much has been said about the benefits of people simply leaving the building when a fire occurs. The question, however, isn't whether most people will leave or not – every study available shows that, when faced with a small fire, most people will try to intervene in that fire and put it out. Why else would over 90 percent of the fires in this country go unreported (CPSC)? Why else would the majority of ***reported*** fires in sprinklered buildings never activate the sprinklers because they don't grow large enough? (Dr. John Hall, NFPA).

It's clear that human nature is to attempt to extinguish a fire if it's in its incipient stage. Fire extinguishers are intended for that specific purpose. So, the question isn't whether people should leave or not; rather, the question is whether we want people to use makeshift means to try to put the fire out, or do we want them to have available a tool that is designed, engineered, and manufactured for that specific purpose? Omitting the requirement for fire extinguishers in these occupancies is placing the building occupants at risk. It's that simple.

We urge the Board to remove the Line 1 Exception in Section 906.1 of the Ohio Building Code.

Proposed Rule Language

PORTABLE FIRE EXTINGUISHERS

906.1 **Where required.** Portable fire extinguishers shall be installed in all of the following locations:

1. In Group A, B, E, F, H, I, M, R-1, R-2, R-4 and S occupancies.

Exceptions:

~~1.1 *In Group 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.*~~

1.~~2~~1. *In Group R-2 occupancies, portable fire extinguishers shall be required only in locations specified in Items 2 through 6 where each dwelling unit is provided with a portable fire extinguisher having a minimum rating of 1-A:10-B:C.*

<u>1.2 In Group E occupancies, portable fire extinguishers shall be required only in locations specified in Items 2 through 6 where each classroom is provided with a portable fire extinguisher having a minimum rating of 2-A:20-B:C.</u>

2. Within 30 feet (9144 mm) of commercial cooking *appliances and domestic cooking appliances in Group I-2 nursing homes*.

3. In areas where flammable or combustible liquids are stored, used or dispensed.

4. On each floor of structures under construction, except Group R-3 occupancies, in accordance with Section 3315.1 of the *fire code*.

5. Where required by the *fire code* sections indicated in Table 906.1.

6. Special-hazard areas, including but not limited to laboratories, computer rooms and generator

2004-2005 National Sample Survey of Unreported Residential Fires

Michael A. Greene
Division of Hazard Analysis
Directorate for Epidemiology
U.S. Consumer Product Safety Commission

Craig Andres
Division of Hazard Analysis
Directorate for Epidemiology
U.S. Consumer Product Safety Commission

July 2009

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

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[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

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[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

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[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

[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*

[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, $1/40^{th}$ were randomly selected as a comparison group. This was similar to the 1984 survey. An abbreviated form of the questionnaire was administered that included demographic questions in order to be able to compare fire risk by demographic group. Non-fire households were also asked about the number, type, and location of smoke alarms, and the availability of fire extinguishers and home sprinkler systems.

Chapter Outline

This report contains 8 chapters. This section briefly describes the content of Chapters 2-8.

Chapter 2 Survey Methodology

This chapter is a technical description of the sample design, management, and weighting of the survey. It does not deal with fire incidence or other substantive issues. The reader can skip this chapter on the first reading and return later to learn more about the survey design.

The chapter begins with a description of how the sample was designed. This includes information about how the survey was stratified, the use of the GENESYS® system to generate samples of telephone numbers, the anticipated sample size and allocation by stratum, and estimated sampling error for that design. The chapter continues with how the telephone interviewing process was managed including interviewer training, data collection, qualifying respondents, and procedures utilized to maximize response rates.

During the telephone interview, more than a half million telephone numbers were dialed. Using the formulas developed by the American Association for Public Opinion Research (AAPOR), the response rate was either 22.5 percent or 31.6 percent depending on how phone numbers with unknown eligibility were allocated.

The next section of Chapter 2 presents the number of survey responses actually obtained in the survey, by stratum, race, ethnicity, and demographic group. This is followed by a discussion of how sample weights were calculated. Those weights were used in all analyses found in subsequent chapters. An appendix to this chapter provides details on the AAPOR procedures.

Chapter 3 Fire Incidence

The purpose of this chapter is to develop and explain the methodology for estimating the annual number of residential fires, including both fire department-attended and unattended fires and to present those estimates.

The chapter begins with a review of the methods used to make fire estimates in the 1974 and 1984 surveys, in particular, concerning how memory recall issues were handled. The surveys asked respondents to recall fire incidents up to one year from the interview (1974 survey) and up to three months from the interview (1984 survey). The analyses in both surveys clearly indicated that respondents did not recall fire incidents and, as expected, recall decreased with increasing time from the interview. This is then followed by a review of the literature on retrospective recall of illness and injury incidents, especially on methods for estimating injury and incident rates in such studies.

In addition to completely forgetting incidents that occurred, respondents may have remembered that a fire occurred, but may not have been able to remember the date it occurred. While many respondents in this survey were able to provide the interviewers with the date of the fire, some were able to identify only the month, and others could not recall either the month or day, but asserted that the incident occurred during the 91-day recall period. These missing dates must be allocated to the 91-day recall period using a statistical procedure (imputation). The methodology for imputing missing fire dates and estimation is outlined in this chapter. Part of the methodology involved classifying fires on the basis of characteristics associated with the severity of the fire incident. Using fire severity in the imputation process took into account that respondents would be more likely to remember dates when more severe fire incidents occurred.

Following imputation of the missing dates, the chapter applies a statistical procedure for selection of the most appropriate recall period. Various possibilities for the recall period were examined leading to selection of the recall period as that with the smallest amount of statistical error. Separate analyses by incident severity were conducted with the result that a 14-day recall period was chosen for the less severe incidents and a 21-day period for more severe incidents. In this chapter, then, household fire incident rates were computed using only the incidents that fell into the 14- or 21-day period.

Results for the number of attended and unattended fires are then presented. It was estimated that there were 7.43 million residential fires annually of which 7.18 million were not reported to fire departments. Reported and unreported fires amounted to 6.6

attended fires per 100 households. These estimates represented a decrease of 71 percent in the number of fires from the 1984 survey estimates, and a decrease of 78 percent in the per household fire incident rate from the 1984 survey. Between 1980 and 2005, official statistics on fire department-attended residential structure fires showed that such fires decreased by 43 percent.

One of the questions motivating the present survey was to compare the decrease in fire department-attended fires with the decrease in fires not attended by fire departments. As mentioned earlier in this chapter, it has been suggested that the almost universal adoption of household smoke alarms in the last 20 years has resulted in people becoming aware of fires at an earlier point in the fire development. This would allow them to extinguish the fire without notifying the fire department. The implication is that over the past 20 years, fire department-attended fires would have decreased much faster than unattended fires. As that was not found in the survey, there does not seem to be support for this conjecture.

Chapter 4 Comparison of Fire and Non-Fire Households

This chapter evaluates fire risk factors by comparing characteristics of fire households with non-fire households. As mentioned above, fire households were defined as the survey respondents who had at least one fire during the three-month recall period, while non-fire households were the households that did not so indicate.

Some of the factors analyzed in the chapter include region of residence, type of housing unit, ownership versus renting, house age, household size, age composition, presence of smokers, income, education, race, and ethnicity. Factors that were significantly different between fire and non-fire households were as follows:

- Fire households were more likely to be renters and less likely to be owners
- Fire households had on average more members and, in particular, more people under 18 but fewer people over 65
- The head of fire households tended to have a higher educational level than the head of non-fire households.

Different from the 1984 survey, the presence of at least one smoker in the household did not appear to differ significantly between fire and non-fire households. The difference in the average number of smokers in fire and non-fire households was borderline significant. In this present survey, the percent of households with smokers was lower than in the 1984 survey.

Chapter 5 Characteristics of Households with Smoke Alarms and Fire Extinguishers

The purpose of Chapter 5 is to compare characteristics of survey respondents that had (1) different smoke alarm installations (including alarm location and alarm interconnection) and (2) fire extinguishers. Fire and non-fire households were compared as well as households with and without risk factors that were suggested by the analysis in Chapter 4.

In contrast to the 1984 survey where 62 percent of households had smoke alarms, 96.7 percent of households had at least one smoke alarm in the present survey. With that large a proportion having smoke alarms, it would be unlikely to find significant differences in the presence of smoke alarms by many household characteristics, but both region variables (South with the lowest proportion of households with alarms) and community type (non-urban with fewer alarms) were significant.

More than 75 percent of households had at least one fire extinguisher. There were significant differences in the percent having at least one extinguisher by type of dwelling (mobile homes and multifamily less likely to have fire extinguishers) and also renters were less likely to have at least one extinguisher in the residence than homeowners.

The chapter then examines the differences in smoke alarms between fire and non-fire households. Non-fire households were significantly more likely to have smoke alarms than fire households, and the difference in the average number of smoke alarms between fire and non-fire households was statistically significant. Controlling for the difference in the size of the dwelling showed that non-fire households had more smoke alarms per floor on average than fire households. In addition, non-fire households were more likely to have smoke alarms on all floors, in all bedrooms, and alarms that were interconnected.

Non-fire households had a larger number of extinguishers than fire households, on average.

The chapter concludes by comparing the two recommended smoke alarm configurations, smoke alarms on all floors and smoke alarms in all bedrooms by some of the risk factors developed in Chapter 4. Non-urban households were significantly less likely to have smoke alarms on all floors, while households with at least one person under 18 were significantly more likely to have smoke alarms on all floors. Non-urban households, households with smokers, and households with at least one person over 65 were less likely to have smoke alarms in all bedrooms, while households with at least one person under 18 were significantly more likely to have alarms in all bedrooms.

Chapter 6 Characteristics of Residential Fires

Chapter 6 returns to the same dataset used in Chapter 3, the fire incidents from the 14- and 21-day recall periods. This chapter and Chapter 7 examine the types of fires, the characteristics of households where they occurred, and the associated fire losses. A particular focus in this chapter is the ratio of unattended to attended fires, in order to shed some light on the differences in fire and household characteristics where attended and unattended incidents occur.

The chapter begins with the demographic breakdown of the estimated 7.4 million attended and unattended fires. Fires are broken down by region of the country, showing that the West region had the highest per household fire incidence and the lowest ratio of unattended to attended incidents. The chapter continues comparing fires in owner occupied and rental housing, single family and other types of housing, urban and non-urban regions, and other characteristics. One important finding noted in this chapter is that the per household fire incidence rate increased with an increasing number of members in the household. Also, households with at least one member under 18 had almost twice as many fires per household as those without a family member under 18. Although households with members 65 and over had a lower household fire incidence rate than households with only younger members, when fires occurred in households with older members, it was more likely to result in fire department attendance than a fire in a household with only younger members.

The chapter continues with descriptions of the fire characteristics, showing that most fires (4.8 million fires or 64 percent of the total) involved cooking appliances. The next largest source of heat was small open flames, such as candles, matches, lighters and other devices (783,000 fires or 10.7 percent). Consistent with the number of cooking fires, most fires were found to start in the kitchen (68 percent), followed by the bedroom (7.5 percent). The highest hourly fire rate was between 5 and 9 pm, which is the time when many cooking fires happen.

The remainder of the chapter focuses on fire losses. Substantial property damage, injuries to household members, and other fire consequences tended to be the exception in these incidents. For example, in 74 percent of incidents there was no smoke damage, in 93 percent of incidents there was no flame damage or flame damage only to the item first ignited, and in 81 percent of incidents the property damage was under $100. In less than 1 percent of incidents, the conditions after the fire required families to stay out of the household for one day or longer.

The chapter also develops an approximate method for determining the uncertainty associated with any of the estimates presented in this chapter, Chapter 7 and Chapter 8. This method, a generalized coefficient of variation, is described in the appendix of Chapter 6.

Chapter 7 Consumer Products Involved in Unattended Residential Fires

Chapter 7 treats some of the same issues as Chapter 6, but the focus in this chapter is unattended fires and consumer products. In Chapter 3, it was estimated that 3.4 percent of total fires were attended by fire departments. As a result, almost all analyses of both attended and unattended fires taken together will be the same as analyses of unattended fires. The exceptions are in any measures associated with the severity of the incident because fire department-attended fires tend to have much larger fire losses than unattended incidents. To develop a better understanding of unattended fires, fire losses and consumer products, the analyses in this chapter only consider unattended incidents.

Another reason to focus on unattended incidents is to be able to compare the results with the 1984 survey. More specifically, one of the main objectives in Chapter 7 is to account for the 69 percent decrease from an estimated 22.9 million unattended fires in 1984 to 7.2 million unattended fires in the current survey. A key issue is if the decrease occurred in all types of fires or just certain types of fires.

One unique feature of this chapter is an estimate of the percentage decrease in the number of unattended fires from the 1984 survey by various characteristics of the fire. This comparison requires modifying the estimation method for the current data to match the 1984 survey. The statistical approach is outlined in the chapter and presented in some detail in an appendix.

Like Chapter 6, Chapter 7 analyzes the room where the fire incident began, the source of heat, item first ignited, damage, injury, and property loss. The analysis focuses on appliance (synonymous with equipment) fires, distinguishing them from non-appliance fires by time of day and item first ignited. Then specific types of fires are studied. These include cooking fires by type of cooking appliance, electrical lighting and wiring fires, heating and cooling appliance fires, other household appliances, and small open flame and cigarette fires.

With respect to the item first ignited, most cooking-related fires (83 percent) involved cooking materials. The second largest category involved linens, probably kitchen towels, and napkins. Most cooking-related fires (81.2 percent) involved ranges, with about twice as many electric ranges involved in fires than gas ranges. The third highest ranking appliance involved in cooking-related fires was microwave ovens (7 percent). Electrical lighting-related and wiring-related fires were most likely to involve light fixtures (23 percent) or lamps (11 percent); the item first ignited most frequently was bedding (24 percent), none reported (22 percent), or electrical wire (21 percent). Heating and cooling appliance-related fires were most often associated with fixed heaters (30 percent of heating fires) and portable heaters (35 percent), and ignited electrical wire (41 percent) or the appliance itself (29 percent).

When the heat source was cigarettes or small open flames, the largest single source was candles (52 percent of cigarette/open flame incidents). When cigarettes were involved, bedding was the most frequently ignited item, while with other open flame incidents, paper was the most frequent item first ignited.

In comparison with the results of the 1984 survey, cooking fires and heating and cooling equipment associated fires decreased at about the same rate as all incidents, other household appliances decreased by a larger percent, and electrical lighting/wiring fires declined less. Non-appliance fires decreased more than the overall decrease, at 84 percent. As the most frequently occurring heat source for non-appliance fires was fires with cigarettes and small open flames, this decline in non-appliance fires probably reflects an overall decrease in smoking-related incidents.

Chapter 8 Operation and Effectiveness of Smoke Alarms and Fire Extinguishers

To examine how smoke alarms and extinguishers reduce fire losses, this chapter uses the fire incidents from the 14/21-day recall period. For the most part, only unattended fires are considered in this chapter.

The chapter opens with a discussion of different ways to characterize the operation of smoke alarms. Smoke alarm operation is described as follows: (1) the alarm sounded, but did not alert anyone to the fire, (2) the sounding alarm alerted residents to the fire, and (3) the alarm provided the only alert of the fire. When residents reported that they were not alerted when the alarm sounded because they were already aware of the fire, the sounding alarm may provide some benefit by confirming the seriousness of the fire or the location of the fire. An alarm that alerts people to the fire first is of greater benefit in providing them with an early warning. If the sounding alarm provides the only alert, a situation that may occur when residents are not near to the fire, this is of even greater benefit.

In the chapter, it was estimated that from the survey data that smoke alarms sounded in 30 percent of the fire incidents (40 percent of attended fires), alerted residents in 11.8 percent of the incidents, and provided the only alert in 9.8 percent of incidents.

Why did the alarm not sound or alert residents more frequently? The main explanation for the alarm not sounding provided by survey respondents was that insufficient smoke reached the alarm. This not only involves the characteristics of the fire but also where alarms were located in the residence. In most cases when the alarm did not sound, residents reported that before the fire, they believed that the alarm was working.

Some highlights of the chapter are as follows. In fires starting in the kitchen, the alarm sounded in 36.9 percent of incidents, alerted residents in 14.9 percent of incidents, and provided the only alert in 12.0 percent of incidents. In fires starting in the bedroom, the alarm sounded in 16.7 percent of incidents, alerting people and providing the only alert in 11.6 percent of fires. In fires involving heating and cooling equipment, the alarm sounded in 17.9 percent of incidents, alerting residents in 4.1 percent and providing the only alert in less than 1 percent of incidents. The alarm sounded in 19.5 percent of candle fires and 27.7 percent of lighter, cigarette, and match fires; alerting people in 6.9 percent of candle fires and 7.9 percent of lighter, cigarette, and match fires; and providing the only alert in 6.2 percent of candle fires and 7.9 percent of lighter, cigarette, and match fires.

Another aspect of this chapter was to analyze alarm operation by how the alarms were configured in the residence. Interconnected alarms sounded in 53.3 percent of incidents as compared with 27.0 percent with non-interconnected alarms, alerted people in 26.0 percent of incidents as compared with 10.0 percent with non-interconnected alarms, and interconnected alarms provided the only alert in 26.0 percent of incidents as compared with 7.6 percent with non-interconnected alarms. Most fires occurred in residences that did not have interconnected alarms.

There also were large differences between alarm responses in residences where the alarms were on all floors in contrast to alarms not on all floors. As shown in Chapter 5, 82 percent of fire households had alarms on all floors. Overall the alarms sounded in 37.1 percent of incidents when the alarms were on all floors as compared with 4.1 percent in residences without alarms on all floors. With alarms on all floors, people were alerted in 14.5 percent of incidents and this was the only alert in 11.9 percent of incidents. In contrast, in residences without alarms on all floors, people were alerted in 1.9 percent of incidents and in each case, this was the only alert.

The other issue considered in the chapter is the use and effectiveness of fire extinguishers. Fire extinguishers were used in 4.5 percent of unattended fire incidents and 17.7 percent of attended fires, often in combination with other methods. Most unattended fires were put out by removing power, putting water on the fire, separating the fuel from the heat source, or other such actions. The most frequent use of extinguishers was in unattended bedroom fires (8.6 percent of incidents), kitchen fires (5.2 percent), candle fires (9.5 percent), and fires in cooking equipment other than stoves (9.9 percent of incidents). There was a somewhat higher chance of the extinguisher being used when it was in the room where the fire started.

Appendix

The survey questionnaire is reprinted in the Appendix at the end of this report.

Chapter 2
Survey Methodology[28]

This chapter describes the technical aspects of how the survey was designed and conducted.

The chapter is organized into five sections. The first section, Sampling Plan, discusses the survey design (including construction of strata), sample size and allocation, sample selection, and collapsing the strata. The second section, Questionnaire Design, briefly describes the development and testing of the survey questionnaire. This is followed by a section on Survey Management, including interviewer training, data collection, determining respondent eligibility, and maximizing response rates. The next section, Responses to the Survey, describes the characteristics of the actual sample and the construction of the weights used in analyzing the data. The last section describes the response rate methodology and presents the response rates.

Sampling Plan

The sampling frame for this survey consisted of all U.S. residential telephone numbers, i.e., all U.S. households with at least one land-line telephone in the home. The frame was developed using the GENESYS[29] sampling system.

GENESYS is a computer program and data system that is used to create random digit dialing (RDD) single-stage probability samples of telephone numbers. It generates each random telephone number by first randomly selecting a block of telephone numbers. A block consists of the area code and the first five digits of the phone numbers. Then a number from 01 to 99 is computer generated and appended to the end of the block number for the full specification of the phone number to be called.

One of the advantages of using this system is that much is known about each block of telephone numbers. This includes whether it contains at least one residential telephone number, so that blocks of phone numbers assigned exclusively to businesses or not-yet assigned blocks will not be called. Additionally, the GENESYS system contains telephone exchange level estimates for over 48 demographic variables such as age, income, home ownership, education, race, whether the block belongs to a metropolitan (urban) or non-metropolitan (non-urban) region, etc. This feature then allows designing a sample that can be stratified to over- or under-sample households along certain demographic variables.

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[28] This chapter was drafted by Synovate, Inc, then edited and reformatted by CPSC staff. Under contract Number GS-23F-8039H and Order Number CPSC-F-02-1316, Synovate participated in the design of the survey questionnaire, tested the questionnaire, and conducted the telephone survey. Synovate also designed the sampling plan.

[29] GENESYS is a product of the Marketing Systems Group, Fort Washington, PA.

The sampling frame of households was stratified to meet the goals of the sampling plan. The strata were constructed such that the resulting sample would accomplish the following:

- Provide a nationally representative probability sample of U.S. households in the 50 states and the District of Columbia.

- Provide sufficient representation of key demographic subgroups including but not limited to: Native Americans, African Americans, households in rural areas, households of Hispanic origin, and the elderly. Race and ethnicity in this report refer to the head of the household only.

- Provide sufficient representation of other demographic and housing characteristics, such as: type of dwelling, age of dwelling, rental versus owned properties, household income, education of head of household, cause of fire and room of origin, and age of occupants.

Sufficient representation meant that there would be adequate numbers of respondents within these subgroups to make comparisons along two important dimensions as follows: (1) if there were differences in fire incidence by subgroup, that is, if the risk of fire was elevated in certain subgroups above the population risk and (2) to determine if there were differences in the number and types of smoke alarms and fire extinguishers by subgroup.

Synovate, Inc., the survey contractor, with the help of Marketing Systems Group, compiled area code and exchange combinations along with key population statistics updated from the 2000 U.S. Census. All area codes/combinations were assigned to 16 strata that were defined and compiled by geographic region of the country, incidence of ethnic/racial categories, and urban/non-urban designations.

Specifically, the sampling design uses these definitions:

- The urban/non-urban strata are determined by whether or not counties are assigned to a Metropolitan Statistical Area (MSA). MSAs are a geographic entity used by federal statistical agencies for collecting, tabulating, and publishing statistical information. MSAs contain a core urban area of at least 50,000 people with at least one county and includes the surrounding counties that have a high degree of geographic or social interaction with the urban core.[30]
- The Native American strata have at least a 25% incidence of Native Americans in this small area definition as reported in the 2000 Census.[31]
- The African American strata have at least a 50% incidence of African Americans in this small area definition as reported in the 2000 Census.

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[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:

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[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.

[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.

[36] See page 1 of the survey instrument in the Appendix to this report.

- Several interviewers had the ability to conduct interviews in Spanish using a Spanish language version of the questionnaire.

- Every telephone number that did not result in contact with a respondent (excluding disconnects, fax numbers, and modems) was dialed up to 40 attempts on successive days in order to increase the chances of finding a potential respondent.

- Production rates, interview length, and sample dispositions were monitored closely every other day to detect potential problems with the sample so they could be addressed and resolved immediately.

- Project management personnel received weekly reports containing the number of refusals received and hours dialed by each interviewer. These reports were closely monitored by supervisory staff. Interviewers with a high refusal to hours-dialed ratio were removed from dialing or provided corrective feedback and monitored more closely. In addition, those who demonstrated the lowest refusal to hours-dialed ratio were selected for refusal conversion interviewing. These interviewers called households that had on previous calls refused to participate.

Non-response Follow-up Results

All non-respondents were re-contacted by telephone one to two weeks following the initial contact in order to secure their cooperation. Those respondents who requested that they not be contacted again were excluded from this effort. The contact was made by more experienced interviewers, who were specially trained in refusal avoidance techniques.

In order to assess the extent of any bias due to non-response, a random subset of those who refused for a second time during the conversion attempt answered a few key demographic questions. This allowed the characterization of any differences between respondents and those who chose not to participate.

Responses to the Survey

Table 2-5 provides the actual number of survey fire households compared with the projections from the sample design.

Table 2-5
Projected and Actual Number of Fire Households in the Survey

Stratum Definition (Stratum Number)	Projected		Actual	
	Responses	Percent	Responses	Percent
All	1,810	100.0	916	100.0
Native American (1)	250	13.8	152	16.6
African American (2)	150	8.3	70	7.6
Hispanic (3)	150	8.3	60	6.6
Asian American (4)	330	18.2	161	17.6
East (5)	190	10.5	105	11.5
Midwest - Urban (6)	171	9.4	67	7.3
Midwest – Non-urban (7)	69	3.8	39	4.3
South – Urban (8)	238	13.1	113	12.3
South – Non-urban (9)	87	4.8	38	4.1
West - Urban (10)	147	8.1	93	10.2
West – Non-urban (11)	28	1.5	18	2.0

As shown in the table, there were 916 actual fire households in the survey compared with a projected 1,810 fire households from the survey design. That projection, as noted previously, was based on a fire incidence rate of 2.36 fires per 100 households in a three-month period (approximately 9.5 fires per 100 households per year) developed on the basis of the 1984 survey. The projection was about twice as high as what was found in the data, resulting in an actual sample of fire households that was about half that projected.

Despite the difference between the actual and projected sample sizes, the proportional distribution of the sample among strata was maintained in the sample, indicating that the racial, ethnic, and demographic distribution would be likely to be as planned. That distribution is shown in Table 2-6 below.

Table 2-6
Projected and Actual Demographic Distribution of the Fire Households in the Survey

Demographic Factor	Projected Number	Projected Percent	Actual Number	Actual Percent
Total	1,810	100.0	916	100.0
White	1,093	60.4	601	65.6
African American	224	12.4	99	10.8
Asian American	174	9.6	37	4.0
Native American	176	9.7	98	10.7
Hispanic	203	11.2	106	11.6
Urban	1,336	73.8	646	70.5
Non-urban	474	26.2	270	29.5
Household Income under $25,000	569	31.4	198	21.6
At Least One Household Member				
Age 65 and over	215	11.9	42	4.6
Age 18 and under	280	15.5	488	53.3
Home Owner	1,249	69.0	571	62.3
Renter	561	31.0	334	36.5
Single Family	1,265	69.9	552	60.3
Multiple Family	422	23.3	255	27.8
Mobile Homes	123	6.8	93	10.2

Notes: The survey question about annual household income had different categories than in the planning documents. The estimated survey proportion for the number and percent of households with income under $25,000 is estimated as all responding households with income under $15,000 plus half the households who reported income between $15,000 and $35,000. Detail lines may not add to totals because of non-response, omitted categories, or in the case of race and ethnicity, that a household head may specify membership in more than one race or ethnic group or no race or ethnic group.

Table 2-6 shows that the sample met the survey design projections in percentage terms by the race and ethnicity breakdowns, except that there were fewer households headed by Asian Americans than expected. The distribution of urban/non-urban households, owners and renters, and dwelling types were fairly close to the projections.

The survey sample was different from the projections in that there was a smaller proportion of households with members 65 or older and more households with members 18 years or younger. The survey also had relatively fewer households with household income under $25,000.

Sample Weighting

Samples are weighted to be able to extrapolate to a target population, in this case all U.S. households. The procedure followed the standard approach of constructing weights that are the inverse of the probability of selecting an element in the sample. Weights were constructed as follows:

The initial weight w_{ih} was defined as the weight associated with the screening process for household *i* in stratum *h.* It was defined as follows:

w_{ih} = $1/L_{ih}$ if household *i* in stratum *h* was a fire household,
= $[(T_h)/(V_h)] * 1/L_{ih}$ if household *i* was a non-fire household in stratum *h*.

where

L_{ih} was the number of telephone lines receiving calls in household *i,* stratum *h* (i.e., distinct telephone numbers ringing in the household). This corrects for the fact that households with more lines have a higher probability of being selected for the survey.
T_h was the total number of non-fire households (households with no eligible fires) in stratum *h*, and
V_h was the sample number of non-fire households in stratum *h*.

The initial weights are proportional to the inverse of the sampling probability, but are not yet the inverse of the sampling probability. The next stage was to make them scale to the total sample size. This was called the design weight, as follows:

$$DesignWeight_{ih} = K_h \, w_{ih}$$

where K_h was a constant assigned to stratum *h* to bring the sum of the initial weights into proportion across the strata, i.e.,

$$K_h = \frac{N_h}{\sum_{h=1}^{H} N_h} \Bigg/ \frac{\sum_{i \in h} w_{ih}}{\sum_{h=1}^{H} \sum_{i \in h} w_{ih}}.$$

In the above equation N_h is the number of households in the U.S. in stratum *h.*

The design weights are intended to sum to the sample size, which in this study was the 3,077 households (916 fire households and 2,161 non-fire households).

The final step was to calculate the expansion weight, the weight that would be applied to the survey responses to make estimates. The expansion weight allows the results to represent the total number of households in the United States. The formula for the expansion weight is

$$ExpansionWeight_{ih} = \frac{N}{\sum_{i \in h} DesignWeight_{ih}} DesignWeight_{ih},$$

where N is the total number of households in the United States (113,343,000).[37]

Table 2-7 presents descriptive statistics on the expansion weights. On average, each fire household in the survey represents 1,409 U.S. households and each non-fire household represents 51,852 households.

[37] The estimated number of households is from the U.S. Bureau of the Census. See www.census.gov/population/socdemo/hh-fam/cps2005/tabH2-all.csv. Note that this differs from the estimated number of households shown in Table 2-1 from the 2000 Census that was used to design the sample.

Table 2-7

Descriptive Statistics for Expansion Weights

	Fire Households	Non-fire Households
Mean	1,409	51,852
Median	1,242	45,408
Standard Deviation	1,193	52,036
Sum	1,290,329	112,052,669
Minimum	11	14
Maximum	3,443	149,742
Number of Households	916	2,161

Response Rate Computations

Final Sample Dispositions and Response Rates

As mentioned previously, the final sample size was 916 fire households and 2,161 non-fire households. The number of fire households was about half the projected number. The difference was a result of lower household fire incidence rates than the rate of 2.36 fires per hundred households that had been projected based on the 1984 survey.

Table 2-8 shows the final dispositions for the entire survey sample. Response rates, shown in that table, were computed using the method proposed by the American Association for Public Opinion Research (AAPOR).[38]

[38] American Association for Public Opinion Research (2000), "Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys," AAPOR, Ann Arbor, MI, pp. 35-37.

In computing the response rates, people who were telephoned were classified as follows:

- Interview
- Eligible/non-interview
- Unknown eligibility
- Not eligible

The interview category included all who were screened, both with full and partial interviews. The eligible/non-interview category was the non-respondents (i.e., those who refused to be interviewed). Unknown eligibility includes telephone lines that were always busy, never answered, or were always answered by answering machines, and those interviews with respondents where it was impossible to complete the screening part of the questionnaire in order to determine eligibility. Not eligible includes fax and data lines, business lines, disconnected numbers, nobody living in the home 18 years old or older, and other such categories. Table 2-8 contains a complete list of these categories.

The formulas for calculation of the response rates specify a fraction where the numerator is the number of screening interviews and the denominator is the number of phone numbers associated with eligible respondents. The four different response rate calculations construct numerators and denominators slightly differently. The formulas are as follows (with RR indicating response rate):

$$RR\ 1 = \frac{Completed\ Screening\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews + UnknownEligibility}$$

$$RR\ 2 = \frac{Completed\ Screening\ Interviews + Partial\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews + UnknownEligibility}$$

$$RR\ 3 = \frac{Completed\ Screening\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews + e * UnknownEligibility}$$

$$RR\ 4 = \frac{Completed\ Screening\ Interviews + Partial\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews + e * UnknownEligibility}$$

where

$$e = \frac{Completed\ Screening\ Interviews + Partial\ Interviews}{Completed\ Screening\ Interviews + Partial\ Interviews + Eligible\ NonInterviews}$$

RR1 and RR3 use Completed Screening Interviews as the numerator, while RR2 and RR4 use Completed and Partial Interviews as the numerator. In this survey, as shown in Table 2-8, there were very few partial responses, so that the difference between RR1 and RR2 was negligible as was the differences between RR3 and RR4.

RR1 and RR2 differ from RR3 and RR4 in the way that unknown eligibility was handled. RR1 and RR2 assume that unknown eligible responses were non-responses (non-interviews). RR3 and RR4 consider the possibility that some of the cases with unknown eligibility may have been business lines or other ineligible categories. RR3 and RR4 estimate the proportion of unknown eligible responses from the known responses and non-responses and then apply that proportion to the unknown eligibility category. That proportion is symbolized in the formulas above as *e*.

Table 2-8 contains the distribution of the responses and the response rate calculations.

Table 2-8
Overall Sample Disposition

Response Category	Number of Responses	Percent
Interview		
Completed Screening Interviews	76,826	**13.2**
Partial Interviews	66	0.0
Total	**76,892**	**13.2**
Eligible/Non-interview		
Refusal and Break Off	95,604	16.5
Total	**95,604**	**16.5**
Unknown Eligibility/Non-interview		
Always Busy	2,526	0.4
No Answer	65,405	11.3
Answering Machine-Don’t Know if Household	22,160	3.8
Call Blocking	4,580	0.8
Housing Unit, Unknown if Eligible Respondent	486	0.1
No Screening Interview Completed	73,851	12.7
Total	**169,008**	**29.1**
Not Eligible		
Fax/Data Line	21,416	3.7
Disconnected Number	130,674	22.5
Non-working Number	21,788	3.8
Temporarily Out of Service	3,428	0.6
Number Changed	10	0.0
Cell Phone	1,091	0.2
Business, Gov’t Office, Other Organization	48,315	8.3
Group Quarters	1,449	0.2
No Eligible Respondent	10,665	1.8
Total	**238,836**	**41.2**
TOTAL PHONE NUMBERS USED	**580,340**	**100.0**
AAPOR Response Rates		
Response Rate 1		22.5
Response Rate 2		22.5
Response Rate 3		31.6
Response Rate 4		31.6

Table 2-8 shows that more than one-half million telephone numbers were called for the survey. There were 76,892 interviews; most of which were with non-fire households, and most were in the 39/40th group that were not used for the survey. More than 95,000 households who were contacted began the interview, were determined to be eligible from the initial screening questions, but then decided against participation. Slightly more than 169,000 households were not able to be reached for various reasons; these count as being of unknown eligibility. Finally, almost half the numbers contacted were ineligible because they were disconnected, business lines, non-working numbers, fax or data lines, or in some other way did not represent a household.

Using this data, it was possible to compute the response rates as 22.5 percent for Response Rates 1 and 2, which consider unknown eligibility as non-responses, and 31.6 percent for Response Rates 3 and 4, where it was estimated that 42 percent of those with unknown eligibility would have been eligible.

Response Rate 3 and Response Rate 4 were considerably lower than the 80 percent response rate for the 1984 survey calculated in the same way.[39] That decline was not unexpected given the decline in response rates to random digit dialing (RDD) telephone surveys over the past 20 years.[40]

Conclusion

This chapter has outlined the construction and management of the survey. The basis for the survey was the 1984 survey. Questions were designed from that survey and then modified after pretesting and cognitive testing. An important aspect of the questionnaire design process was to refine the screening questions to help respondents recall if they had a fire in the previous 90 days.

The survey sample was developed from the GENESYS sampling system and census data. The strata were designed to over-sample ethnic and racial groups to provide reasonable estimates from households. The sample also contained an urban/non-urban breakdown. Sample size was allocated to strata on the basis of expected numbers of cases in the ethnic, racial, and geographic breakdowns.

The sample of fire households was about half the number expected. This was because the planning factor for fire households assumed 2.86 fires per 100 households, whereas in fact, there were about half as many households with fires. The smaller number of fire households signaled that the household fire rate had dropped substantially from 1984. Estimates of the household fire rates are presented in the next chapter.

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[39] Audits and Surveys (1985), *op cit.*, Appendix A.

[40] There is an extensive literature on the decreasing response rates. Some authors believe that the decline is probably associated also with caller id, answering machines, and the response to telemarketing. See for example Khare, M (2006), "Sample Design and Issues with Telephone Multi-Mode Surveys." Paper presented at the National Center for Health Statistics Data Users Conference, Washington, DC.

Chapter 3
Fire Incidence

This chapter presents the methods used to estimate fire incidence and then presents the estimates using data from the survey. The methods are examples of techniques for adjusting for lack of recall that is present in many retrospective surveys. The literature indicates that people are often unable to recall recent events. As a result, rates (i.e. incidents divided by time) estimated from retrospective surveys tend to decrease with increasing recall periods. Short recall periods, on the other hand, have smaller sample sizes, with larger sampling variance in the rate estimates. An important decision in these analyses is how much of the recall period to use for making estimates. This chapter applies a method for finding the length of the recall period that balances the bias from the underestimates associated with longer recall periods with the increased variance associated with smaller sample sizes from shorter recall periods.[41]

Following the discussion of the methods for making estimates from recalled events, the chapter presents the annual fire incidence estimates. From the survey, it was estimated that there were 7.4 million annual household fires in 2004-2005, of which 254,441 (97 percent) were fire department-attended and 7.2 million were unattended. This was 6.56 fires per 100 households.

This chapter begins with a discussion of the analytical methods followed by the results of the survey and the CPSC staff's conclusion. Of particular interest in this chapter is the decrease in residential structure fires between this survey and the 1984 residential fire survey.

Methods

Memory and Recall Issues

The analysis of fire incidence rates was based on a series of questions designed to prompt the respondent to recall all home fire incidents that occurred up to 90 days before the interview. The questionnaire defined "fire" as

> *…any incident large or small that resulted in unwanted flames or smoke and could have caused damage to life or property if left unchecked...*

Home was defined as

> *…house, apartment or other residence where you live…*

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[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. Stage 1. 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.

[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

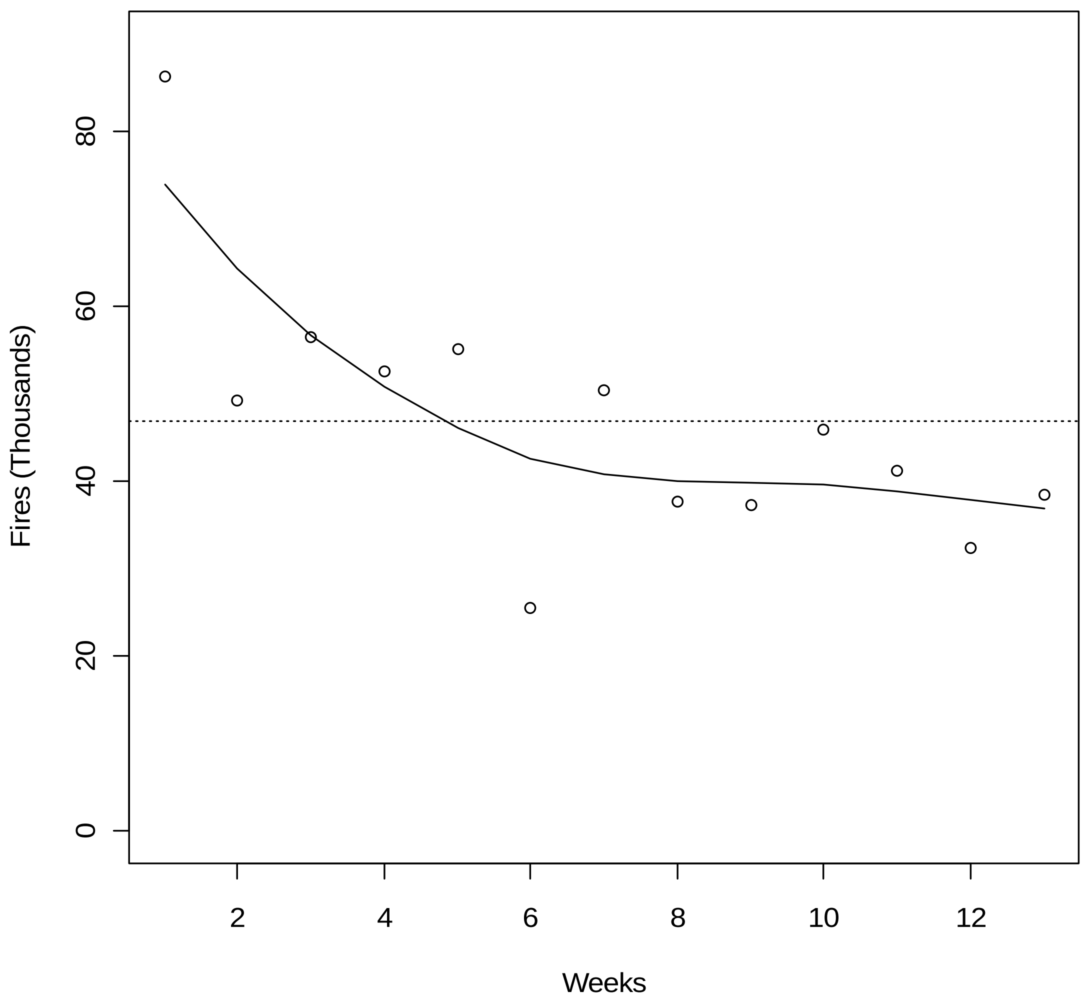
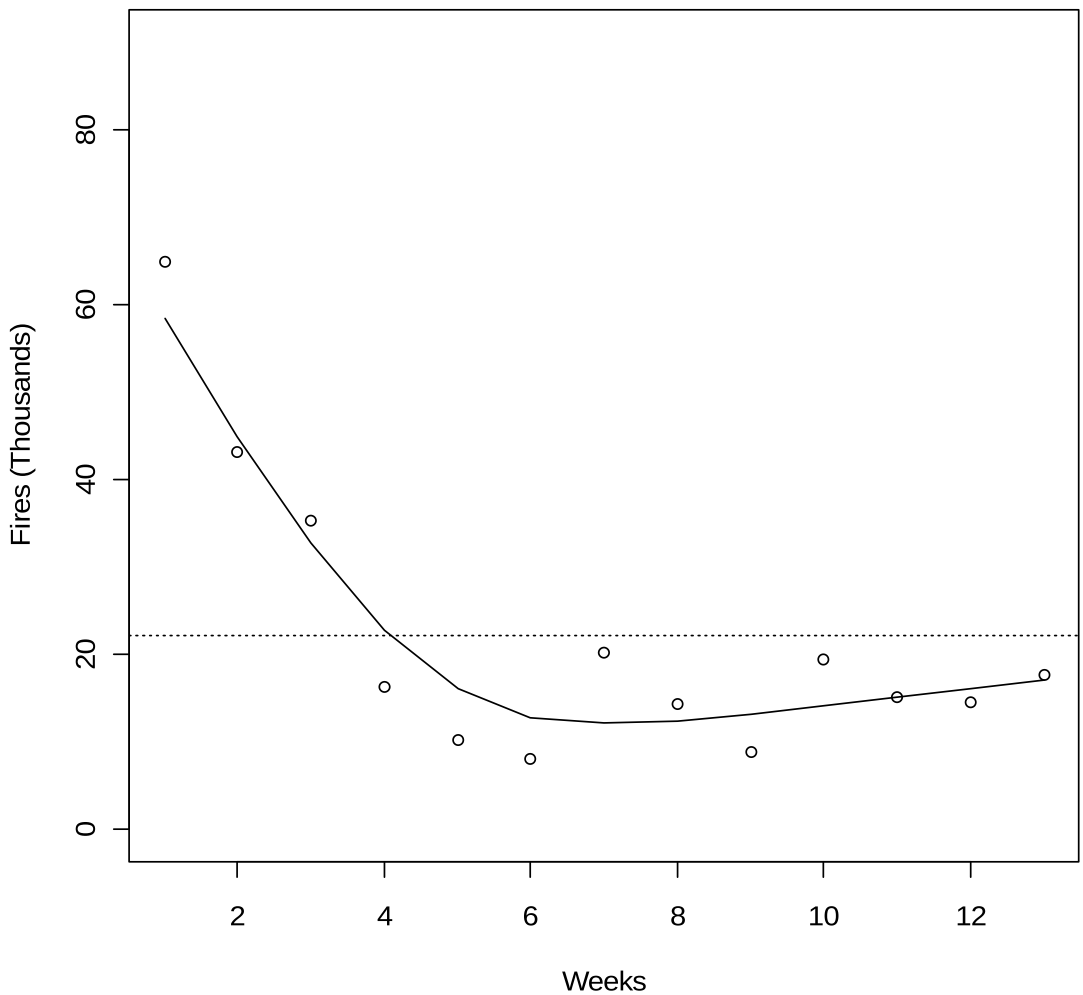


Figure 3-2 shows the same plot for the low severity fires. The estimated weighted average number of fires was 22,150, about 47 percent of the average of the high severity fires (Standard Deviation = 16,290, Range 8,143 – 64,774, Coefficient of Variation = 73.5 percent). Like Figure 3-1, the largest number 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		1-2 weeks		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		1-2 weeks		1-3 weeks	
	Estimated	Fitted	SE	Bias	RMSE	Bias	RMSE	Bias	RMSE
1	3701	3574	704	0	704	367	794	711	1001
1-2	3162	3207	462	-367	**590**	0	**462**	344	576
1-3	2855	2863	358	-711	796	-344	496	0	**358**
1-4	2508	2558	294	-1015	1057	-648	712	-304	423
1-5	2250	2307	241	-1266	1289	-899	931	-555	606
1-6	2066	2113	208	-1460	1475	-1093	1113	-749	777
1-7	1998	1971	189	-1602	1614	-1235	1250	-891	911
1-8	1891	1868	170	-1706	1714	-1339	1350	-995	1009
1-9	1778	1792	156	-1781	1788	-1414	1423	-1070	1082
1-10	1751	1739	147	-1835	1841	-1468	1475	-1124	1134
1-11	1706	1699	138	-1875	1880	-1508	1514	-1164	1172
1-12	1676	1667	131	-1906	1911	-1540	1545	-1195	1203
1-13	1654	1639	124	-1935	1939	-1568	1573	-1224	1230

Notes: See Table 3-1.

Table 3-2 shows that, aside from week 1, the optimum estimation period is the reference period week. The bias tends to be larger (in absolute value) than the high severity incidents in Table 3-1. This indicates that the low severity incidents were more difficult to recall than high severity incidents, as also shown in comparing Figures 3-1 (high severity) and 3-2 (low severity).

In analyzing Tables 3-1 and 3-2, it is clear that one can only choose a recall period after having chosen a reference period. The choice of 1-2 weeks as a reference period was made in keeping with WSHF. Using the lowest value of the RMSE for the high and low severity incidents resulted in a 1-3 week recall period for the high severity fire incidents and a 1-2 week recall period for the low severity incidents.

Annual Residential Fire Estimates

Table 3-3 shows the annual fire estimates based on the recall periods from the last section.

Table 3-3
2004-2005 Fire Estimates by Fire Department Attendance

Fire Department Attendance	Estimated Fires per Year (95% Confidence Interval)	Fires per 100 Households (95% Confidence Interval)
Both	7,430,069 (6,195,938 - 8,664,199)	6.56 (5.46 - 7.64)
Attended Only	254,441 (65,165 - 443,716)	0.22 (0.06 - 0.39)
Unattended Only	7,175,628 (5,933,397 - 8,417,859)	6.33 (5.23 - 7.42)

Notes: Number of fires per household based on 113,343,000 households. Household estimates from http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH2-all.csv.

Table 3-3 shows that there were an estimated 7.4 million household fires per year, which translates to 6.56 fires per 100 households per year. Of these fires, 7.2 million fires were not fire department-attended, according to the survey respondents, and 254,000 were fire department-attended. The NFPA estimates of 410,000 fire department-attended residential structure fires in 2004 and 396,000 in 2005 are within the 95 percent confidence interval for the number of fire department-attended fires.[68] Note that 3.4 percent of fires, or one in 29.2 fires was fire department-attended.

Table 3-4 shows the distribution of estimated total residential fires and per household fire rates by region of the country.[69]

[68] Karter MJ (2005), "Fire Loss in the United States in 2004," National Fire Protection Association, Quincy, MA, and Karter MJ (2006), "Fire Loss in the United States in 2005," National Fire Protection Association, Quincy, MA. The NFPA survey is a probability sample of all U.S. fire departments and typically samples more than 2,500 departments. It is considered the most accurate national sample of fire department-attended fires.

[69] Regions were defined as follows: Northeast: CT, MA, ME, NH, NJ, NY, PA, RI, VT; South: AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV; Midwest: IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, WI; West: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY.

Table 3-4
2004-2005 Fire Estimates by U.S. Region

Region	Estimated Fires per Year (95% Confidence Interval)	Fires per 100 Households (95% Confidence Interval)
All	7,430,069 (6,195,938 - 8,664,199)	6.56 (5.46 - 7.64)
West	2,271.425 (1,911,500 - 2,631,350)	9.09 (7.65 - 10.53)
South	2,822,345 (2,436.329 - 3,208,362)	6.85 (5.91 -7.78)
Midwest	1,065,578 (837,943 - 1,293,212)	4.11 (3.23 - 4.99)
Northeast	1,270,721 (1,063.596 - 1,477,845)	6.00 (5.02 - 6.98)

Notes: Number of fires per household based on 113,343,000 households. Household estimates from http://www.census.gov/population /socdemo/hh-fam/cps2005/tabH2-all.csv.

Table 3-4 shows the distribution of fires by region of the country. The West region is shown to have the highest per household fire rate at 9.09 fires per 100 households, followed by the South, Northeast, and Midwest. Interestingly, this differs from fire department-attended fires. NFPA statistics, based on their probability sample of U.S. fire departments, show the West has the lowest per capita fire incidence and the South has the highest.[70]

One of the objectives for the 2004-2005 survey was to compare the decrease in unreported fire incidence with the decrease in reported fire incidence. Some have suggested that newer technology, such as more and better smoke alarms, would make it possible for residents to detect and extinguish fires when the fire was smaller, thus reducing or eliminating the need for fire department assistance.[71] This would then result in a greater decrease in fire department-attended fires than unattended fires. The results from the survey suggest that this conjecture may not be true. In 1980, using estimates based on the NFPA survey and NFIRS, CPSC staff estimated there were 655,500 fire department-attended residential structure fires, while in 2005, there were 375,100

[70] Karter MJ (2003), "U.S. Fire Experience by Region." National Fire Protection Association, Quincy, MA, Table 3, page 8.
[71] This conjecture has appeared in a number of places. For example, see Audits and Surveys (1985), *op cit.*, page 20.

unintentional residential structure fires.[72] This is a decrease of 43 percent. On the other hand, the number of unreported fires has dropped from 22.9 million in the 1984 survey to 7.2 million, a decrease of 68.7 percent.[73]

The decrease in the number of unreported fires is even more interesting because the number of households has increased from 84 million to 113.3 million, an almost one-third increase in the number of households in the last 20 years.[74] Taking this into account with rates, the 1984 survey estimated an annual household incidence rate of 28.3 (reported and unreported) fires per 100 households per year. The 2004-2005 survey showed that the household fire incidence estimate dropped by 76.8 percent to 6.6 fires per 100 households per year.

Conclusion

Estimation of events from retrospective surveys immediately confronts the analyst with problems associated with recall. This occurred in the 1974 survey, with a one-year recall period and the 1984 survey where the recall period was three months. In the 1984 survey, because of recall problems, fire incidence rates were estimated only from the previous month's data. To determine the length of the recall period for the current survey, a method was adapted from WSHF that involved a tradeoff between sampling variance and recall bias.

The tradeoff is as follows: lower sampling variance is associated with longer recall periods, but longer recall periods have fewer events recalled per week leading to a downward bias in the estimate of annual fire incidence rates. In keeping with WSHF, the two-week period was defined as the reference period. Applying the WSHF method required finding the recall period with the smallest mean square error, defined as the sum of the square of the bias and the sampling variance.

The particular refinement of the WSHF method involved stratifying the recall period by the severity of fire incidents. It seemed plausible that incidents that were more severe would be remembered more easily. A severity indicator was developed that defined higher severity cases as those where a smoke detector operated, an attempt was made to extinguish the fire, there was obvious flame damage, the fire department-attended, or people had to leave the residence during the fire. The analysis showed that

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[72] The 1980 estimates are in Mah J (2001), *op cit.*, Table 6. 2005 estimates from Chowdhury R, Greene M and Miller D (2007), *loc cit.* page 21. Statistics for 1984 were not available. As fires have been decreasing over time, the number of fires in 1984 were likely to have been less than in 1980, and as a result, the percentage decrease in reported fires had we been able to use the 1984 estimates, would have been lower than reported above.

[73] The most appropriate comparison in the 1984 survey was unreported residential structure fires. That excludes brush fires and motor vehicle fires that were sampled in the 1984 survey, but were not in the 2004-2005 survey. See Audits and Surveys, *op cit.*, page 22.

[74] The 1984 survey was based on a population of 83,815,800 households and on 23.7 million (reported and unreported) residential structure fires in the 1984 survey. See Audits and Surveys, *op cit.*, page 22. The increase from 1984 to 2004-2005 was 35 percent.

the best (lowest mean square error) recall period was 21 days for these higher severity incidents. For the other, lower severity incidents, a 14-day recall period was best. This made sense because one would expect lower severity incidents to be more difficult to recall.

Using the 14-day low severity and 21-day high severity recall periods, annual fire incidence was estimated at 7.4 million fires, of which 7.2 million were unattended by fire departments and 254,000 were fire department-attended. The estimate of fire department-attended was lower than the comparable estimate from the NFPA annual survey, but the sample size for attended fires in the Residential Fire Survey was small and the confidence interval was large. On a per household basis, the estimates were 6.56 total fires per 100 households. When broken down by region, the West had the highest per household fire incidence rate and the Midwest had the lowest.

The estimates in this survey are substantially lower than the "recall adjusted" 1984 survey. The earlier survey estimated 25.2 million total residential fires (23.7 million residential structural fires) on an estimated U.S. population of 83.8 million households. This was a household incidence rate of 28.3 residential structure fires per 100 households per year. The current survey shows that to have decreased to 7.4 million residential structural fires, a decrease of 76.8 percent.

Although the 1984 survey and the present survey differ in the estimation methodology and in some of the survey questions, the difference in the household fire incidence estimates is too large to be explained by differences in methodology or survey questions. As a result, it seems safe to conclude that there has been a substantial change in the number of household fires. Factors associated with those changes are the explored in Chapter 6 and Chapter 7 of this report.

Chapter 4
Comparisons of Fire and Non-fire Households

In Chapter 3, it was estimated that the annual household fire incidence rate was 6.56 fires per 100 households per year. The purpose of Chapter 4 is to identify the socioeconomic characteristics that differ between fire and non-fire households. Previous research has identified presence of smokers, mobile home housing type, presence of young and old household members, minority status, low income, and alcohol use as more likely to characterize fire households, that is, these characteristics are risk factors for fires.[75]

Fire households are defined in this chapter and in Chapter 5 as households with at least one fire in the 91-day recall period. This definition is somewhat different from the definition used in Chapters 3, 6, 7, and 8 where only fires occurring in the 14- and 21-day recall periods were used in the analysis. The 1984 survey in comparing fire and non-fire households also used the full three-month period in the comparisons even though fire incidence rates were estimated from a one-month recall period. Reasons for this different definition are discussed in the next section.

The tables in this chapter contrast fire and non-fire households according to region of residence, housing characteristics, household size and age distribution, number of smokers, and other demographic characteristics.

Some of the differences between fire and non-fire households in the present survey were as follows:

- Fire households were more likely to be renters and less likely to be owners of their residences than non-fire households.
- Fire households had more members than non-fire households. In comparing household sizes by age group (under 18, 18-64, 65 and over), fire households had more members under 18 and between 18 and 64 than non-fire households. Non-fire households had more people 65 and over.
- The heads of fire households tended to have higher educational levels than heads of non-fire households.

The following variables differed significantly between fire and non-fire households: type of dwelling, age of residence, race or ethnicity, whether or not there was at least one smoker in the household, and household income. On average, there were a larger number of smokers in fire households than non-fire households, with a difference that was almost

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[75] For example, see Runyan CW, Bangdiwala SI, Linzer MA, Sacks JJ and Butts J (1992), "Risk Factors for Fatal Residential Fires," *New England Journal of Medicine, 12,* 327: 859-863. Mobley C, Sugarman JR, Deam C and Giles L (1994), "Prevalence of Risk Factors for Residential Fire and Burn Injuries in an American Indian Community," *Public Health Reports, 109,* 5, 702-705. Warda L, Tenenbein M, Moffatt MEK (1999), "House Fire Injury Prevention Update. Part I. A Review of Risk Factors for Fatal and Non-fatal House Fire Injury." *Injury Prevention* 5: 145-150.

statistically significant. This is different from the 1984 survey, where there was a significant difference in the proportion of fire households with smokers than non-fire households. The newer finding about smokers might reflect the overall decline in smoking rates in the U.S. over the past 20 years.

The next section describes the methods used in this chapter. The results and conclusion sections follow.

Methods

Defining Fire Households

An issue arising in this chapter and in Chapter 5 is how to define fire and non-fire households. In Chapter 3, in estimating the annual household fire incidence rate, the only fires that were counted were those low severity fires in the 14-day recall period and the high severity fires in the 21-day recall period. Extending this idea would result in defining households with fires in the 14 or 21 days before the interview as fire households and all other households as non-fire households. This would have resulted in defining 257 households as fire households.[76] The issue, then, is how to assign the remaining 659 households that had fires between 22 and 91 days before the interview. The following choices were considered:

- Include these cases with the non-fire households
- Exclude the cases from the analysis, that is, treat them neither as fire households nor non-fire households
- Include the cases with the fire households.

The last choice, to include these cases with the fire households, was selected. The reasons are discussed below.

The analyses in Chapter 3 suggested that some of the non-fire households may actually have had fires during the 14/21-day recall period but were unable to remember them. Thus, it seems extremely likely that there were non-fire households that actually had fires but were unable to recall them. The effect of these apparent misclassifications is to blur the differences in characteristics between fire and non-fire households. This meant that stronger differences in characteristics would be necessary in order to find them in the data. Therefore, including the 22-91 day fire households with the non-fire households would further contaminate the non-fire households with households known to have had fires, further weakening the ability to identify factors that distinguished between fire and non-fire households.

[76] Recall that in Chapter 3, missing dates were imputed for some fire incidents. For a given household with a missing fire date to be imputed, in one of the imputations, a fire date could fall in the 14- or 21-day recall period, while on another imputation, that same fire date might fall outside the recall period. Thus, the number of fire households would depend on the particular imputation.

The second option of discarding these cases was rejected because it reduced the size of the sample without providing any substantive benefit. There would still be non-fire households that actually had fires. The third option of including the 22-91 day fire households with the other fire households seemed to be the best option because these households were known to have had fires and, as a result, were more likely to resemble the fire households than the non-fire households.[77]

Another reason for grouping the 22-91 day fire households with the fire households was for consistency with the 1984 survey. Aware of recall issues, the authors of the 1984 survey used a one-month period for estimating fire incidence rates, but the full three-month period was used for comparing factors that differed between fire and non-fire households.[78] Using the same definition of fire households facilitates making comparisons between the two surveys.

Statistical Analyses

The tables in this chapter were prepared using Proc Surveyfreq, averages were computed with Proc Surveymeans, and differences between averages were estimated using Proc Surveyreg, all in the SAS® software system.[79] Two-way tables were tested for independence between the particular survey variable measuring some household characteristic and whether the household was a fire or non-fire household, i.e., whether there was an association between household fire status and the characteristic tested. The test statistic used was the Rao-Scott Likelihood Ratio F statistic, a test statistic that is corrected for the survey design.[80] This was different from the test statistic and the procedure used in the 1984 survey.[81]

Statistical tests were applied to the actual table shown or, when cell counts were small, to a collapsed version of the table. Table notes indicate whether the test statistic came from the original table or a collapsed version. Data in tables are shown in percentages. Missing data (not associated with survey skip patterns), responses of "don't

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[77] In view of the analysis of fire severity in Chapter 3, it is likely that the fires recalled in the 22-91 day period among households that only had fires in that period would be of greater severity than those in the 14- and 21-day recall periods.

[78] Audits and Surveys (1985), *op cit.,* p. 12. The recall period for estimating fire incidence rates was the calendar month before the month of the interview. All respondents were interviewed in the first two weeks of the month.

[79] SAS Institute Inc. (2004), *SAS/STAT®, 9.1 User's Guide.* Cary, NC: SAS Institute Inc.

[80] *Ibid*., volume 9, pages 4219-4221. See also Rao, JNK and Scott, AJ (1984), "On Chi-Squared Tests for Multiway Contingency Tables with Cell Properties Estimated from Survey Data," *The Annals of Statistics*, 12, 46-60 and Rao, JNK and Scott, AJ (1987), "On Simple Adjustments to Chi-Square Tests with Survey Data," *The Annals of Statistics*, 15, 385-397. The correction for the survey design involves the proportions under the null hypothesis of independence. The F test is recommended as a better approximation.

[81] The 1984 survey used unweighted chi square hypothesis tests. The text does not explain the computational details, but it is likely that the chi square test was applied to the original survey data before weighting. This was a reasonable practice in the 1980s before the advent of modern sample survey software, but is no longer common practice.

know," and refusals to respond were excluded before the computation of percentages -- a procedure that essentially allocates non-responses in proportion to the responses.

Results

Region of Residence

Table 4-1 shows the distribution of region of residence for fire and non-fire households.

Table 4-1
U. S. Region of Residence by Fire and Non-fire Households (Percent)

U. S. Region	Fire Households	Non-fire Households
Northeast	18.9	19.3
South	35.3	36.8
Midwest	18.8	23.2
West	26.9	20.8

Notes: Based on n = 3077 observations. Test statistics for the table contrasting fire and non-fire households by region, F =3.1390, p = 0.0243. Weighted distribution of the survey (i.e., fire and non-fire households) was as follows: *Northeast* 19.3 percent, *South* 36.7 percent, *Midwest* 23.2 percent, and *West* 20.8 percent. Census data by region are as follows: *Northeast* 18.7 percent, *South* 36.4 percent, *Midwest* 22.9 percent, and *West* 22.0 percent. Source: U.S. Bureau of the Census, Table H2. Households, by Type, Age of Members, Region of Residence, and Age, Race and Hispanic Origin of Householder for 2005, are available at http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH2-all.csv. Regions are defined in the footnote below.[82]

In comparing fire and non-fire households by region, note that there were relatively more fire households than non-fire households in the West (i.e., 26.9 percent vs. 20.8 percent), about the same balance between fire and non-fire households in the South and Northeast, and fewer fire households than non-fire households in the Midwest. The difference between fire and non-fire households by region was statistically significant. This pattern is similar to the difference in per capita household fire rates shown in Table 3-4 of Chapter 3, where the West had the highest rates, the Midwest had the lowest rates, and the South and Northeast were in the middle. As noted in Chapter 3, the regional distribution was different from statistics on fire department-attended fires as reported by the NFPA, where the West had the lowest per capita rates.[83]

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[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

<u>Smoke Alarms.</u> 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.

[120] The survey asked if alarms had been tested only of fire households in the situation when the alarm did not sound during the fire. There is more information on this in Chapter 8.
[121] U.S. Fire Administration (2006), "Investigation of Fatal Residential Structure Fires with Operational Smoke Alarms." Topical Fire Research Series, U.S. Fire Administration, Emmitsburg, MD, page 4.
[122] Hall JR Jr. (2005), "Home Cooking Fire Patterns and Trends." National Fire Protection Association, Quincy, MA, page 6.
[123] For example, see Fire Protection Association Australia (2005), "Fire Safety Data Sheet: Fire Extinguishers." Victoria, Australia.

Chapter 6
Characteristics of Residential Fires

This chapter and the next two chapters return to the analysis of fires that was begun in Chapter 3. In that chapter, it was estimated that there were 7.43 million fires annually, of which 254,000 were attended by fire departments and 7.18 million were unattended. That was a ratio of 28.2 unattended fires for each fire department-attended fire, or, to put it another way, about 3.5 percent of all residential fires were attended by fire departments.

This chapter has two objectives, first, to begin to describe the characteristics of residential fires and, second, to contrast fire incidents that were attended by fire departments with those that were not. Chapter 7, which follows, analyzes only unattended fires, presenting a more detailed breakdown of the characteristics of those fires and the households that experienced them. Chapter 7 also compares fire incidence in the present survey with the 1984 survey, in part to provide a more detailed analysis of the factors associated with the decline in fires between 1984 and the present survey.[124] Chapter 8 focuses on the role played by smoke alarms and fire extinguishers in fires.

Following the description of the methods immediately below, the results are separated into four sections as follows:

- Comparison of demographic and other characteristics of households with attended and unattended fire incidents
- Comparison of fire characteristics of attended and unattended fire incidents
- Fire losses in attended and unattended incidents
- Presence or absence of smoke alarms and extinguishers in attended and unattended incidents

The last part of the chapter discusses and summarizes the characteristics that discriminate between attended and unattended fires. An appendix to the chapter presents estimates of the amount of the sampling error as related to the estimated number of fires.

Methods

The analyses in Chapters 6, 7, and 8 are based on the 14-day recall period for low severity incidents and the 21-day recall period for high severity incidents, as introduced in Chapter 3. Non-fire households or households where the fire occurred outside the 14/21-day recall period are not considered in these chapters.[125] This makes the data different from Chapters 4 and 5, which defined fire and non-fire households on the basis of whether a fire occurred in the full 91-day period. Also, the unit of analysis in Chapters

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[124] The 1984 survey is found in Audits and Surveys, Inc. (1985), *op cit.*
[125] In Chapter 7, comparisons between the present survey and the 1984 survey use all fires in the three-month period. See that chapter for details.

6, 7 and 8 is the fire, not the household, thus households with two fires in the period provide two separate records, and those with three fires provide three records.

The data in this chapter and the next two chapters were prepared in a similar way to the data used to estimate fire incident rates in Chapter 3. First, non-fire household records were removed, leaving a dataset with the 916 fire household records, describing 961 fire incidents. Each record contained up to three fire incidents and a description of the household characteristics. The dataset was then merged with the imputation dataset that contained 15 fire dates for each fire. Variables in the imputation dataset were the date of each fire incident reported by the household, the severity of each fire, the sampling weight (expansion weight from Chapter 2), the date of the telephone interview with the household, and the household stratum.[126] If the fire household had specified month and day of the fire, then the fire date on each of the 15 imputation records would have been identical. Otherwise, when day or month was missing, the dates were imputed 15 times using the probabilistic imputation process as described in Chapter 3. The reason for multiple imputations was to incorporate some additional variability in the dates of the fire, ultimately leading to additional variability in the household fire incidence rates.

The merged dataset contained (15 x 916=) 13,740 records, i.e., one record for each fire household. This was then expanded to the number of fires (15 x 961=14,415 fire records), with each record containing both household, and fire characteristics. Because each fire incident was replicated 15 times, the weights were then divided by 15 to bring them back to the correct sampling weights. This then allowed the sample to represent the 7.43 million annual fires in the U.S. that were estimated in Chapter 3.

The tables in this chapter were developed by partitioning the fire incidents into various categories associated with the fire, the household, or both. Examples include region of the country, age of residence, household income, fire department-attended or unattended. SAS® data step programs were written to extract the cases and assign the categories. Tabulation of the estimated number of fires in each category was done using Proc Freq or Proc SQL in the SAS system.

While all fire incidents (i.e., attended and unattended collectively) and unattended fire incidents (separately) are estimated reasonably precisely with coefficients of variation (CVs) of 8.5 and 8.8 percent, respectively, fire department-attended fires are estimated with much less precision, with a CV of 37.9 percent, because there are far fewer attended incidents in the survey.[127] Of the 961 fire incidents in the survey, between 260 and 271 incidents were in the 14/21-day recall period and were used to estimate the total number of fires. These are the only incidents used in this chapter and the next two chapters. Of these incidents, between 14 and 16 incidents were fire department-attended.

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[126] There were 11 strata, as discussed in Chapter 2.
[127] The CV is the standard deviation divided by the mean and is expressed as a percent. The standard deviation includes the variability attributable to sampling and to imputation. For more details see Chapter 3.

The small number of fire department-attended incidents not only contributes to the amount of sampling variability in the estimated incident rate (measured by the size of the CV) but also restricts further analysis of attended fires. With between 14 and 16 fire department-attended fires, there can be at most 16 different areas where the fire started, 16 different heat sources, 16 different items first ignited, etc. As a result, some low probability categories in the tables are likely to have no estimated attended fires -- not because there were no attended fire incidents in the U.S. during the year, but because the survey did not have any of these incidents. These cases are indicated with a dash in the tables rather than a zero. The reader needs to be aware of this limitation of the data when looking at the attended fires and the ratio of unattended to attended fires in the tables in this chapter. This issue also extends to any breakdown of fire incidents, such as area of fire origin, heat source, etc. where the number of estimated fires is relatively low and therefore likely to have been based on a small number of actual responses.

Like the estimates for attended and unattended fires in Chapter 3, every estimated number of fires in this chapter and every ratio of unattended fires to attended fires have an associated standard error and confidence interval. To avoid cluttering the tables, these statistics are not presented in the tables. Instead, the reader can get a sense of the precision of the estimate from the coefficient of variation. As the estimated number of fires increases, the CV decreases. Tables relating the CV to the estimated number of fires and text describing how the tables were constructed are found in the appendix to this chapter. These tables can be used as a generalized variance (CV) function. For more information on the generalized variance function, see Wolter.[128]

The tables in this chapter show estimated fires (in thousands), broken down by unattended and attended, and the ratio of unattended to attended fires.

Results

Household and Demographic Characteristics

Table 6-1 shows the breakdown of attended and unattended fires by area of the country.

[128] Wolter KM (1985), *Introduction to Variance Estimation*. Springer-Verlag, NY, Chapter 5.

Table 6-1
Estimated Unattended and Attended Fires by Region
(Thousands of Fires)

Region	All Fires	Unattended Fires	Attended Fires	Unattended Fires per Attended Fires
All	7,430	7,176	254	28.2
South	2,822	2,717	105	25.9
West	2,271	2,175	97	22.5
Northeast	1,271	1,238	33	37.8
Midwest	1,066	1,046	20	52.4

Notes: Totals may not add due to rounding. The last column is Unattended Fires divided by Attended Fires. Ratios are computed in SAS® based on the unrounded estimated number of fires and may not agree exactly with the ratio of rounded fires. The first row, *All*, does not change in any of the tables and will not appear in any other tables in this chapter. The percentage of U.S. households by region is as follows: Northeast 18.7 percent, South 36.4 percent, Midwest 22.9 percent and West 22.0 percent. See Chapter 4, Table 4-1 for a listing of states in each region. Approximate CVs for estimated fires in thousands: 1,000, 27.2 percent; 2,000, 22.1 percent; 3,000, 17.9 percent. For details about how the CV is calculated, see the appendix to this chapter.

In Table 6-1, it appears that the largest estimated number of fires, both unattended and attended, was in the South, followed by the West, Northeast, and Midwest.[129] This is not surprising considering that the South (as defined in the survey) has the largest number of households; the West and Midwest have about the same number of households; and the Northeast has the fewest households. Correcting for the number of households, then, the number of fires (both unattended and attended) per 100 households was as follows: South 6.85, West 9.09, Northeast 6.00, and Midwest 4.11.[130] In addition to having the smallest per household fire rate, the Midwest also had proportionately fewer fire department-attended fires with 52.4 unattended fires per attended fire. This was followed by the Northeast at 37.8 unattended to attended fires, the South and the West at 25.9 and 22.5, respectively.

Of the 7.43 million fires, 5.98 million occurred in urban regions and 1.45 million in non-urban regions. In urban regions, 5.83 million were unattended and 154,000 were attended, while in non-urban regions, 1.35 million were unattended and 101,000 were

[129] Usually the term "estimated" will not appear with fires. The reader should understand that all statistics in this survey are estimated, not actual counts of events.
[130] Households by region from the U.S. Bureau of the Census obtained from http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH2-all.csv.

attended. The ratio of unattended to attended fires was 37.9 in urban regions and 13.4 in non-urban regions.

By dwelling type, 4.63 million fires occurred in single family residences and 2.64 million occurred in other types of residences.[131] Other types included apartments, mobile or manufactured homes, multifamily dwellings, townhouses, row houses and condos. Within single family residences, 115,000 fires were fire department-attended, for a ratio of 39.2 unattended fires per attended fire. Other home types had 124,000 fire department-attended fires, for a ratio of 20.3 unattended fires per attended fire.

In owner occupied housing, there were 4.86 million fires, of which 194,000 were fire department-attended. Among renters, there were 2.53 million fires, of which 45,000 were fire department-attended. Note that in the U.S. there are more than twice as many households that own rather than rent their residences.[132] Thus, the number of fires per 100 households was 6.19 for owner occupied housing and 7.58 for rental housing. Owners had 24.1 unattended fires for each attended fire, while renters had 55.1 unattended fires for each attended fire.[133]

Table 6-2 shows the relationship between the age of residence and fire department attendance.

[131] Respondents did not know the type of residence or refused to respond in cases covering 157,000 fires.
[132] Households by type of occupancy from the U.S. Bureau of the Census at http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-all.csv.
[133] Respondents accounting for 46,000 fires did not know or refused to answer if they rented or owned the residence.

Table 6-2
Attended and Unattended Fires by Age of Residence
(Thousands of Fires)

Age of Residence (years)	All Fires	Unattended Fires	Attended Fires	Ratio
0-15	2,669	2,667	2	1,182.0
16-25	1,280	1,224	56	21.8
26-35	948	885	63	14.1
36-45	699	628	71	8.8
46 or older	1,474	1,427	47	30.5

Notes: See notes for Table 6-1. Ratio is Unattended Fires divided by Attended Fires. Respondents reporting 360,000 fires did not know or refused to provide the age of the dwelling. All quantities are estimates. Approximate CVs for fires in thousands: 700, 37.2 percent; 1,000, 27.2 percent; 2,500, 19.9 percent.

In the survey data, as shown in Table 6-2, there were almost no fire department-attended fires in properties 15 years or newer. The ratio of unattended to attended fires appears to decline as properties age. This suggests that fires in older properties are more likely to involve fire departments than newer properties. For properties 46 years old or older, however, the ratio is higher with relatively fewer attended fires.

Table 6-3 shows the distribution of attended and unattended fires by household income.

Table 6-3
Attended and Unattended Fires by Household Income
(Thousands of Fires)

Household Income	All Fires	Unattended Fires	Attended Fires	Ratio
$0-$14,999	628	628	-	-
$15,000-$34,999	1,894	1,781	113	15.8
$35,000-$74,999	1,630	1,564	66	23.8
$75,000 or more	2,040	2,010	30	67.9

Notes: See notes for Tables 6-1 and 6-2. Also, the table does not include responses representing 1.24 million fires where the respondent either refused to provide or did not know the household income. No fire department-attended fires were reported for survey respondents with household incomes less than $15,000 per year. This is shown with a dash (-) in the table to symbolize that infrequent outcomes are unlikely to be reported in samples. It does not mean that there were no fire department-attended fires in the U.S. occurring in households with incomes less than $15,000 per year. Approximate CVs for fires in thousands: 600, 42.2 percent; 1,500, 24.5 percent; 2,000, 22.1 percent.

Table 6-3 shows that there were no fire department-attended fires in residences where households reported incomes of $15,000 or less. The relationship between household income and unattended fires shows that as incomes increase the ratio of unattended to attended fires increases, suggesting that relatively more attended fires occurred in lower income residences.

With respect to the household size, no clear pattern emerged relating the number of people in the household to the distribution of attended and unattended fires, as shown in Table 6-4 below.

Table 6-4
Attended and Unattended Fires by Household Size
(Thousands of Fires)

Number of People in the Household	All Fires	Unattended Fires	Attended Fires	Ratio
1	951	941	11	89.2
2	1,788	1,737	51	34.1
3	1,522	1,442	80	18.0
4	1,637	1,614	23	69.0
5 or more	1,427	1,353	74	18.3

Notes: See notes for Tables 6-1 and 6-2. The table omits responses representing 104,000 fires where the respondent refused to provide the household size. Approximate CVs for fires in thousands: 1,000, 27.2 percent; 1,500, 24.5 percent.

Taking the distribution of household size in the population into account, it appears that per household fire incidence increases with household size.[134] Households with a single member had 3.2 fires per 100 households, two member households had 4.8 fires, three member households had 8.3 fires, four member households had 10.0 fires, and larger households had 12.9 fires per 100 households. This pattern of increasing fire incidence was also consistent for unattended fires and attended fires separately. The ratio of unattended to attended fires was not consistently increasing or decreasing with household size, as shown above.

Households with at least one member under 18 years of age reported 3.78 million fire incidents, of which 3.65 million were unattended and 124,000 were attended. Households with no members under 18 had 3.56 million fires, of which 3.43 million were unattended and 131,000 were attended. The unattended to attended ratios were 29.5 for households with a member under 18 and 26.3 for households without any members under 18; both ratios are close to the overall ratio of 28.2 unattended fires per attended fire. Taking the number of households in the population into account showed 9.4 fires per 100 households in households with at least one member under 18 and 4.9 fires per 100 households when no household members were under 18.[135]

[134] In 2005, there were 30.1 million households with a single member, 37.4 million with two members, 18.3 million with three members, 16.4 million with four members, and 11.1 million with five or more members. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-all.csv.
[135]There were 40.1 million households with at least one member under 18 and 73.3 million households with no members under 18. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-all.csv.

Households with at least one member at least 65 years of age reported 344,000 fires, of which 312,000 were unattended and 32,000 were attended. Households with no members 65 years of age and older reported 6.99 million fires, 6.78 million unattended and 222,000 attended. Taking the household population into account, this was 8.1 fires per 100 households for those with all members 64 and younger and 1.3 fires per 100 households for all households with at least one member over 64.[136] The ratios were 30.5 unattended fires for each attended fire for households with members 64 and younger and 9.7 unattended fires to attended fires for households with at least one household member over 64.[137]

With respect to ethnicity, households identifying themselves as having a household head of Hispanic or Latino descent reported 777,000 fires, of which 684,000 were unattended and 93,000 were attended, for a ratio of 7.4 unattended fires to attended fires. On a population basis, there were 6.4 fires per 100 such households.[138]

By race, families with a White head of household reported 5.32 million fires, 5.15 million unattended and 173,000 attended fires for a ratio of 29.8 unattended fires to attended fires. This was 5.7 fires per 100 households.[139] Families with a Black household head reported 640,000 fires, of which 600,000 were unattended and 40,000 were attended, for a ratio of 15 unattended fires per attended fire. Correcting for population, there were an estimated 4.6 fires per 100 households.[140]

Fire Characteristics

This section focuses on the characteristics of residential fires.

Table 6-5 shows the distribution of unattended and attended fires by the location in the residence where the fire started.

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[136] There were 86.8 million households with all members under 65 and 26.5 million with at least one member 65 or over. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-all.csv.
[137] Responses are not shown for both age group analyses representing 93,000 fires where the respondent did not know or refused to provide information about the household composition.
[138] Respondents refused to disclose the ethnicity of the head of household in cases representing an estimated 345,000 fires. There were 12.2 million households with a Hispanic head. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-hisp.csv. Note that Hispanic persons may be of any race and, as a result, may also be counted as Black or White household heads.
[139] Based on 92.9 million households. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-whitealone.csv.
[140] Based on 13.8 million households. Source: http://www.census.gov/population/socdemo/hh-fam/cps2005/tabH1-blackalone.csv.

Table 6-5
Attended and Unattended Fires by Area of Fire Origin
(Thousands of Fires)

Area of Fire Origin	All Fires	Unattended Fires	Attended Fires	Ratio
Kitchen	5,080	4,987	93	53.4
Living room	569	530	39	13.7
Bedroom	505	505	-	-
Bathroom	438	438	-	-
Other areas	373	355	18	20.1
Basement	210	199	11	17.3
Dining room	160	140	20	7.0
Attached garage	95	22	73	0.3

Notes: See notes for Tables 6-1 and 6-2. *Other areas* include exterior of the house, siding, hall or entryway, porch or deck, inside enclosed wall space, laundry room, storage area, attic, or unspecified areas. The last category had more than half the incidents. Numbers may not add to totals due to rounding. Approximate CVs for fires in thousands: 150, 74.5 percent; 400, 54.3 percent; 5,000, 11.8 percent.

Table 6-5 shows that the largest number of fires at 5,080,000 began in the kitchen. Most were not attended by the fire service and the ratio is about twice the overall average at 53.4 unattended fires to attended fires. Also, fires beginning in bedrooms and bathrooms with 505,000 and 438,000 incidents, respectively, were also unlikely to be fire department-attended. On the other hand, fires starting in living rooms (569,000 incidents), dining rooms or dining areas (160,000 incidents), or basements (210,000 incidents) and garages (95,000 incidents) were more likely to be fire department-attended.

Table 6-6 shows the distribution of types of fire by heat source.

Table 6-6

Attended and Unattended Fires by Heat Source
(Thousands of Fires)

Heat Source	All Fires	Unattended Fires	Attended Fires	Ratio
Cooking appliances	4,757	4,664	93	49.9
Open flame	783	744	39	19.1
Other household appliances	671	651	20	32.6
Electrical lighting and wiring	616	616	-	-
Heating and cooling equipment	326	281	46	6.2
Cigarettes	167	155	11	13.5
A fire that spread to the house	92	47	45	1.0
Other (unspecified)	17	17	-	-

Notes: See notes for Tables 6-1 and 6-2. *Open flame* includes candle, match, lighter, torch, spark from a fireplace, and fireworks. Approximate CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 600, 42.2 percent; 800, 32.8 percent; 4,500, 13.1 percent.

As expected from Table 6-5 where the majority of estimated fires began in the kitchen, cooking appliances dominate the heat sources shown in Table 6-6. A larger proportion of cooking appliance fires is likely to be unattended by the fire service, with a ratio of 49.9 unattended to attended fires. Other household appliances (non-cooking by definition), the third most frequent source of heat with 671,000 fires, were also less likely to be attended by fire departments, with a ratio of 32.6 unattended to attended fires. There were no attended fires recorded for electrical lighting and wiring fires, or other unspecified fires. On the other hand, fires originating in heating and cooling equipment (326,000 incidents) or a lit cigarette (167,000 incidents) were more likely to involve fire department attendance, with ratios of 6.2 and 13.5 unattended to attended fires, respectively. Fires involving open flame were also more likely to be fire department-attended, with 19.1 unattended fires per attended fire.

Table 6-7 displays the item first ignited in residential fires.

Table 6-7
Attended and Unattended Fires by Item First Ignited
(Thousands of Fires)

Item First Ignited	All Fires	Unattended Fires	Attended Fires	Ratio
Cooking materials	4,009	3,915	93	41.9
Appliance	690	690	-	-
Unspecified	660	660	-	-
Paper	417	407	10	40.8
Linen	361	361	-	-
Bedding	253	253	-	-
Electrical wire	244	244	1	422.0
Clothing	130	130	-	.
Cabinetry	110	72	39	1.8
Household utensils	96	96	-	-
Light vegetation	95	95	-	-
Decoration	73	73	-	-
Floor covering	64	64	-	-
Structural members	55	10	45	0.2
Other materials	172	107	65	1.6

Notes: See notes for Tables 6-1 and 6-2. *Other materials* include rubbish, heavy vegetation, a person burned by a fire or flame, upholstered furniture, animal, pipe, mattress, or wood. Note that none of these categories was associated with more than 45,000 fire incidents. Approximate CVs for fires in thousands: 150, 74.5 percent; 200, 70.0 percent; 400, 54.3 percent; 700, 37.2 percent; 4,000, 14.6 percent.

As shown in Table 6-7, the most frequent item first ignited was cooking materials, accounting for 4.0 million incidents, with 41.9 unattended fire incidents for each attended incident.[141] The second most frequent item first ignited in fires was an appliance,

[141]Item First Ignited refers to the fuel load that was ignited by the heat source and at least for a short time had the capability to sustain the fire. This produced some confusion among many survey respondents who specified the container or the heat source instead. For example, frequently in cooking fires, respondents mentioned the pan or pot on the stove as the item first ignited. This is impossible because metal cookware cannot ignite except at very high temperatures. We changed this to "cooking materials," assuming that the respondent meant that the contents of the cookware had ignited. Other respondents specified the source of heat as the item first ignited, for example when they specified "appliance" as the item first ignited. Respondents may have believed that objects engulfed in flames were ignited. There is a more detailed discussion about the process for coding Item First Ignited in Chapter 7.

probably the cooking appliances in many cases. There were no fire department-attended fires for many categories including appliances, unspecified, linen, bedding, clothing, household utensils, and others. Of the Items First Ignited categories, only cabinetry, structural members (walls, floors, beams) and other materials were associated with a substantial proportion of attended fires relative to unattended fires.

Table 6-8
Attended and Unattended Fires by Time of Day
(Thousands of Fires)

Time Of Day	All Fires	Unattended Fires	Attended Fires	Ratio	Fires per Hour
6 am – noon	1,287	1,226	61	20.0	214.5
Noon – 5 pm	1,923	1,864	60	31.2	384.6
5 – 9 pm	2,827	2,766	61	45.0	706.8
9 pm – midnight	898	887	11	77.4	299.3
Midnight – 6 am	494	433	61	7.2	82.3

Notes: See notes for Tables 6-1 and 6-2. Time of Day includes the left endpoint but does not include the right endpoint. Time of Day was determined from two variables. Respondents were first asked what time the fire occurred. If they reported that they did not know, they were then asked if the fire occurred in one of the following periods, the morning, afternoon, evening, at night, or overnight. If they asked for further clarification, the Time of Day categories shown in Table 6-8 were read to them. Approximate CVs for fires in thousands: 400, 54.3 percent; 900, 28.9 percent; 1,000, 27.2 percent; 2,000, 22.1 percent; 3,000, 17.9 percent.

Table 6-8 shows most fires occurred between 5 pm and 9 pm, which is consistent with most fires in the survey being cooking related. To compare the distribution of fires, it is best to compare fires per hour rather than total fires in Table 6-8 because some time categories have more hours than other time categories. On an hourly basis, 5 pm to 9 pm had the highest hourly fire incidence followed by noon to 5 pm and 9 pm to midnight. Fires occurring between midnight and noon were less frequent on an hourly basis.

In terms of the ratio of unattended to attended fires, fires between noon and midnight were more likely to be unattended than fires between midnight and noon. Many of the fires later in the day were cooking fires, which previous tables have shown to involve fire department attendance less frequently than fires involving other heat sources and different areas of origin.

Fire Losses

The next set of tables contrasts fire department-unattended and attended fires by the extent of fire losses. In general, the tables show that fire departments were likely to have attended fires with greater fire losses.

Table 6-9
Attended and Unattended Fires by Extent of Flame Damage
(Thousands of Fires)

Flame Damage	All Fires	Unattended Fires	Attended Fires	Ratio
None	4,429	4,397	32	136.0
Item first ignited only	2,507	2,458	49	50.2
Several items	302	229	73	3.1
Whole room	81	36	45	0.8
Beyond room	39	-	39	-
Whole house	15	-	15	-
Outside house only	55	55	0	190.0

Notes: See notes for Tables 6-1 and 6-2. The table omits responses involving 1,000 fires where respondents did not know the extent of flame damage. Attended fires for *Outside house only* is greater than zero but rounded to zero. There were no reported unattended fires for *Beyond room* and *Whole house* categories. Approximate CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 2,500, 19.9 percent; 4,500, 13.1 percent.

Aside from the last row, Outside house only, Table 6-9 is arranged in order of increasing flame damage. Table 6-9 shows that as the extent of flame damage became larger, it was more likely that the incident was fire department-attended.

As shown in the table, most fires did not involve any flame damage or involved damage only to the item first ignited, and most were not attended by fire departments. When there was no flame damage, as was the case with 4.4 million fires, there were 136 unattended fires for each attended fire. When the damage was to the item first ignited only, which occurred in 2.5 million fires, there were 50.2 unattended fires to each attended fire. Damage to several items resulted in 3.1 unattended fires to every attended fire. When the damage involved the whole room, there were more attended fires than unattended fires; and when the damage spread outside the room or to the whole house, all fires were attended by fire departments.

Table 6-10
Attended and Unattended Fires by Extent of Smoke Damage
(Thousands of Fires)

Smoke Damage	All Fires	Unattended Fires	Attended Fires	Ratio
None	5,472	5,442	31	178.0
A little smoke damage	1,164	1,104	60	18.5
Damage in most of the room	338	314	23	13.5
Damage to another room	91	80	11	7.0
Damage in whole house	315	186	129	1.4
Outside of house only	48	47	0	164.0

Notes: See notes for Tables 6-1 and 6-2. Omits responses associated with 2,000 fires where respondents did not know or refused to provide information on the extent of smoke damage. *Outside of house only* attended fires was greater than zero but rounded to zero. Approximate CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 5,000, 11.8 percent.

Like Table 6-9, the extent of smoke damage is in ascending order in Table 6-10, with the exception of the last row. Table 6-10 shows that, like flame damage, most fires also involved no smoke damage or a small amount of smoke damage. Of the 7.4 million fires, almost 5.5 million had no smoke damage, and 1.2 million had what respondents reported to be “a little smoke damage.” On the other hand, relatively few fires, under one-half million incidents, had smoke damage that spread to another room or the whole house.

Table 6-10 also shows that as smoke damage increased, the ratio of unattended fires to attended fires decreased, indicating more fire department presence was associated with fires with greater amounts of smoke damage. For example, when there was no smoke damage, there were 178 unattended fires for every attended fire. This decreased to 18.5 unattended fires for every attended fire (below the survey average of 28.2) for fires involving a little smoke damage, 13.5 when most of the room was damaged by smoke, and to 7.0 when another room was involved.

Table 6-11
Attended and Unattended Fires by Cost of Property Damage
(Thousands of Fires)

Property Loss	All Fires	Unattended Fires	Attended Fires	Ratio
None	3,819	3,810	9	407.0
$1-$99	2,212	2,182	30	72.4
$100-$999	844	834	10	83.6
Over $1000	303	109	194	0.6

Note: See notes for Tables 6-1 and 6-2. Also, respondents were asked to specify an estimate for property damage that would include the cost of repair or replacement of the home and contents. They were asked to include costs even if the costs were covered by insurance. The table omits responses associated with 251,000 fire incidents where the respondents did not know or refused to provide an estimate of the property damage. Approximate CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 800, 32.8 percent; 2,000, 22.1 percent; 4,000, 14.6 percent.

Table 6-11 shows that most residential fires had no reported property damage, and for these fires, almost all were not attended by the fire service. This pattern of almost no fire department attendance generally held true until the fire damage exceeded $1000, where there were more attended fires than unattended fires.

In 65,000 fire incidents, the conditions after the fire required families to stay out of the residence for one night or more. Of these, 9,600 fires were unattended and 55,000 were attended for a ratio of 0.2 unattended fires to attended fires; i.e., almost all such fires were attended by fire departments. In the remaining 7.4 million fires (7.2 million unattended and 199,000 attended), where the respondents could return immediately after the fire, the ratio was 35.9.

The last measure of fire losses is whether people were hurt or injured in the incident. There were an estimated 130,000 people who got sick or were injured in fires.[142] All the incidents where these fire losses occurred were reported to have been unattended by fire departments.

[142] Survey respondents reported in question 72 that somebody was hurt, got sick, or died in the fire in an estimated 180,000 fire incidents. When question 72 was answered positively, then the respondents were asked questions 74 and 76 about the number of deaths and injuries, respectively. There were no reported deaths in the answer to question 74, and there were an estimated 130,000 people reported to have been injured or sickened in the fire. It is likely that respondents may have changed their minds about several injuries or illnesses. Survey interviewers did not probe about the discrepancy. In any case, the relative standard error (or CV) is so large for an estimated 130,000 or 180,000 illnesses or injuries that the difference between 130,000 or 180,000 incidents is not statistically meaningful.

Smoke Alarms and Extinguishers

As noted in Chapter 4, most fire and non-fire households had smoke alarms. There were 6.5 million fires (6.3 million unattended and 239,000 attended) where there were smoke alarms present and 749,000 fires (734,000 unattended and 15,000 attended) in residences where there were no smoke alarms. The ratios were 26.4 unattended fires for each attended fire in residences with smoke alarms and 47.4 unattended fires for each attended fire where there were no smoke alarms present. In residences where smoke alarm were present, it was more likely that fires were attended rather than unattended, but such an effect may be due to other housing, demographic, or fire characteristics.

With respect to fire extinguishers, there were 4.7 million fires in residences with extinguishers, of which 4.6 million were unattended fires and 150,000 were attended fires. Households without extinguishers had 2.7 million incidents of which 2.6 million were unattended and 105,000 were attended. Households with extinguishers had 30.7 unattended fires per attended fire, while those households without extinguishers had 24.6 unattended fires per attended fire. This indicates the presence of extinguishers had at best a small effect in reducing the number of fire department-attended fires.

Conclusion

This chapter presented descriptions of the characteristics of the estimated 7.4 million fire department-attended and unattended fires from the Residential Fire Survey. Like Chapter 3, the analysis was based on the 14- and 21-day recall periods, scaled to estimate annual and per household fire incidence. Estimates in this chapter have more sampling variability than total fire estimates from Chapter 3, because they are based on partitions of the data, which result in smaller samples. As shown in the appendix to the chapter, the sampling variability, expressed as a percent of the estimate, decreases with increasing estimates. Estimates of less than one million fires have a coefficient of variation of at least 27 percent; estimates less than one-half million, 50 percent; and estimates of less than 250,000, about 66 percent.

In the chapter, it was shown that the largest number of fires was in the South, followed by the West, Northeast, and Midwest. Given how the regions were defined, the South had the largest population of households, and the Northeast and West had the lowest. On a per household basis, the West had the largest fire incidence at 9.09 fires per 100 households, followed by the South and Northeast, with the Midwest as the lowest. About twice as many fires occurred in owner occupied housing as renter occupied housing. This was expected because there was about twice as much owner occupied housing as renter occupied housing in the U.S. Correcting for the type of occupancy showed that there were 6.19 fires per 100 households for owner occupied housing and 7.58 fires per 100 households for renter occupied housing.

In terms of the ratio of unattended to attended fires, the pattern was the same as the per household basis by region. The West had the lowest ratio of unattended to attended fires (i.e., a larger proportion of fires were fire department-attended than in other regions), followed by the South and Northeast, with the Midwest as the highest. Although owner occupied housing had a smaller per capita fire incidence, there was a higher ratio of unattended to attended fires among renters than owners.

In urban regions, fires were three times more likely to be unattended than in non-urban regions. About twice as many fires occurred in single family residences than other types of residences. This was to be expected because more people live in single family homes than other types of residences. In single family home fires, there were 39.9 unattended fires per attended fire, while in non-single family housing there were 20.7 unattended fires per attended fire. As housing of all types aged, the ratio of unattended to attended fires decreased, indicating that there were relatively more attended fires in older housing. This ratio increased with income, indicating that lower income households had relatively more attended fires.

The per household fire incidence rate also was shown to increase with increasing household size. Households with one member had 3.2 fires per 100 households, two members 4.8 fires, and five and larger households 12.9 fires per 100 households. Households with a family member under 18 had 9.4 fires per 100 households in contrast to those without anyone under 18 at 4.9 fires per 100 households. Households with a family member 65 or older had 1.3 fires per 100 households in contrast to those without anybody 65 or older at 8.1 fires per 100 households.

There was no consistent pattern between the ratio of unattended to attended fires and household size, or whether the household had a family member under 18. However, households with at least one member 65 or older had 9.5 attended fires for every unattended fire in contrast to other households with 30.5 when all the household members were under the age of 65. Thus, there were fewer fires in households with older members, but when fires occurred, they were more likely to be fire department-attended.

By race and ethnicity characteristics, the fire rate was 4.6 fires per 100 households for households with a Black household head, 5.7 fires per 100 households for households with a White household head and 6.4 fires per 100 households for households with a Hispanic or Latino head of household. Also, households headed by Hispanic and Black persons had fewer unattended fires per attended fire than households headed by White persons.

Most fires (5.1 million -- both attended and unattended) began in the kitchen, and most fires (4.8 million) were cooking-related. These fires were less likely to be fire department-attended than other fires as there were 49.9 unattended cooking appliance fires per fire department-attended fire. Almost all cooking fires began in the kitchen. Fires starting in the living room and dining room, although much less frequent, were more likely to involve the fire department, as were fires involving cigarettes and other open flame heat sources. Heating and cooling equipment fires also were more likely to involve the fire department, as were fires starting in the basement, as well as fires involving cabinetry or structural materials.

By time of day, the most likely time for fires was between 5 pm and 9 pm, followed by noon to 5 pm. The period 5 pm to 9 pm also had the second highest ratio of unattended to attended fires, consistent with this time being the time that the evening meal is cooked. On the other hand, fires occurring between midnight and noon, while occurring less frequently on a per hour basis than other times of the day, had the lowest ratio of unattended to attended fires. Thus fires occurring between midnight and noon were relatively more likely to involve fire departments.

Most fires involved no loss or very small losses (although with so many fires, the total losses were not insignificant). According to respondents, most fires had no flame damage and no smoke damage. In these cases, with no reported damage or property loss, the ratio of fire department-unattended to attended incidents was quite high. For example, the ratio was 136.0 unattended to attended fires when there was no flame damage, 178.0 when there was no smoke damage, and 407.0 when there was no property loss. In contrast, when there was flame damage to several items or the whole room; smoke damage to most of the room, another room or the whole house; and property damage over $1000, the proportion of unattended to attended fires was much lower.

Most residences, as described in Chapter 4, had smoke alarms. Households with smoke alarms were more likely to have fire department-attended incidents than households without smoke alarms. For households with smoke alarms, there were 26.4 unattended fires per attended fire, while those without smoke alarms had 47.4 unattended fires per attended fire. This difference in the ratio of unattended to attended fires may be related to other household characteristics that differ in smoke alarm and non-smoke alarm households.

Households with fire extinguishers had 30.7 unattended fires to attended fires while, non-extinguisher households had 24.6 unattended fires to attended fires. Everything else being constant, extinguishers may be associated with a small reduction in the proportion of fire department-attended fires.

The findings of this chapter should be considered as associations between fires and other factors rather than causal relationships, because examining one factor at a time only can provide an overall characterization of incidents. The next chapter continues this examination in a more detailed way. In that chapter, fire incidents are analyzed by source of heat, i.e., appliance and non-appliance fires. Within the categories of appliance fires, cooking fires, electrical lighting and electrical wiring fires, heating and cooling appliance fires, and other household appliance fires are analyzed separately. Non-appliance fires include cigarette fires and small open flame fires. The next chapter also compares the number of various types of non-fire department-attended fires with the estimates from the 1984 survey.

Appendix to Chapter 6

Generalized Coefficient of Variation[143]

As mentioned in the text for this chapter, it is undesirable to put confidence intervals or coefficients of variations (CV) with each estimate in the text. However, reporting statistics without a measure of sampling error does not provide the reader with any sense of precision of the estimate. An approach to this is to provide a generalized coefficient of variation that can guide the reader about the approximate precision of any given estimate.

The CV is the standard error (standard deviation of the estimate) divided by the parameter estimate. When normal distribution theory holds, the 95 percent confidence interval for parameters such as means or proportions can be expressed as the

$$\text{Parameter Estimate} * (1 \pm 1.96 * \text{CV}/100) \qquad (1)$$

where the CV is a percent. Equation (1) shows that the variability around the parameter estimate is about twice the CV.

All other things being equal, the CV should decrease with increasing parameter estimates.

To estimate the relationship between the estimated number of fires and the CV, we randomly generated samples from the dataset of different sizes, ranging from 1.5 percent of the fire incidents to 85 percent of the incidents.[144] Only incidents in the 14/21-day recall period were used. Graphical analysis showed that the relationship was exponential, which could be linearized by using the log of the CV instead of the CV.

After transforming to the log of CV, the graphical analysis shows that from an estimated 1,000,000 fires to 6,500,000 fires, the graph was linear and very smooth (R^2 *adjusted*=0.9443). The equation for the CV estimated by the regression relationship was

$$\text{CV} = 33.4567 * exp(-0.0002081119 * \text{Fires}/1000) \qquad (2)$$

Selected values of the CV computed with equation (2) are shown in Table A3-1 below.

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[143] For more information on the generalized variance function see Wolter (1985), *op cit.*, Chapter 5.
[144] Sampling of cases and computation of estimated standard errors used the SAS® System (Proc Surveymeans and Proc MIAnalyze); similar to the approach as that used in Chapter 3. Graphical analysis and regression computations were made in the *R* language.

Table A3-1
Generalized Coefficients of Variation
(1,000,000-6,000,000 Fires)

Estimated Number of Fires (thousands)	Coefficient of Variation (percent)
1,000	27.2
1,500	24.5
2,000	22.1
2,500	19.9
3,000	17.9
3,500	16.1
4,000	14.6
4,500	13.1
5,000	11.8
5,500	10.7
6,000	9.6

For example, if the estimated number of fires was 3,000,000 (shown as 3,000 in Table A3-1), then the CV is 17.9 percent and the 95 percent confidence interval would be 1,946,000 - 4,054,000. To put it another way, the confidence interval would be plus or minus approximately 35.8 percent of the parameter estimate.

The equation fits best in the middle of the range. The values in Table A3-1 are most accurate in the middle of the table and less accurate at the lower or upper end.

A separate regression model was fitted to values from 200,000 to 1,000,000 fires. The fitted equation was

$$CV = 90.0531 * exp(-0.001262848 * Fires/1000) \qquad (3)$$

The fit was also good, with an R^2 *adjusted* value of 0.8896. Tabled values of equation (3) are below in Table A3-2.

Table A3-2
Generalized Coefficients of Variation
(150,000-950,000 Fires)

Estimated Number of Fires (thousands)	Coefficient of Variation (percent)
150	74.5
200	70.0
250	65.7
300	61.7
350	57.9
400	54.3
450	51.0
500	47.9
550	45.0
600	42.2
650	39.6
700	37.2
750	34.9
800	32.8
850	30.8
900	28.9
950	27.1

The variance and CV of parameter estimates from survey data depends on the number of cases, the weights associated with the cases, and the distribution of the values of the estimates within and between the strata. Two estimates that resulted in the same estimated number of fires could have different CVs because the number of fires between or within strata was different. However, the generalized CVs should provide the reader with an approximate value of the sampling variability of estimates of various sizes.

Chapter 7
Consumer Products Involved in Unattended Residential Fires

In Chapter 3, it was estimated that there were 7.43 million residential fires in the U.S., of which 7.18 million were not attended by the fire service. The estimated number of unattended fires was about one-third of the 22.9 million unattended residential structure fires estimated to have occurred in 1984 by the last residential fire survey. One question raised by the current survey estimates in Chapter 3 is why there has been such a steep decline in the number of residential fires, and in particular, unattended fires. To understand this decline, it is necessary to examine the nature of residential fires more closely. This examination was begun in Chapter 6, and continues in this chapter where the focus is on where in the residence the fire began and the consumer products that were involved in the fire.

A major objective of this chapter is to compare fires by type between the 1984 survey and the current survey. Some methodological issues with this comparison are discussed in the next section.

The analysis in this chapter, like in Chapters 3, 6, and 8, is based on fires rather than households. The source data for the fire estimates in this chapter are the low severity fire incidents that occurred during the 14-day recall period and the high severity incidents that occurred during the 21-day recall period. To facilitate comparison with the 1984 survey, only fire incidents reported not to have been attended by fire departments are used in this chapter. If all fire incidents had been used instead of only unattended incidents, the results would differ very slightly because of the small number of attended fires. Separate analyses for only attended fires are not recommended because the estimates from attended fires have large relative variances because of the small number of such incidents.

Following the methods section, the chapter begins with an overview of the origin and causes of residential fires as reported in the survey, including the room of origin, time of origin, types of equipment or appliances, item first ignited in the fire, and other characteristics. Then the chapter focuses on the major categories of equipment (or appliances) involved in residential fires, namely fires associated with cooking equipment, electrical wiring, and heating and cooling equipment. Fires not involving appliances, such as those associated with candle, match, lighter, and cigarette heat sources are then analyzed. The last section is a discussion and summary of the results. An appendix to this chapter provides more detail on the methods used in making comparisons between estimates from the current survey and the 1984 survey.

Methods

One objective of this chapter is to compare the fire estimates from the current survey with the estimates from the 1984 survey. By breaking down the estimates by fire origin, heat source, cause, and other factors, it is possible to develop some insight as to how the composition of unreported residential fires has changed in the 20 years between the surveys. However, this raises a problem because there is a major difference between the two surveys in the way that the data are analyzed. In the 1984 survey, even though a one-month recall period was used for estimating total attended and unattended fire incidence, data from the full three months were used for more detailed analyses. These included analyses of where fires started in the residence, the item first ignited, and other such breakdowns. The three-month estimates were then scaled to the totals from the one-month period, so that the total number of fires agreed with the one-month estimates.[145]

This then presents two options for the analysis of the current survey as follows:

- <u>Option 1</u>. Estimate consumer product-related fire incidence in the current survey using the 14/21-day recall period.
- <u>Option 2</u>. 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."

[149] United States Fire Administration (2003), "NFIRS 5.0 Complete Reference Guide." Emmitsburg, MD, pages 4-18.

Table 7-3
Item First Ignited in Unattended Residential Fires
(Thousands of Fires)

Item First Ignited	Number of Fires	Percent
All fires	7,176	100.0
Cooking materials	3,915	54.6
Appliance casing or housing	690	9.6
None or unspecified	660	9.2
Paper	407	5.7
Linen	361	5.0
Bedding	253	3.5
Electrical wire	244	3.4
Clothing	130	1.8
Household utensils	96	1.3
Light vegetation	95	1.3
Other items	325	4.5

Notes: See notes for Table 7-1. *Other items* include the following in descending order of frequency: cabinetry, floor covering, heavy vegetation, person or animal, rubbish, and structural members. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 400, 54.3 percent; 700, 37.2 percent; 4,000, 14.6 percent. Items with estimated numbers of fires under 90,000 are included in *Other items* and are not presented on separate lines. Because of the difficulties in interpreting the survey responses to the questions associated with Items First Ignited, as discussed in the text, some responses may not be reliable.

In Table 7-3, the largest category was cooking materials at 3.9 million fires or 54.6 percent of the total. This result is consistent with cooking fires as the most frequent type of fire incident. Some other items listed in the table such as appliance casing or housing, linen, and clothing can be ignited by cooking equipment. Appliance casing or housing, none or unspecified (no item mentioned), paper, linen, bedding, electrical wire, and clothing were the remaining categories with appreciable estimated numbers of incidents.

An estimated 130,000 people were injured or got sick in these incidents; approximately one injury or illness for every 56 fires. Of these, 102,000 illnesses or injuries were associated with cooking fires and 27,000 were associated with open flame fires.[150] About half the illnesses or injuries in cooking fires involved cooking materials (food, cooking oil, or grease). When asked what type of medical attention was required, the largest response category was no medical attention (97,000 illnesses/injuries), and the

[150] The respondent(s) did not specify the type of open flame. It was not a candle, match, lighter, torch or spark from fireplace.

second largest was first aid received at the scene (32,000 illnesses/injuries). The most frequent type of injury was burns (101,000 illnesses/injuries), followed by other, unspecified (28,000).[151]

Respondents were asked if they had to stay somewhere other than their residence for a night or more because of the fire. There were an estimated 9,600 fires where this occurred. In these incidents, the residents returned within a week. All of these were cooking-related fires.

Table 7-4 below shows the average and total dollar value of property loss by heat source. These fires involved an estimated total damage to buildings and contents of $612 million.

[151] The injury and illness estimates above are based on very small sample sizes and, as a result, have CVs that are at least 75 percent. Also, in the introduction to Chapter 6, it was pointed out that low probability events are unlikely to be captured when there are small sample sizes. This does not mean that low probability events such as serious injuries and hospitalization do not occur in fires, just that they were not captured in the data.

Table 7-4
Average and Total Dollar Value of Property Loss
by Heat Source for Unattended Residential Fires
(Thousands of Fires)

Heat Source	Number of Fires	Average Loss Per Fire ($)	Total Loss (Million $)
All heat sources	7,176	85.32	612.2
Cooking appliances	4,664	70.30	327.9
Open flame	744	25.79	19.2
Other household appliances	651	242.58	157.9
Electrical lighting and wiring	616	70.30	43.3
Heating and cooling equipment	281	180.94	50.8
Cigarettes	155	16.95	2.6
Other heat sources	64	48.83	3.1

Notes: See notes for Table 7-1. Definitions of heat sources are found in the notes for Table 7-2. Dollar loss is direct loss per fire, as reported in the survey, including expenses for repairing the residence and replacement of the contents of damaged areas. Property loss was not reported for an estimated 240,000 fires. Average damage is based on records reporting property loss; total loss is computed from the number of fires and the average loss per fire. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 600, 42.2 percent; 4,500, 13.1 percent.

The largest category of total dollar loss involved cooking appliances, at $327.9 million, with an average loss of $70.30 per incident. The loss attributed to cooking fires represented more than half the total estimated loss from all unattended fires.

By individual incident, the costliest types of incidents involved other household appliances with an average cost per fire of $242.58 (total loss $157.9 million), heating and cooling equipment at $180.94 per fire (total of $50.8 million), and something else at $179.99 per fire ($3.1 million).[152] Fires involving appliances tended to be more costly on average than other types of fires because the cost may have included repair or replacement of the appliance. Note that cigarette and open flame incidents had the lowest reported property damage per incident at $16.95 and $25.79 per incident, collectively accounting for almost $22 million or 4 percent of estimated total fire losses.

Household Appliance/Equipment Fires -- An Overview

[152] There is more detail on other household appliances in Table 7-16 and Table 7-17.

As shown in Table 7-2, the source of heat for most fires was cooking appliances. In the analysis of fire data, fire incidents are often separated into those involving appliances or equipment and those where the heat source was not an appliance.[153] In Table 7-5, appliances included the following categories: cooking appliances, electrical lighting or wiring, another household appliance, and heating or cooling equipment. Non-appliances included various open flame sources (as described in Table 7-2) and lit cigarettes, lightning, and unspecified.

Collectively, appliances were involved in 6.2 million fire incidents, accounting for 86.6 percent of all unattended residential fires. By type of area, 84.7 percent of fires in urban areas (4.9 million fires) involved appliances, while in non-urban areas 94.7 percent (1.3 million fires) involved appliances. In detached single family homes, 81.8 percent of the fires (3.8 million fires) involved appliances, while in other types of residences, 95.0 percent of the fires (2.4 million fires) involved appliances.

Between 1984 and 2004, the estimated number of appliance fires not attended by the fire service decreased by 65.3 percent, and non-appliance fires decreased by 84.0 percent.[154] As the largest component of non-appliance fires were those started by cigarettes and small open flames, this decline in non-appliance fires probably reflects the decrease in smoking-related incidents.

Table 7-5 records the estimated number of unattended residential appliance fires and non-appliance fires by time of day when they occurred.

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[153] Appliance and Equipment are used in this text as synonyms. The National Fire Incident Reporting System (NFIRS) uses the term equipment and does not use the term appliance, but in keeping with the 1984 survey and more widespread usage, the term appliance is usually used in this report.

[154] Appliance and non-appliance fires are from the 1984 report in Audits and Surveys (1985), Table 6-2. Tabulations of non-appliance fires were not further broken down into smoking materials, open flame, etc. in the 1984 survey, so those comparisons cannot be made with the present survey.

Table 7-5
Time of Fire Occurrence of Unattended Residential Fires
By Appliance and Non-appliance Fires
(Thousands of Fires)

Time of Day[155]	All	Number of Fires Appliance	Non-appliance
All times	7,176	6,212	964
6 am – noon	1,226	1,147	79
Noon – 5 pm	1,864	1,544	320
5 – 9 pm	2,766	2,408	358
9 pm – midnight	887	696	190
Midnight – 6 am	433	417	17

Note: Notes: See notes for Table 7-1. Also, Time of Day includes the left but not the right endpoint, e.g., fires occurring at noon are in the *Noon – 5 pm* time period. The table excludes equipment classified as other (0.2 percent of incidents). Appliance fires include cooking appliances, heating and air-conditioning equipment, electrical lighting or wiring, and other household appliances. Non-appliance fires include all other categories. Estimated CVs for fires in thousands: 200, 70.0 percent; 400, 54.3 percent; 700, 37.2 percent; 1,000, 27.2 percent; 1,500, 24.5 percent; 2,500, 19.9 percent; 3,000, 17.9 percent.

Table 7-5 shows that most appliance fires (38.1 percent) and most non-appliance fires (37.1 percent) occurred between 5 and 9 pm. The highest hourly fire incidence rate was also in that period, at 1,648 appliance fires per hour and 24 non-appliance fires per hour.[156] The next highest hourly rate was 845 appliance fires per hour between noon and 5 pm.

Table 7-6 shows item first ignited by appliance and non-appliance fires.

[155] The time categories shown in the table were selected because the survey offered respondents a choice of specifying the actual time of the incident, or if they were unable to recall the time, the time periods in the table.
[156] Note that each part of the day in the table may contain a different number of hours. For example, the periods *6 am – Noon* and *Midnight – 6 am* each include 6 hours, *Noon – 5 pm* has 5 hours, etc. To compare rates with different numbers of hours, hourly rates were calculated by dividing the number of fires by the product of the number of hours in the period and the number of days in the year (365.25). The time categories were taken from the survey instrument. For more details, see Table 6-8, in Chapter 6 and the text following that table.

Table 7-6
Item First Ignited in Unattended Residential Fires
by Appliance and Non-appliance Fires
(Thousands of Fires)

Item	Appliance Fires Number	Appliance Fires Percent	Non-appliance Fires Number	Non-appliance Fires Percent
All	6,212	100.0	964	100.0
Cooking materials	3,879	62.5	-	-
Appliance case	649	10.4	-	-
None	483	7.8	177	18.4
Linen	318	5.1	-	-
Electrical wire	244	3.9	-	-
Paper	219	3.5	188	19.5
Bedding	179	2.9	-	-
Household utensils	92	1.5	-	-
Light vegetation	-	0.0	92	9.6
Other	149	2.4	503	52.2

Notes: See notes for Table 7-1. Items first ignited with estimated numbers of fires fewer than 90,000 are shown collectively in the *Other* category.[157] Dashes in the table indicate estimated number of fires under 90,000. Items first ignited for Appliance-*Other* fires include clothing and floor coverings. Items first ignited for Non-appliance-*Other* Fires include bedding, decorations, cabinetry, heavy vegetation, clothing, and other items. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 600, 42.2 percent; 4,000, 14.6 percent.

The distribution of items first ignited by appliance and non-appliance fires are very different. As cooking fires were the largest category of appliance fires, it is not surprising that cooking materials represented the largest category of item first ignited with 3.9 million fires (62.5 percent) where an appliance was the heat source. These are followed by appliance case (housing and casing) at 649,000 fires (10.4 percent) which were also probably largely cooking related. No item first ignited reported (483,000 fires or 7.8 percent), linen (mostly kitchen towels, pot holders, etc. at 318,000 or 5.1 percent), paper (219,000 fires or 3.5 percent), electrical wiring (244,000 fires or 3.9 percent), and bedding (179,000 fires or 2.9 percent) constitute almost all the remaining items. For fires that had non-appliance heat sources, paper was the largest category of item first ignited at 188,000 fires or 19.5 percent, followed by no item reported (177,000 fires or 18.4 percent), and light vegetation (92,000 fires or 9.6 percent).

[157] Excluding detailed estimates with fewer than 90,000 fires will not be consistently used in this chapter, but is being used with item first ignited, because it appears that the question may not have been answered reliably by many respondents. See the discussion following Table 7-3.

The next sections contain analyses on the four main categories of fires with appliances as heat sources as follows: cooking fires, electrical wiring fires, heating and cooling equipment fires, and other household appliance fires.

Cooking Fires

Table 7-7 shows the types of cooking appliances involved in residential fires.

Table 7-7
Cooking Appliances Involved in Unattended Residential Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All cooking appliances	4,664	100.0	63.3
Stove/Range (all power types)	3,789	81.2	61.4
Electric	2,596	55.7	
Gas	1,131	24.2	
Other	62	1.3	
Microwave oven	332	7.1	
Toaster oven, toaster	208	4.5	69.0
Outdoor grill	124	2.7	
Coffeemaker, teapot	68	1.5	85.3
Countertop oven	48	1.0	
Other cooking appliance	42	0.9	
Unspecified	52	1.1	

Note: See notes for Table 7-1. Also, *Unspecified* includes fires where the respondent identified the heat source as “other appliance” and “don’t know” and those who indicated that the fire involved a cooking appliance but did not answer the question to specify the appliance. The category *Stove/Range* includes electric, gas and other powered stoves. *Gas* includes the responses “gas, type unknown,” “natural gas,” and “propane.” *Other* power sources for *Stove/Range* include wood, charcoal, and fuel oil, and the response “other.” Percentage decreases are only presented for the categories reported in the 1984 survey. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 1,000, 27.2 percent; 2,500, 19.9 percent; 4,000, 14.6 percent.

Table 7-7 shows that stoves (including both the top burners and the oven unit), accounted for the largest amount of fire department-unattended cooking appliance-related fires at 3.8 million fires (81.2 percent). Electric stoves were involved in 55.7 percent of the incidents and gas stoves were involved in 24.2 percent of the cooking appliance fires.

According to the American Housing Survey in 2005, 61 percent of households used electricity as their cooking fuel and 39 percent used gas.[158] This would indicate about 3.8 stove fires per 100 households with electric stoves per year and 2.6 stove fires per 100 households with gas stoves per year. This is about a 47 percent higher unattended fire risk factor for electric stoves. The risk factor for attended fires computed from official statistics also shows a 47 percent increased risk factor for electric stoves as compared with gas. Interestingly, the official statistics show that the risk of civilian injury due to electric stoves was 118 percent higher and property damage was 133 percent higher. However, the risk of fire deaths for gas stoves was 15 percent higher.[159]

Cooking appliance-related unattended fires decreased 63.3 percent between 1984 and 2004, a slightly smaller decrease than all fires.[160] There was a similar decrease in stove-related fires and toaster oven-related fires. Coffee and teapot fires decreased the most by 85.3 percent. The 1984 survey reported the number of fires associated with some other cooking appliances, such as deep fryers and frying pans. For 2004 there were too few fires involving these cooking appliances to show in Table 7-7; however, the estimated number of fires decreased by 92.0 and 95.5 percent, respectively.

In the 2004 survey, 71.5 percent of cooking appliance fires involved electric appliances and 23.1 percent involved gas (natural gas, propane, butane, or type of gas unspecified). In comparison with the 1984 survey, there was a 57.6 percent decrease in electrically powered cooking appliance fires since 1984 and a 68.6 percent decrease in gas appliance-related fires.[161]

Table 7-8 shows that most of the cooking-related fires involved food, cooking oil, or grease catching on fire. This type of incident accounted for 83.2 percent of the cooking-related fires or 3.9 million fires. Also, 289,000 fires involved linens (6.2 percent), mostly dish towels, pot holders, and tablecloths. The remaining items first ignited that accounted for more than 90,000 fires were no item first reported (126,000 fires and 2.7 percent), and paper (95,000 fires and 2 percent). Items with small estimated numbers of fires are shown in the Other line. These included household utensils such as plastic spoons and containers, clothing, appliance housings or casings, bedding, and light vegetation. Collectively they accounted for 275,000 fires and about 5.9 percent of the total.

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[158] U.S. Census Bureau (2006b), Current Housing Reports, Series H150/05, *American Housing Survey for the United States: 2005*. U.S. Government Printing Office, Washington, DC, 20401, Table 1A-5, page 6.
[159] Hall JR Jr. (2005), *op cit*.,, page 8, and Table 8, page 27. Also, Smith L, Monticone R, and Gillum B (1999), "Range Fires: Characteristics Reported in National Fire Data and a CPSC Special Study." U.S. Consumer Product Safety Commission, Washington, DC.
[160] Cooking fires in 1984 from Audits and Surveys (1985), *op cit*. All cooking fires from Table 6-4, page 38. Appliance detail from Table 6-5, page 39.
[161] In 1984, 66.6 percent of cooking appliance fires used electric power and 28.9 percent used gas. See Audits and Surveys (1985), *op cit*., page 41.

Table 7-8
Item First Ignited in Unattended Residential Cooking Fires
(Thousands of Fires)

Item First Ignited	Number of Fires	Percent
All	4,664	100.0
Cooking materials	3,879	83.2
Linen	289	6.2
No item reported	126	2.7
Paper	95	2.0
Other	275	5.9

Notes: See notes for Table 7-1. *Other* includes clothing, household utensils, appliance housing or casing, bedding, and light vegetation. Estimated CVs for fires in thousands: 150, 74.5; 300, 61.7; 4,000, 4.6.

When asked if the cooking appliance was working properly before the fire, in 98.7 percent of the incidents, respondents said that the appliance was working properly. The only appliances with substantially lower percentages of incidents where the appliance was said to be working properly before the fire were coffeemakers and teapots, which were said to have worked properly in 65.3 percent of the incidents where they were the heat source. No comparable statistics were reported for the 1984 survey, either for all cooking fires or coffeemaker/teapot fires. [162] In the 1984 survey, equipment failure was associated with the fire in 59.2 percent of the toaster fire incidents and 47.2 percent of the toaster oven fires. In contrast, in the 2004 survey, there were no reported toaster or toaster oven incidents where the appliances were reported as not working properly before the fire.

The next three tables display the consequences of fire department-unattended cooking fires. Tables 7-9 and 7-10 show the number of fires by flame and smoke damage categories. Table 7-11 presents an estimate of the amount of property damage by type of cooking fire. All of these tables depart from the usual format of comparing with the 1984 survey because damage and injury estimates were not presented in that survey.

[162] Audits and Surveys (1985), *op cit.*, page 41. As the structure of the questions in the two surveys was not identical, comparisons may be difficult. Question 19 in the 1984 survey asked, "In your opinion what caused the fire? Was it … 1. Equipment or product failure, 2. Human carelessness, 3. Children playing with fire, 4. Something else (specify):" The 2004 survey asked, "Did the source of heat that started the fire seem to be working properly just before the fire?" There were no questions in the 2004 survey asking if human carelessness caused the fire.

Table 7-9
Extent of Flame Damage Associated with
Unattended Residential Cooking Appliance Fires
(Thousands of Fires)

Source of Heat	All Incidents	No Flame Damage	Confined to One Item	Several Items
All cooking appliances	4,664	2,867	1,630	166
Stove/Range	3,788	2,398	1,275	115
Electric	2,596	1,734	825	37
Gas	1,131	602	451	78
Other	62	62	0	0
Microwave oven	332	190	136	6
Toaster oven, toaster	208	137	71	0
Coffeemaker, teapot	68	0	24	45
Countertop oven	48	33	15	0
Outdoor grill	124	37	87	0
Other appliance	42	42	0	0
Unspecified	52	30	22	0

Notes: See notes for Table 7-1. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 450, 51.0 percent; 600, 42.2 percent; 1,000, 27.2 percent; 2,500, 19.9 percent; 4,000 14.6 percent.

Table 7-9 shows that for fire department-unattended cooking fires, in general, the amount of flame damage was small. For example, an estimated 166,000 fire incidents (3.6 percent) resulted in flame damage beyond the original item where the fire started; the other items had either no flame damage or damage to a single item, typically the appliance itself. For all stoves and ranges, 97.0 percent of the incidents had no flame damage or damage was confined to a single item, while 115,000 incidents had damage that spread beyond a single item. Only coffeemakers and teapots showed a sizeable proportion of incidents involving flame damage beyond the original item (45,000 of 68,000 incidents or 65.3 percent).

Table 7-10 shows the extent of smoke damage associated with fire department-unattended cooking fires.

Table 7-10
Extent of Smoke Damage Associated with
Unattended Residential Cooking Appliance Fires
(Thousands of Fires)

Source of Heat	All Incidents	No Smoke Damage	Little Damage or Only Room of Origin	Smoke Damage to Other Rooms or Whole House
All cooking appliances	4,664	3,564	907	191
Stove/Range	3,788	2,880	721	188
Electric	2,596	1,920	487	188
Gas	1,131	897	233	0
Other	62	62	0	0
Microwave oven	332	303	24	3
Toaster oven, toaster	208	176	32	0
Coffeemaker, teapot	68	23	45	0
Countertop oven	48	48	0	0
Outdoor grill	124	124	0	0
Other appliances	42	9	34	0
Unspecified	52	1	52	0

Notes: See notes for Table 7-1. Also, for *Microwave oven*, the column All Incidents includes an estimated 2,400 fires where the smoke damage was not specified. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent; 500, 47.9 percent; 700, 37.2 percent; 1,000, 27.2 percent; 2,000, 22.1 percent; 3,000, 17.9 percent; 4,000, 14.6 percent.

Like flame damage, the amount of smoke damage per fire tended to be low. An estimated 191,000 cooking fires (4.1 percent) involved smoke damage beyond the room where the fire started. There was almost no smoke damage beyond the room of origin for fires involving appliances other than stoves.

Table 7-11
Estimated Property Damage Associated with
Unattended Residential Cooking Appliance Fires
(Thousands of Fires)

Source of Heat	All	None	$1-$9	$10-$99	Over $100
All cooking appliances	4,664	2,810	408	954	352
Stove/Range	3,788	2,414	359	679	202
Electric	2,596	1,723	259	386	119
Gas	1,131	633	95	293	84
Other	62	57	5	0	0
Microwave oven	332	100	49	59	125
Toaster oven, toaster	208	138	0	69	0
Coffeemaker, teapot	68	0	0	68	0
Countertop oven	48	48	0	0	0
Outdoor grill	124	68	0	57	0
Other appliance	42	13	0	0	24
Unspecified	52	30	0	22	1

Note: See notes for Table 7-1. Also, the All category and subtotals include some estimated fires where the respondent did not know or refused to state the amount of property damage. These estimates do not appear in other columns These were as follows: *Electric stoves*, 119,000 fires; *Gas stoves*, 25,000 fires; *Other appliances* 6,000 fires; and *Toaster oven, toaster* < 1000 fires. Estimated CVs for fires in thousands: 150, 74.5; 300, 61.7; 600, 42.2; 1,000, 27.2; 1,500 24.5; 2,500 19.9; 4,000, 14.6.

Table 7-11 shows that an estimated 2.8 million cooking fires (60.2 percent) had no reported financial loss from property damage and most cooking fires had little loss. For ranges and stoves, for example, there were an estimated 881,000 fires (23.3 percent) with property damage of $10 or more, while 63.7 percent had no reported property damage. An estimated 202,000 range or stove fires had estimated property damage of $100 or more. Also, of note in this table is the high proportion of microwave oven fires with property damage over $100. Respondents were not asked to detail the types of property damage leading to the estimate, but for microwave ovens, some of the cost probably involved replacement or repair of the appliance.

The 1984 survey also presented property loss estimates for selected kitchen appliances. For fires associated with ranges and ovens, 70.7 percent had no property damage.[163] However, it is difficult to compare non-zero dollar losses between the two periods without correcting for inflation.

Few cooking-related fires were serious enough to require people to leave the residence. There were an estimated 9,600 fires, comprised of 5,700 range or oven fires and 3,300 microwave oven fires and 600 toaster oven fires, in which respondents reported leaving the residence. All respondents who were forced to leave reported that they were able to return home in less than a week.

Also, relatively few cooking-related fires involved injuries. There were an estimated 102,000 people injured in these incidents. Seventy-two percent of the injured victims had burns and the remaining 28 percent reported their injuries as “other” (i.e., not a burn, smoke inhalation, a laceration, bruise, or fracture.) Twenty-eight percent of victims required medical treatment, and that treatment was described as having received first aid at the scene. No victims were hospitalized.

Electrical Lighting and Wiring Fires

At 616,000 estimated fires, electrical lighting and wiring fires ranked fourth in the number of unattended fire incidents. Table 7-12 shows the distribution of the estimated unattended fires by type of lighting and wiring appliance.

[163] Audits and Surveys (1985), *op cit.*, page 42.

Table 7-12
Electrical Lighting and Wiring Equipment Involved
in Unattended Residential Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All lighting and wiring	616	100.0	51.7
Light fixture	140	22.7	45.4
Lamp and light bulb	68	11.1	
Fuse, circuit breaker panel	62	10.0	83.2
Cord (unspecified)	57	9.3	
Other installed wiring	48	7.8	36.3
Other lighting and wiring	43	7.0	
Lamp cord	36	5.8	
Extension cord	5	0.8	90.6
Unspecified	157	25.5	

Notes: See notes for Table 7-1. Estimated CVs for fires in thousands: 150, 74.5 percent; 600, 42.2 percent.

Aside from the Unspecified category, Table 7-12 shows that the largest number of electrical lighting and wiring fires was associated with light fixtures, at 140,000 fires or 22.7 percent of the total. Lamp and light bulb related incidents accounted for 68,000 fires and 11.1 percent of the total. Wiring accounted for about 146,000 fires. Wiring fires included 57,000 fires associated with cords (unspecified), 48,000 fires from other installed wiring, 36,000 incidents that were lamp cord fires, and 5,000 fires involving extension cords. Some of the fires reported in the category of other lighting and wiring may have also involved wiring.

Also, Table 7-12 shows that electrical lighting and wiring fires decreased by 51.7 percent from the 1984 survey, where there were an estimated 864,000 incidents.[164] The largest percentage drop occurred in fuse and circuit breaker panel fires at 83.2 percent and extension cord fires at 90.6 percent. Light fixture-related fires with a decrease of 45.4 percent and other installed wiring-related fires at 36.3 percent did not decrease as much as all fires.

[164] Audits and Surveys (1985), *op cit.*, page 45. The percentage decreases are based on the comparable estimate of 438,000 fires. See the appendix to this chapter for the description of the methodology used in comparing between the surveys.

Table 7-13 presents the distribution of items first ignited in fire department-unattended electrical fires.

Table 7-13
Item First Ignited in Unattended Residential Electrical Fires
(Thousands of Fires)

Item	Number of Fires	Percent
All lighting and wiring fires	616	100.0
Bedding	149	24.1
No item reported	137	22.3
Electrical wiring	130	21.1
Other	200	32.5

Notes: See notes for Table 7-1. The *Other* category includes appliance housings and casings, paper, and linens. Estimated CVs for fires in thousands: 150, 74.5 percent; 600, 42.2 percent.

An estimated 24.1 percent of the items first ignited were bedding (sheets, pillows, bedclothes), accounting for about 149,000 fires. Respondents did not specify the item first ignited in 22.3 percent of incidents, or 137,000 fires, possibly indicating that nothing was ignited except the heat source itself. Electrical wiring and the Other category (appliance casings, paper, and linens), accounted for the rest of the items first ignited in electrical fires.

Respondents said that the electrical lighting and wiring equipment was working properly before the fire in an estimated 553,000 fires or 89.7 percent of the incidents. The equipment most frequently mentioned as not working properly before the fire was Cord (unspecified), accounting for an estimated 57,000 fire incidents.

Of the 616,000 electrical lighting and wiring fires, respondents reported no flame damage occurred in 488,000 fires (79.2 percent). Of the remaining 127,000 fires, flame damage was confined to the first item ignited. In an estimated 458,000 fires (74.5 percent), respondents reported no smoke damage at all. In the remaining 158,000 incidents, respondents were unable to describe how much smoke damage had occurred, if any.

In 270,000 incidents (43.8 percent), respondents indicated that property damage resulting from the fire was $10 or less. In 97,000 fires (16 percent), damage was between $10 and $99, and in 237,000 fires (38.5 percent), the damage exceeded $100. The last category, for damage over $100, included an estimated 85,000 light fixtures fires; 72,000 fires where the respondent did not know the specific wiring or lighting source of the incident; 43,000 incidents involving other wiring or lighting; and 37,000 incidents involving fuses, circuit breakers, and panel boards.

There were no injuries reported to have resulted from electrical lighting and wiring fire incidents.

Heating and Cooling Appliance Fires

Heating and cooling appliances were involved in an estimated 281,000 fires, about 4 percent of all fire department-unattended incidents, ranking immediately after electrical lighting and wiring fires in the total number of appliance fire incidents. Table 7-14 shows the distribution of the number of fires by the type of equipment.

Table 7-14
Heating and Cooling Appliances Involved in Unattended Residential Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All heating and cooling	281	100.0	69.5
Central and fixed heating	85	30.1	73.0
Fixed local heating equipment	84	30.1	
Central heating furnace	-	-	
Portable heater	97	34.5	71.7
Heating stove	10	3.6	
Unspecified	89	31.8	
Water heater	-	-	69.4
Fireplace	-	-	99.4

Notes: See notes for Table 7-1. The *Unspecified* category includes the responses “don’t know,” “refused,” and “other heating and cooling appliances.” The 1984 survey estimates for totals were from Audits and Surveys, Inc., *op cit.*, (1985, Table 6-3, page 37) except for air conditioning which was in Table 6-13, page 49. Some of the detailed estimates from the 1984 survey were in Table 6-12, page 48. The 1984 survey separates heating from cooling equipment, which is no longer possible because of equipment such as heat pumps that provide both residential heating and cooling. There were an estimated 200 fires involving central heating furnaces (shown as “-”, otherwise it would need to be shown as 0.2). There were no fires involving water heaters or fireplaces during the 14/21-day recall period, but there were fires during the three-month period, which were used to compute the percentage decrease. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent.

Of the estimated 281,000 unattended heating and cooling fires, the largest category was associated with portable heaters at 97,000 fires, accounting for 34.5 percent of the total incidents. Central and fixed heating equipment-related incidents collectively represented 85,000 incidents (30.1 percent), of which less than 1,000 incidents were associated with central heating. There were no incidents involving air conditioners, fireplaces, or installed water heaters. Respondents did not specify the type of heating equipment in an estimated 89,000 incidents.

In comparing with the 1984 survey, overall heating and cooling equipment-related incidents decreased 69.5 percent from the estimated 675,000 incidents in 1984.[165] This was about the same decrease observed for all equipment types. In both the present survey and the 1984 survey, portable heaters accounted for the largest number of heating and cooling equipment-related fires.[166]

In the incidents involving equipment attached to a chimney or vent, all the incidents involved the equipment itself, not the chimney or vent. All the portable heaters were powered by electricity. Respondents indicated that most of the fixed local heater incidents involved either “other” fuel or “gas (type unknown).”[167] Respondents said that the equipment was the main source of heat in their homes for less than 1,000 of the 281,000 fire incidents. All equipment was said to be working properly before the fire.

Item first ignited in unattended heating and cooling equipment-related fires is shown in table 7-15.

[165] See notes for Table 7-14.
[166] Audits and Surveys (1985), *op cit.*, page 47, Table 6-12.
[167] The survey question was, “What kind of fuel/source of power did it use?” The individual’s response was then recorded verbatim, without presenting the individual with a list of likely fuel/power types.

Table 7-15
Item First Ignited in Unattended Residential
Heating and Cooling Equipment Fires
(Thousands of Fires)

Item	Number of Fires	Percent
All heating and cooling	281	100.0
Electrical wire	114	40.5
Appliance	80	28.6
Other	87	30.9

Notes: See notes for Table 7-1. *Other* includes paper, no item first ignited reported, household utensils, and linens. Estimated CVs for fires in thousands: 150, 74.5 percent; 300, 61.7 percent.

Heating and cooling equipment fires ignited electrical wire, possibly attached to the appliance itself, in 114,000 fires (40.5 percent) and other parts of the appliance itself in 80,000 fires (28.6 percent). The remaining items first ignited were paper, household utensils, and linens. All fires where the items first ignited were appliances and household utensils involved fixed heating and cooling equipment such as central and fixed heating, water heaters, fireplaces, and stoves. When the item first ignited was specified, portable heater fires involved only electrical wire as the item first ignited.

Flame damage was reported as "none" in an estimated 194,000 incidents (69 percent). Only fires associated with portable heaters were reported to have had flame damage spreading to several items (30,000 estimated incidents). An estimated 57,000 incidents involved flame damage confined to the first item ignited. In 219,000 incidents (78 percent), there was no smoke damage reported. Of the remaining 61,000 incidents, there was little smoke damage or the smoke damage was confined to the room of origin. No property damage was reported in 193,000 incidents (69 percent). Damage was reported as between $10 and $100 in 30,000 incidents (11 percent) and over $100 in 57,000 incidents (20 percent).

There were less than 200 injuries estimated to have occurred in heating and cooling equipment-related fire incidents.

Other Household Appliances

Table 7-16 shows the estimated number of fires associated with other household appliances. This category ranked third as the heat source in unattended fires, behind cooking appliances and open flames, with an estimated 651,000 fires or 9 percent of the total unattended fires. This was an 84.4 percent decrease from the 1984 survey where an estimated 2.03 million fires involved other household appliances.[168]

Table 7-16
Sources of Heat for Other Household Appliances Involved
in Unattended Residential Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent	Percentage Decrease from 1984 Survey
All other household appliances	651	100.0	84.4
Personal grooming equipment	234	35.9	
Home office equipment	90	13.8	33.4
Clothes washer	75	11.5	89.6
Humidifier	70	10.8	
Iron	60	9.2	89.4
Refrigerator or freezer	37	5.7	77.9
Home entertainment	23	3.6	95.2
Unspecified	62	9.5	

Notes: See notes for Table 7-1. Also, *Unspecified* includes the responses "don't know" and "other household appliances." Estimated CVs for fires in thousands: 150, 74.5 percent; 250, 65.7 percent; 650, 42.2 percent.

The largest number of fires involved personal grooming appliances such as hair dryers, curling irons, etc. These appliances were associated with an estimated 234,000 fires, more than one-third of the other household appliance-related incidents. There were 90,000 fires involving home office equipment (personal computers, printers, faxes, etc.), accounting for 13.8 percent of incidents; clothes washers involved 75,000 fires (11.5 percent), and humidifiers involved 70,000 fires (10.8 percent).

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[168] Audits and Surveys (1985), *op cit*., page 37, Table 6-3. In the 1984 survey, other appliances (TVs, radios, dryers, washers, and tools) accounted for 1,891,000 fires and air conditioning and refrigeration accounted for 143,000 fires.

Fire incidents involving other household appliances declined 84.4 percent between the two surveys, a larger decline than the 69.3 percent decline for unattended fires in general. The decrease in the number of fires in home entertainment equipment, clothes washers, irons, refrigerator/freezers, clothes dryers, vacuum cleaners, and power tools contributed to the decline. The single category not following this trend was home office equipment where the reduction was about one-third. The lower decline might have been a result of the proliferation of personal computers and other office equipment in residences.

Table 7-17 shows the distribution of items first ignited in the other appliance fires.

Table 7-17
Item First Ignited in Unattended
Residential Fires Involving Other Appliances
(Thousands of Fires)

Item	Number of Fires	Percent
All	651	100.0
Appliance casing	406	62.4
No item reported	185	28.4
Floor covering	60	9.2

Notes: See notes for Table 7-1. Estimated CVs for fires in thousands: 150, 74.5 percent; 400, 54.3 percent; 650, 42.2 percent.

Table 7-17 shows that in most of the incidents, the item first ignited was the appliance itself. Floor coverings, primarily rugs, were the items first ignited in 9.2 percent of the incidents, representing 60,000 fires.

All appliances described in Table 7-17 were powered by electricity. In all the incidents, the survey respondents reported that the appliances had been working properly before the fire.

In 484,000 incidents (74 percent), there was no flame damage, while in the remaining 167,000 incidents; the flame damage was confined to the item that was ignited first or the appliance itself. The incidents with flame damage were approximately equally divided among fires involving personal grooming equipment, irons, and the “don’t know” category.

Smoke damage estimates were similar. In 506,000 incidents (78 percent), there was no smoke damage; in 70,000 incidents (11 percent), the smoke damage was confined to the room of origin; and in 74,000 incidents (11 percent), the smoke damage spread to another room or area. Only fires involving clothes washers and humidifiers produced smoke damage to the room of origin or to another room.

In 561,000 incidents (86 percent), there was some property damage. No property damage was reported for 90,000 incidents (14 percent). Property damage was between $1 and $100 in 365,000 incidents (56 percent). Property damage over $100 was reported for 196,000 incidents (30 percent). Fires involving home entertainment systems, refrigerators or freezers, and clothes washers had property damage of $100.

There were no injuries reported in any of these incidents.

Cigarette and Small Open Flame Fires[169]

Table 7-18 shows the distribution of heat sources for cigarette and small open flame fires. The table does not show the percentage decrease from the 1984 survey because that survey did not report on the number of fires associated with cigarette and small open flame heat sources.

[169] This is the first and only detailed section on non-appliance fires in this chapter. In addition to the cigarette and small open flame heat sources, there were an estimated 47,000 fires that began outside the house and spread to the house and 17,000 fires where the heat source was not specified. Neither of these categories had a sufficient estimated number of fires to warrant more detailed breakdowns in the chapter.

Table 7-18
Unattended Residential Cigarette
and Small Open Flame Fires
(Thousands of Fires)

Source of Heat	Number of Fires	Percent
All small open flame and cigarettes	900	100.0
Candle	465	51.6
Cigarette	155	17.2
Lighter	140	15.6
Match	84	9.4
Other open flame	55	6.1

Notes: See notes for Table 7-1. Also, *Other open flame* includes torch, spark from fireplace, and other unspecified open flame sources. Estimated CVs for fires in thousands: 150, 74.5 percent; 450, 51.0 percent; 900, 28.9 percent.

Table 7-18 shows that the largest proportion of incidents, slightly more than half at 465,000, involved candles. Lighters and cigarettes accounted collectively for almost 300,000 fires, while matches were the source of heat in 84,000 incidents.

Children under 10 started an estimated 35,000 small open flame and cigarette fires (3.8 percent). No incidents were started by children under 5. An estimated 30,000 fires involved lighters and the remainder involved other open flames including torches, matches, and unspecified heat sources.

Table 7-19 shows the distribution of item first ignited in unattended cigarette and small open flame-related fires.

Table 7-19
Item First Ignited in Unattended Residential
Cigarette and Small Open Flame Fires
(Thousands of Fires)

Item	Number of Fires	Percent
All cigarettes	155	100.0
Bedding	74	47.7
Other	81	52.3
All open flame	744	100.0
Paper	169	22.7
No item reported	161	21.7
Decoration	73	9.8
Cabinetry	72	9.6
Other	270	36.3

Notes: See notes for Table 7-1. The category *Other*, under *All cigarettes*, includes heavy vegetation, paper, rubbish, and floor coverings. The category *Other*, under *All open flame*, includes light vegetation, clothing, linens, appliance casings, cooking materials, and other items. Estimated CVs for fires in thousands: 150, 74.5 percent; 400, 54.3 percent; 700, 37.2 percent.

Table 7-19 shows cigarette fires and small open flame fires separately because the patterns of items first ignited are different for the different types of heat sources.

For fires involving cigarettes as the heat source, the largest single category of item first ignited was bedding at 74,000 incidents (47.7 percent). In incidents where the heat sources involved open flame, the largest single category of item first ignited was paper, at 169,000 incidents, accounting for 22.7 percent of the open flame incidents, followed by no item reported at an estimated 161,000 incidents.

In the 465,000 estimated candle fires, there was no reported flame damage in 156,000 fires, the flame damage was confined to the first item ignited in 240,000 fires, the flame damage involved several items in 33,000 fires, and the whole room in 36,000 fires. There was no smoke damage in 356,000 candle fires, a little smoke damage in 72,000 candle fires, and smoke damage in the room of origin in 36,000 candle fires. In 246,000 candle fires, there was no reported dollar amount of property damage. In 67,000 incidents, damage was $100 or more, damage was between $10 and $99 in 52,000 incidents, and between $1 and $9 in 69,000 incidents.

With respect to fires associated with lighters, for an estimated 127,000 fires, survey respondents reported that there was no flame damage. In the remaining incidents, 13,000 fires, the flame damage involved only the item first ignited. None of the lighter fires produced any smoke damage. Also, most fire incidents, 127,000, did not result in any property damage, although 3,000 fires had estimated losses between $1 and $9 and 10,000 fires had losses between $10 and $99.

Cigarette-related fires had no flame damage in one-third of the incidents (52,000 fires), flame damage to only the item first ignited in 100,000 fires, and flame damage to several items in 3,000 fires. Smoke damage was split almost 50-50 between none (80,000 incidents) and to the room of origin (75,000 incidents). More than two-thirds of the incidents, 106,000 fires, had no reported dollar loss from the fire, while for 17,000 incidents, reported dollar losses were greater than $100, 17,000 reported losses between $10 and $99, and 15,000 incidents involved losses under $10.

Incidents involving matches resulted in flame damage to the first item ignited and no smoke damage in all 84,000 incidents. No property damage was reported in 29,000 incidents (34 percent), and respondents did not know the amount of damage in the remaining incidents. For incidents involving other open flame heat sources, no flame damage was reported in 29,000 of the 55,000 incidents, damage to the first item in 23,000 incidents, and to the outside of the house in 3,000 incidents (fires starting outside the house). There was no smoke damage in 31,000 incidents, a little smoke damage in 23,000 incidents, and damage to the outside of the house in 1,000 incidents. Property damage was reported as none for an estimated 9,000 fires, $1-9 for 3,000 fires, and $10-99 for 42,000 fires.

Three percent of the incidents (27,000) involved injuries. In 24,000 of these incidents, no medical attention was required, while in 3,000 incidents, first aid at the scene was required. All the injuries were burns. In these injury incidents, 24,000 fires were started with matches, while in the remaining 3,000 incidents, a lighter was the heat source.

Conclusion

The analysis in this chapter used the same methodology as that used in Chapters 3 and 6, by using low severity incidents in the 14-day recall period and high severity incidents in the 21-day recall period and then scaling to a calendar year.

The only departure from this methodology was when comparing the estimated number of fires with the estimates in the 1984 survey. Similar to the 1984 survey, the comparison statistics used the entire three-month recall period, scaled to the total number of fires from the 14/21-day recall period. As pointed out earlier in this chapter and as fully developed in Chapter 3, there is evidence that survey respondents tend to remember incidents of greater severity longer than incidents with less severity. As a result, the data from the three-month recall period in either survey is weighted toward more serious incidents than would be found in a general sample of fires.

Because the three-month recall period is weighted toward more serious incidents, neither survey used the three-month recall period for making estimates of annual fire incidence. However, the 1984 survey used the three-month period for analysis of the types of fires. The reasoning for that choice of period was not stated in their report, but it was probably motivated by the need to obtain an adequate sample size for the more detailed analyses. In order to compare the results from the two surveys, it is necessary to use data from the current survey covering the same period. Otherwise, everything else being equal, comparing a 14/21-day survey to a three-month survey, the 14/21-day survey would show, on average, less severe fires and lower fire losses. In order to avoid that apparent artifactual decline in severity, it was necessary to develop a second set of estimates in the current survey based on the three-month period but scaled to the calendar year. This was essentially the same procedure used for the 1984 survey, and the estimates should then be comparable. These three-month estimates are used only for computing the percentage change in fire incidents. The estimated number of fires based on the three-month recall period using the current survey does not appear anywhere in the chapter.

Using these comparable three-month estimates in this chapter, it was estimated that there was a 69.3 percent decrease in the number of fire department-unattended fires between 1984 and 2004. The decrease in the number of cooking appliance-related fires was slightly less, at 63.3 percent. However, as cooking fires represent about two-thirds of the incidents, the decline in cooking fires explains a large part of the decrease in total incidents.

Other household appliance fires declined 84.4 percent, and heating and cooling equipment fires declined 69.0 percent. Electrical lighting and wiring fires did not decline as much, at 51.7 percent of the 1984 incidents. Because the 1984 survey did not present estimates of fires associated with smoking materials and open flames, it is not possible to calculate the decrease in the number of fires; but it seems likely that the decrease was at least as large as the overall decrease of 69.3 percent, and perhaps considerably more. One clue is that the 1984 survey presented estimates for the number of non-appliance fires, a category that included smoking and small open flame fires. Using that estimate, it was possible to show that there was an 84.0 percent decrease in non-appliance fires. Some of that decrease was undoubtedly due to decreases in smoking and small open flame fires, which in turn were likely to be related to decreases in smoking in the population.

Similar to the 1984 survey, most of the 7.2 million fires that were not attended by fire departments occurred in kitchens and most involved cooking appliances. Unattended fires resulted in an estimated 130,000 injuries, most frequently burns. Most injuries did not require medical attention; for those that did, first aid at the scene was the most frequently reported treatment. In 9,600 incidents, residents had to leave the home for a night or more because of the fire but in all cases were able to return within a week. The

7.2 million incidents resulted in an estimated $612 million in property damage and loss from the fire.

About 81 percent of the 4.7 million cooking appliance-related fires involved ranges or stoves, with about twice as many electric range fires as gas range fires. As there are more electric stoves in use in the population, such a result was not unexpected. Correcting for the number of stoves by fuel type, the fire risk factors were estimated at 3.8 electric stove fires per 100 households and 2.6 gas stove fires per 100 households. It is worth noting that the increased fire risk associated with electric stoves is consistent with official statistics on fire department-attended fires. Official statistics also show that electric stove fires have a higher risk of injury and property loss but a lower risk of death.

After range fires, microwave ovens accounted for 7.1 percent of the cooking appliance fires; and toaster oven fires accounted for 4.5 percent of these incidents. The most frequently mentioned item first ignited was cooking materials (foodstuffs, grease, etc.) at 83.2 percent of the incidents, with linens (dish towels, pot holders, table cloths) second at 6.2 percent. The estimated total dollar loss from cooking fires was $328 million.

After cooking appliances, open flame and cigarette fires were the next largest category, accounting for an estimated 900,000 incidents. With open flame fires, paper was the most frequently mentioned item first ignited, while cigarette fires most frequently ignited bedding. Cigarette fires involved $2.6 million in property loss, while open flame incidents involved $19 million. The average loss in these incidents was the lowest of all the heat source categories.

There were 651,000 household appliance fires, involving $158 million in property damage. Appliances such as dishwashers, clothes washers and dryers, TVs, home entertainment equipment, computers, and home office equipment averaged $243 per incident in losses, the largest average loss per fire. Household appliance fires decreased 84.4 percent from the 1984 survey, the largest percentage decrease among the different types of equipment involved in fires. This finding is noteworthy because there are many more of household appliances in the home now than there were in 1984.

Electrical lighting and wiring fires accounted for 616,000 incidents and $43 million in fire losses. There was a 51.7 percent decrease in the number of incidents between the two surveys, the smallest percentage decrease observed among different categories of equipment. Heating and cooling equipment fires involved 281,000 incidents and $51 million in losses. There was a 69.5 percent decrease in the number of incidents from the 1984 survey, just about the same percentage as all incidents.

To conclude, numerically, the largest drop in fire department-unattended fires between the two surveys was in fires associated with cooking equipment. There were over 12,000,000 fire department-unattended cooking equipment related-fires in 1984, which was more than the total number of fire department-unattended fires in the 2004 survey. In percentage terms, non-appliance fires decreased almost 84 percent from 2004, almost 20 percentage points more than appliance fires. The 1984 survey did not present estimates for the number of cigarette fires, but there is a strong possibility that much of that decline in these types of fires was associated with decreases in the number of cigarette fires, which in turn was probably associated with decreases in the number of smokers over the last 20 years.

Appendix to Chapter 7

Calculation of the Percentage Change Between the 2004 Survey and the 1984 Survey

Several tables in this chapter show the percentage changes in the estimated number of unattended fires between the current survey and the 1984 survey. As mentioned in the text, estimates of the number of equipment specific fires in the 1984 survey used a different procedure than the estimate for total fires. The purpose of this appendix is to describe the methodology and the similar methodology used in the 2004 survey that was used to compare estimates.

The key difference from the 1984 survey was that the estimate of total fires in that survey was based on a one-month recall period, but the estimate of equipment specific fires was based on a three-month recall period. To take into account that respondents may have forgotten incidents occurring earlier in the recall period, the authors of the 1984 survey scaled the incidents to the total estimated from the one-month period. This corrects for some forgotten incidents but it does not take into account the problem that incidents of lesser severity are less likely to be recalled. As a result, the mixture of types of fires over a three-month period is likely to have fires of greater severity than those in the one-month period.

As a result, comparing equipment specific fires in the 1984 survey with those in the 2004 survey based on the 14/21-day recall period would be likely to show a decrease in incident severity. That decrease would be an artifact of two different recall periods, not necessarily a true decrease in severity.

The solution used in this chapter was to compare estimates calculated in the same way. The comparable estimates from the 2004 survey were calculated by using the full three-month period, but scaling to the total based on the 14/21 day recall period. However, this creates two estimates for every category, one estimate based on the 14/21-day recall period, believed to be the most accurate, and the other based on the three-month period, the most comparable. To avoid confusing the reader with two different sets of fire estimates, the comparable estimate is used only to compute the percentage change between the 1984 and 2004 survey. The comparable estimates are not shown in this chapter.

The percentage change between the two surveys is computed as follows:

Pct Change = 100 * (1 – 2004 survey estimate/1984 survey estimate)

where the 2004 survey estimate is computed on the basis of the full three-month period, scaled to the 2004 annual estimates from the 14/21-day recall period analysis.

The example below shows how some of the percentage changes were computed in Table 7-2 in the chapter.

Table 7A-1
Changes in Selected Appliance Categories

Equipment	2004 Best Estimate	2004 Comparable Estimate	1984 Survey Estimate	Percent Change from 1984 Survey
All fires	7,176	6,854	22,322	69.3
Cooking appliances	4,664	4,533	12,344	63.3
Other household appliances	651	316	2,034	84.4
Electrical lighting and wiring	616	430	890	51.7
Heating and cooling	281	233	763	69.5

Column 2 in Table 7A-1 (2004 Best Estimate) shows the estimated number of fires appearing in Table 7-2 in the text. These were computed using the 14/21-day recall period scaled to the calendar year. The next column (2004 Comparable Estimate) shows the 2004 estimates that were comparable to the 1984 survey. The 2004 Comparable Estimate does not appear anywhere in the chapter, to avoid confusing the reader with estimates that are believed to be less accurate. It is used only to calculate the Percent Change that appears in chapter tables.

Chapter 8
Operation and Effectiveness of Smoke Alarms and Fire Extinguishers

Having characterized fire households and residential fires in previous chapters, this chapter investigates how residents became aware of fires and how these fires were extinguished. This involves examining the role of smoke alarms and fire extinguishers in residential fires.

As shown in Chapter 5, smoke alarms have become almost universal in homes, with an estimated 96.7 percent of U.S. households having at least one smoke alarm.[170] This is a substantial increase from the mid-1970s where alarm prevalence was about 20 percent, 62 percent of households in 1984, and 84 percent in the mid-1990s.[171] As many have noted, smoke alarms are an inexpensive method of providing early warning in residential fires. This can translate into saving lives and preventing injuries. According to the NFPA, the death rate in fire department-attended home structure fires was twice as high in homes fires where no smoke alarm was present as compared with home fires where an alarm was present.[172]

This chapter explores two issues about smoke alarms. After looking at how residents became aware of a fire, including because of an alarm sounding, the chapter then characterizes how alarms operated in various fire scenarios. The benefits from smoke alarm operation follow in increasing order:

- The smoke alarm sounds
- The smoke alarm alerts household members to the fire
- When the alarm sounds, it provides the only alert of the fire

If the alarm alerted people at the same time as some other event, such as a household member smelling smoke, the alarm may have provided a benefit by confirming the existence of the fire. If the alarm provided the only alert of the fire, then the alarm is of even greater benefit by providing an earlier warning of the fire. This can allow household members to put their escape plans into action earlier or apply some other strategy.

The second issue about alarms concerns the reasons why alarms did not operate during residential fires. This first requires determining if enough smoke reached the alarm so that it should have operated. After establishing that the alarm should have operated, according to the survey respondent, the remaining focus is on the condition of

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[170] This was 96.8 percent of non-fire households and 92.7 percent of fire households.

[171] Ahrens M (2007b), *op cit.* Ballesteros M, Kresnow MJ, (2007), "Prevalence of Residential Smoke Alarms and Fire Escape Plans in the U.S: Results from the Second Injury Control and Risk Survey (ICARIS-2)," *Public Health Reports*, Vol. 122, pp. 224-231. Audits and Surveys (1985), *op cit.,* page 53. Market Facts (1993), "Smoke Detector Operability Study Final Report," Washington, DC, page 7. Smith CL (1994), "Smoke Detector Operability Survey, Report on Findings," U.S. Consumer Product Safety Commission, Bethesda, MD.

[172] Ahrens (2007b), *op cit.,* page 18.

the alarm, including the respondent's perception of whether the alarm was in working order and when it was last tested.

The chapter then addresses how the fire was put out and the usage of fire extinguishers, especially focusing on whether the extinguishers operated when residents tried to use them. Different from smoke alarms, the use of fire extinguishers to fight fires is controversial because such actions might cause occupants to delay leaving the residence.[173]

Following a brief description of the methods, the chapter then begins with an overview of how residents were alerted to the fire (smoke alarms), and how the fire was put out (fire extinguishers). Specific types of fires are then considered in subsequent sections. The chapter concludes with a discussion section.

Methods

Like the previous two chapters and Chapter 3, the unit of analysis in this chapter is fires using the annual fire incidence rates based on the 14- and 21-day recall periods. From the analysis in Chapter 3, this involves an estimated 7.43 million fires, of which 254,000 were attended by fire services and 7.18 million were unattended.

For the most part, the analyses in the chapter use the percentage of total incidents, rather than percentages conditional on some other factor. For example, when considering if a smoke alarm alerted people to a fire, the percent of such cases is computed as the estimated number of incidents where the alarm alerted people divided by the estimated total fire incidents. In order for an alarm to have alerted people, a number of events must have occurred as follows: someone was home, there was an installed smoke alarm, the alarm was in working order, enough smoke must have reached the alarm, the alarm sounded, and someone heard it. Thus, the percent of such cases is an estimate for the joint probability that all these events occurred. Another type of computation is the conditional probability of an alarm alerting someone given that someone was home and the alarm sounded. This would be computed from the estimated number of fire incidents where the alarm alerted people divided by the estimated number of fire incidents where people were home, an alarm was present, and the alarm sounded.

This report presents the first computation, because that represents the overall benefit of the alarm. Readers who prefer the second computation will find enough information in the tables to estimate those probabilities.

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[173] According to the NFPA, "… A portable fire extinguisher can save lives and property by putting out a small fire or containing it until the fire department arrives; but portable extinguishers have limitations. Because fire grows and spreads so rapidly, the number one priority for residents is to get out safely…" From the fact sheet on fire extinguishers: http://www.nfpa.org/itemDetail.asp?categoryID=277&itemID=18264&URL=Research%20&%20Reports/Fact%20sheets/Fire%20protection%20equipment/Fire%20extinguishers

The tables in this chapter look different from the other tables in this report because, for the most part, they contain only percentages. This is to facilitate comparisons of smoke alarm and extinguisher operation for different types of fires, (e.g., attended or unattended fires, kitchen or living room fires, etc.). Every table presents the estimated total number of fires, allowing the reader to reconstruct the estimated number of fires in any particular table cell, if desired.

Different from the last two chapters, the tables in this chapter do not contain coefficients of variation (CV). As shown in the appendix to Chapter 6, the CV is inversely proportional to the estimated number of fires. Estimates of appropriate CVs are available from the tables in the appendix to Chapter 6 after the percentages are converted to the estimated number of fires.

The survey questionnaire requested information on the respondents' fire losses, some of which were presented in earlier chapters. These include information on injuries, time away from home, lost time from work, flame damage, smoke damage, and dollar value of property damage. It is tempting to try to relate the fire losses to how the smoke alarm or fire extinguisher operated during the incident. Everything else being constant, one would think that incidents in which the alarm operated would have fewer fire losses than in those fires where the alarm did not operate. However, everything cannot be held constant. In particular, smoke alarm operation and use of an extinguisher may indicate a more serious fire than when the alarm did not operate and when the extinguisher was not needed. Because of this, Chapter 8 does not relate alarm operation or extinguisher operation to fire losses, and such an analysis is discouraged.[174]

Each section in this chapter presents estimates in a series of five tables. The first three tables contain information on smoke alarms. These are as follows:

Method of Discovery of the Fire
Smoke Alarm Operation
Reasons for Non-operating Smoke Alarms

The remaining two tables address extinguishers. These are as follows:

How the Fire Was Extinguished
Location and Use of the Fire Extinguisher

These sets of tables are presented for a number of different scenarios. The first set of tables includes all fire incidents, contrasting between fire department-attended and unattended incidents. All the remaining tables in the chapter are for unattended fires only. The next set of tables is by the area of fire origin (where the fire began), followed

[174] It is also problematical to relate the presence of smoke alarms to fire losses. First, most of the residences in the survey had smoke alarms, resulting in a small sample size and imprecise estimates for fires in residences without smoke alarms. Second, residences that do not have smoke alarms may be different from those that do in ways that are related to the type of fire and fire damage. Thus, the presence of smoke alarms and fire extinguishers may be a proxy for some other variable associated with fires.

by heat source (appliance fires first and non-appliance fires second), then finally by the different smoke alarm configurations in residences.

As in previous chapters, all computations were made using the SAS® software system. Unless otherwise noted, the data are based on the 14- and 21-day recall periods developed in Chapter 3. Missing dates are imputed using the multiple imputation procedure from Chapter 3. All the cases are weighted by the appropriate sampling weights to provide national level annual estimates. When it is desirable in this chapter to compare results with the 1984 survey, estimates are made based on the full three-month recall period scaled to the annual estimates based on the 14/21-day totals in the same way as was done in Chapter 6. The text notes when estimates are based on the three-month period.

Results

Overview: All Incidents

This section considers all fire incidents, examining smoke alarm and extinguisher performance in fire department-attended and unattended incidents. As shown in Chapter 6, more than two-thirds of fire incidents began in the kitchen. As a result, the estimates in summary tables are dominated by cooking fires. Later tables in the chapter contrast smoke alarm and extinguisher use in cooking and non-cooking fire incidents.

Table 8-1 presents the method of discovery for all fires, unattended fires, and attended fires.

Table 8-1
Method of Discovery by Attended and Unattended Fires
(Percent of Fires)

Method of Discovery	All Fires	Unattended Fires	Attended Fires
Nobody home	4.0	2.8	38.9
Person present at fire origin	22.7	23.2	8.9
Other evidence of fire			
Smelled smoke	18.2	18.9	-
Saw flames	16.0	16.6	-
Saw smoke	14.3	14.0	23.7
Heard fire	3.1	3.2	-
Felt heat	1.7	1.8	-
Smoke alarm alerted people	11.8	11.8	12.5
Someone else provided an alert	3.6	3.8	-
Something else provided an alert	1.3	0.8	15.7
Estimated number of fires (thousands)	*7,430*	*7,176*	*254*

Notes: Multiple responses were permitted to the survey questions about how residents discovered a fire. The table omits responses associated with a small number of incidents where the respondent said they did not know or refused to answer how the fire was discovered; in general, the “refused” and “don’t know” responses are not included in tables. When respondents reported nobody was at home, no further questions were posed to them about the fire incident. Detail lines may not sum to 100 percent due to rounding, multiple responses, or omission of “refused” and “don’t know” responses. Estimated percentages are based on the total number of fires shown in the last row of the table, i.e., 7.43 million, 7.176 million unattended fires and 254,000 attended fires. Dashes (-) indicate estimates of 0 (zero) percent from the data, but the dashes indicate that the population percent may be greater than zero.

Table 8-1 describes how people discovered that there was a fire. In that table, for the estimated 7.4 million residential fires, nobody was home in 4.0 percent of incidents; thus, someone was at home in the other 96.0 percent of incidents. When nobody was home, it would have been impossible for respondents to answer the remaining questions about whether the alarm sounded, what alerted them to the fire, etc. Consequently, when the survey respondent indicated that nobody was home when the fire started, questions about the alarm sounding and notifying residents were skipped. Thus, it is possible that fires where nobody was home had sounding alarms, or even alarms that alerted neighbors or bystanders.

In Table 8-1, the responses about method of discovery of the fire were very different for fire department-attended and unattended fires. Nobody was home in 38.9 percent of fire department-attended fires in contrast to nobody home in 2.8 percent of unattended fires. Fires that started when nobody was home were qualitatively different from fires started with a resident at home. For example, when someone was home at the time of the fire, 66.5 percent of the fire incidents involved a cooking appliance, 8.6 percent involved electrical lighting or electrical wiring, 8.6 percent involved another household appliance, 5.6 percent involved a candle and 3.2 percent involved heating or cooling equipment. In contrast, when nobody was home when the fire started, 32.7 percent involved heating or cooling equipment, 22.7 percent involved a candle, 20.3 percent involved another household appliance, and 5.7 percent involved cooking appliances. Similar differences might also be expected in the room of fire origin and the item first ignited.

As shown Table 8-1, in 22.7 percent of incidents, someone was present at the fire when it started. Respondents indicated that they smelled smoke in 18.2 percent of fires, saw flames in 16.0 percent, saw smoke in 14.3 percent, and heard or felt the fire in 4.8 percent of incidents. Respondents indicated that in 11.8 percent of fires, the smoke alarm alerted them to the fire. Other means of alerting people to the fire included another household member telling the respondent about the fire, or something else (unspecified) provided the alert of the fire.

For those incidents when people were home at the time of the fire, people were alerted to the fire by the smoke alarm (possibly in combination with other evidence of fire) in 11.8 percent of the fires. Conditional on someone being home, people were alerted by the alarm in 12.1 percent of unattended fires and in 20.5 percent of attended fires.[175]

Table 8-2 describes further how the smoke alarm operated during the fire.

[175] Calculated from the estimated number of fires. Similar calculations can be made from Table 8-1. First note that for unattended fires, someone was home in (100 - 2.8 =) 97.2 percent of incidents and for attended fires someone was at home in (100 - 38.9 =) 61.1 percent. Then the smoke alarm alerted people conditional on someone home in (11.8 / 97.2 =) 12.1 percent for unattended fires and (12.5 / 61.1 =) 20.5 percent for attended fires.

Table 8-2
Smoke Alarm Operation by Attended and Unattended Fires
(Percent of Fires)

Smoke Alarm Operation	All Fires	Unattended Fires	Attended Fires
When the fire started			
Someone was at home	96.0	97.2	61.1
Nobody was home	4.0	2.8	38.9
If someone was home			
There was a smoke alarm	85.6	86.4	61.1
There was no smoke alarm	9.7	10.1	0.0
If there was a smoke alarm and someone home			
The alarm sounded	30.3	30.0	40.0
The alarm did not sound	55.2	56.5	20.7
If people were home and the alarm sounded			
It alerted people to the fire	11.8	11.8	12.5
Something else alerted people	18.5	18.2	27.5
If the smoke alarm alerted people			
It provided the only alert	9.8	9.7	12.5
Something else also alerted people	2.0	2.1	0.0
All Fires	*7,430*	*7,176*	*254*

Notes: See Table 8-1.

Table 8-2 shows that in 85.6 percent of fires (86.4 percent for unattended and 61.1 percent for attended), someone was home and there was at least one smoke alarm in the residence. When considering the presence of alarms alone, regardless of whether someone was home, the survey responses indicated that 88.6 percent of fires occurred in households that had alarms (88.4 percent for unattended fires and 93.9 percent for attended fires).[176] Thus the main distinction between attended and unattended fires is not so much the presence of alarms, but whether someone was at home during the fire.

[176] In Chapter 5, it was shown that 92.7 percent of fire households had at least one smoke alarm. There are two reasons for the difference between this number and the estimate that 88.6 percent of fires occurred in households that had alarms. First, the data in this chapter are based on fires, not households, so that households with more than one fire are counted more than once. Second, the analysis in Chapter 5 was based on all fire households, i.e. those with fires in the full 91-day period, while the statistics in this chapter are from households with fires in the 14- and 21-day recall periods. From this comparison it seems likely that households with higher fire household incidence rates are slightly less likely to have smoke alarms.

Table 8-2 also shows that someone was home and the smoke alarm sounded in 30.3 percent of incidents (30.0 percent unattended and 40.0 percent attended). Using calculations that are comparable to the 1984 survey, the alarms in the present survey sounded in 24 percent more unattended incidents and in 21 percent more attended incidents than as reported in the 1984 survey.[177]

As shown in both Table 8-1 and Table 8-2, the alarm alerted people to the fire in 11.8 percent of incidents. In 18.5 percent of incidents, something else also alerted people to the fire. In 9.8 percent of incidents, the sounding alarm was the only alert of the fire.

One measure of the benefit of smoke alarms may be seen in those 9.8 percent of incidents where the alarm provided the only alert. If the household did not have an alarm, it is not necessarily true that they would have been unaware of the fire, because the other alerting events shown in Table 8-1 might have occurred. However, the sounding alarm in those 9.8 percent of incidents may have provided the respondents with additional time to extinguish or contain the fire or to put escape plans into action.

Table 8-3 addresses the estimated 55.2 percent of fires (56.5 percent unattended and 20.7 percent attended) where the smoke alarm did not sound.

[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

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 39/40^{ths} 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 <u>in starting the fire</u>? **(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 |
Refused .... 4 |

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.

ROLF JENSEN & ASSOCIATES, INC.
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January 8, 2014

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Study on the Life Cycle Cost of Portable Fire Extinguishers

Richard W. Bukowski, P.E., FSFPE

RJA undertook this project to determine the cost of portable fire extinguishers over their life cycle, estimated to be 24 years, including purchase, installation, and all service requirements. This analysis may be used to determine the value of portable fire extinguishers in commercial properties. The study methodology utilized the accepted international standard, *Standard for Measuring Life Cycle Costs of Buildings and Building Systems, ASTM E0917-05*. This analysis can be used to estimate the total economic impact of the provision of portable extinguishers in accordance with NFPA 10 in any size facility for any assumed rate of return. Here, the discount (interest) rate used is 5%, which is typical for equipment investment analyses.

Typical costs of procurement, periodic inspection, maintenance, and testing as required by NFPA 10 were obtained from publically available sources and include initial (or replacement) cost and costs associated with required on-site servicing. Required monthly inspections are assumed to be performed by employees at a typical loaded salary rate and annual maintenance, periodic recharge, and hydrostatic testing required to be performed by certified professionals is assumed to be done on site.

NFPA 10 requires that for Class A hazards, an extinguisher must be within a 75 foot travel distance of any point; which is not directly useful in assessing cost. Most cost estimating guides (e.g., Means) express costs in cost per square foot of floor area. To determine a reasonable value for number of extinguishers per floor area, the floorplans of a dozen health care facilities ranging in size from 33,000 sq. ft. to 560,000 sq. ft. and requiring from 15 to 420 extinguishers, were examined. This resulted in a range of 1500 to 2000 sq. ft. per extinguisher. Note that NFPA-10 allows these extinguishers to cover no more than 6,000 square feet, so the cost per foot can vary significantly.

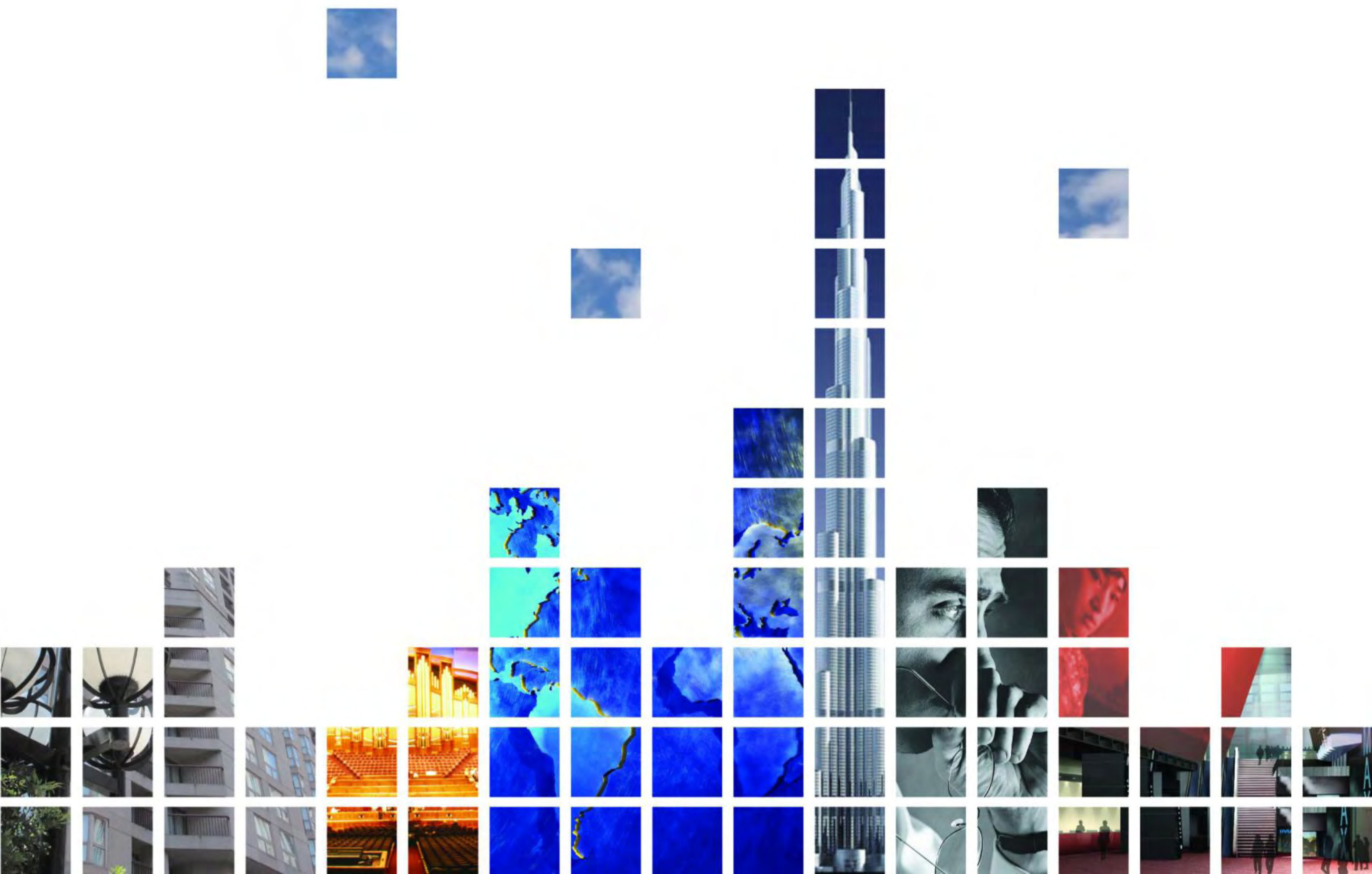
Actual inspection, maintenance and testing costs gathered for this study consist of a fixed service charge per facility per visit and a per extinguisher charge. To distribute the per visit charge over multiple extinguishers, costs per extinguisher were determined as 10% of the costs for 10 extinguishers per facility.

Because actual costs vary depending on many factors, including the facility size and geographic location, costs are reported as a range, following conservative assumptions in each case. Obtaining a cost per square foot was accomplished by using the actual number of extinguishers required in each health care facility divided by their gross floor area.

Based on the actual health care facility extinguisher location drawings, the annual cost per square foot for procurement, installation, and all required inspection, testing, and maintenance over a 24 year life (all paid at the time of purchase) 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.

ROLF JENSEN & ASSOCIATES, INC.
FIRE PROTECTION CONSULTANTS

STUDY ON THE LIFE CYCLE COST OF PORTABLE FIRE EXTINGUISHERS



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STUDY ON THE LIFE CYCLE COST OF PORTABLE FIRE EXTINGUISHERS

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Prepared for:

Fire Equipment Manufacturers' Association
Cleveland, Ohio

January 8, 2014

RJA Project No. C58655

BACKGROUND

First developed in the early 19th century, portable fire extinguishers have long played an important role in fire safety strategy. When detected early by building occupants, portable extinguishers can be used to extinguish a fire before any significant damage occurs, often eliminating the need for fire department suppression activities. As a required feature in many buildings, portable extinguishers are subject to regular inspection and maintenance by the model fire codes, International Fire Code (IFC) and NFPA 1, and by the primary technical standard, NFPA 10, *Standard for Portable Fire Extinguishers*. Since proposals to the model codes that would mandate portable extinguishers in certain occupancies are required to consider the economic impact of such mandates, this life cycle cost analysis quantifies the impact for any size facility.

LIFE CYCLE COST ANALYSIS

Life Cycle Cost (LCC) analysis is a widely accepted methodology for comparing alternative investments or purchases to determine the most cost-effective option under a specific set of assumptions. There is a consensus standard in the US published by ASTM International that details the methodology for such an analysis, *Standard Practice for Measuring Life Cycle Costs of Buildings and Building Systems, ASTM E0917-05*.

LCC techniques are used to collect all associated costs, either single costs at a point in the system life or recurring costs over the system life, and move them to a single point in time utilizing an assumed discount (interest) rate. The discount rate selected represents the interest rate that could be realized if the money spent on the system was invested. LCC permits valid comparisons of cost over a specific period, even if the life of the alternative systems vary, since replacement costs and even cost of removal and disposal (including any salvage value) can be included.

PORTABLE EXTINGUISHER REQUIREMENTS

NFPA 10, *Standard for Portable Fire Extinguishers,* is the base document for the requirements for portable fire extinguishers and is either adopted by reference or extracted to the fire codes (NFPA 1 and the IFC), building codes (NFPA 5000, NFPA 101, and the IBC), and to specialty documents for specific occupancies, such as boats and RVs. Portable extinguishers are required in a long list of occupancies, primarily divided among those containing Class A hazards and those with Class B hazards. Sufficient Class A- or B-rated extinguishers are to be provided so that the maximum travel distance from any point to an extinguisher is 75 feet for Class A, or 30 to 50 feet from the hazard (depending on rating) for Class B. Class D and K hazards are handled as special cases with extinguishers located near the hazards.

INSPECTION AND MAINTENANCE

Portable extinguishers are required to be visually inspected at 30-day intervals and maintained at intervals of 1 year with an examination of internal parts at 1 year (unpressurized), 3 years (AFFF and FFFP) or 5/6 years (stored pressure) where such maintenance generally involves disassembly for examination of internal parts, recharging, and replacement of some parts. Pressurized extinguishers require hydrostatic pressure testing at 5 or 12 year intervals depending on agent.

MONTHLY INSPECTIONS

Every extinguisher must be inspected every 30 days to determine that:

1. The extinguisher is present;
2. Access and visibility is not obstructed; and,
3. Pressure is within a specified range.

While maintenance (annual or longer) must be performed by certified personnel [NFPA 10, Sec. 7.1.2], monthly inspections can be performed by anyone. Often these are performed by staff of the facility as an additional duty but, in any case, the recordkeeping requirements must be followed to demonstrate compliance to various authorities.

DATA AND ASSUMPTIONS

Annual extinguisher maintenance required by NFPA 10 is usually performed by an extinguisher technician under a separate contract. RJA obtained (via online search) public details of fire extinguisher contract awards by municipalities that included prices for new extinguishers and for performance of required inspections and maintenance on portable extinguishers located in municipal facilities ranging from a small town to an entire state. Quoted prices, which often included a per-building service charge and a per-extinguisher charge, covered a range reflecting the size of areas needing services and the number of extinguishers present in any building.

Because the cost data includes ranges for some costs, the economic analysis was performed as a bracketing, present value comparison. Further, since such cost analyses require an assumed service life for the equipment, it was assumed that the life of an extinguisher is 24 years, having been hydrostatically tested once (at 12 years) and then replaced at Year 24, just before a second hydrostatic test is due. For an assumed 24 year service life, there will be one hydrostatic test at Year 12 and three disassembly and recharge services at Years 6, 12, and 18 because any service due at the end of life would not be performed.

The salvage value at the end of the service life is assumed to be zero since the initial cost of each component is low. Also, disposal costs of the units and equipment are assumed to be zero.

Another assumption is the discount (interest) rate. This is set at the estimated (annual) rate of return that could be realized on alternative investment of the funds to be used for the purchase being evaluated. A rate of inflation may be included in the discount rate but does not have to be. A discount rate that includes inflation over the service life is called the *nominal* discount rate and one that does not include inflation is called the *real* discount rate. The nominal discount rate (i) is defined as:

$$i = (1+r)(1+I)-1$$

where r is the (annual) interest rate and I is the (annual) inflation rate.

Since inflation has been very low for some years, the real discount rate was used for this analysis. The baseline discount rate was assumed to be 5% which is the commonly used value for economic analysis

COST ANALYSIS SPREADSHEET

The economic analysis is easily performed using an Excel spreadsheet. See Appendix A, Present Value Analysis, attached to this report. Costs per extinguisher were listed using the low and high costs obtained to bracket the values. Costs were further categorized as first, monthly, semi-annual, annual, maintain and recharge (6 years), and hydrostatic test (12 years) to facilitate identification of costs that had the greatest impact on the overall cost.

The assumed number of extinguishers in the facility, interest rate, and service life assumptions were based to the extent possible on actual buildings. RJA examined drawings for a dozen actual health care facilities ranging in size from 33,000 sq. ft. to 560,000 sq. ft. to determine the number of extinguishers required in each, which ranged from 15 to 420. The number of extinguishers required in each facility was then divided by the gross floor area to obtain the number of extinguishers per sq. ft. This ranged from 1500 to 2000 sq. ft. per extinguisher across all 12 facilities. NFPA 10 limits area coverage to not more than 6000 sq. ft., but other requirements make this density difficult to reach in real buildings. For this analysis, it was assumed that all extinguishers are nominal 5 pound ABC dry chemical type units rated 2-A:10-B:C, as these would be the most common in these applications.

It should be understood that in a present value analysis such as this, the discount (interest) rate only affects future payments, reducing their present cost. Thus, changing the assumed discount rate will only reduce monthly, semi-annual, annual, 6- and 12-year costs that are assumed to be made at the end of the period. (Monthly costs are paid at the end of the year in which they accrued.) First costs are not affected by the discount rate.

Monthly inspection costs consist of a per-extinguisher charge only, based on the cost of an employee spending 10 to 20 minutes per month per extinguisher at $18/hr salary (including benefits) performing the inspection. If these inspections are performed by an outside contractor, the cost would likely be higher, consisting of a service charge and a per-extinguisher charge.

Annual, 6- and 12-year costs include both a fixed service charge (one per visit per facility) and a per-extinguisher charge. Costs associated with the 6- and 12-year maintenance do not include costs associated with the provision of temporary replacement extinguishers since NFPA 10 does not require such replacements where maintenance is performed on-site as is the common practice of the service industry.

Charges for hydrostatic testing are applied at Year 12 but not at Year 24 since the analysis assumes that the extinguisher will be replaced at that time. Similarly, the disassembly and recharge is performed at Years 6, 12, and 18, but not at Year 24 because the extinguisher is assumed to be replaced.

RESULTS

Because actual costs vary depending on many factors, including the facility size and geographic location, costs were calculated as a bracketing range, following conservative assumptions in each case. For 5 lb., 2-A:10-B:C extinguishers the first cost (procurement, installation, and all required inspection, testing, and maintenance over a 24 year life all paid at the time of purchase) ranged from just over $700 to just over $1400 per extinguisher.

Based on the actual health care facility extinguisher location drawings, the annual cost per square foot ranged from $.015 to $.04 per square foot per year. If a facility was able to maximize extinguisher coverage at 6,000 square feet per extinguisher, the annual cost per foot would range from .005 to $.01. While unlikely that any facility can achieve the maximum permitted coverage, this calculation is provided for comparative purposes.

APPENDIX A -- PRESENT VALUE ANALYSIS

RJA PROJECT NO. C58655-1

Activity	Cost per Extinguisher		Service Charge per Facility Visit		Notes
	Low	High	Low	High	
Initial extinguisher purchase (5 lb., 2-A:10-B:C)	$40	$56	NA	NA	Plans for 12 health care facilities were reviewed to determine extinguisher quantities and sizes
Monthly inspection labor cost (10 to 20 minutes per extinguisher per month @$18/hr.)	$3	$6	$3	$6	Where inspection performed by owner, no service charge assessed
Annual maintenance per NFPA 10	$3	$6	$50	$100	
Disassembly and recharge per NFPA 10 @ 6, 12, 18 years, incl. cost of temporary replacements	$10	$12	$50	$100	
Hydrostatic testing @12 years, incl. recharge and cost of temp. repl.	$20	$25	$50	$100	Assumes extinguisher is replaced before second hydro. test

First costs	$400	$560	
Monthly insp. cost	$33	$66	Assumes "payment" at end of each year (24 periods in analysis).
Annual NFPA 10 cost per year	$80	$160	
Maintain and recharge per 6 years	$150	$220	
Hydrostatic test per 12 years	$150	$230	
Total extinguishers per facility	**10**		Calculation amortizes service charge over 10 extinguishers per facility
Interest rate (%)	**5%**		
Service life (years)	**24**		
First cost	($400)	($560)	
Annual costs over life	($6,568)	($13,136)	
6 year costs over life	($258)	($378)	
12 year costs over life	($84)	($128)	
Total cost over life per exnguisher	**($731)**	**($1,420)**	
Square feet per extinguisher	2000	1500	
Annual cost per extinguisher per sq ft	($0.015)	($0.039)	

U.S. Experience with Sprinklers

JOHN R. HALL, JR.

June 2013

National Fire Protection Association
Fire Analysis and Research Division

U.S. EXPERIENCE WITH SPRINKLERS

JOHN R. HALL, JR.

June 2013

National Fire Protection Association
Fire Analysis and Research Division

Abstract

Automatic sprinklers are highly effective elements of total system designs for fire protection in buildings. They save lives and property, producing large reductions in the number of deaths per thousand fires, in average direct property damage per fire, and especially in the likelihood of a fire with large loss of life or large property loss. In 2009, 4.6% of occupied homes (including apartments) had sprinklers, up from 3.9% in 2007, and 18.5% of occupied homes built in the previous four years had sprinklers. In 2007-2011 fires in all types of structures, when sprinklers were present in the fire area of a fire large enough to activate sprinklers in a building not under construction, sprinklers operated 91% of the time. When they operated, they were effective 96% of the time, resulting in a combined performance of operating effectively in 87% of reported fires where sprinklers were present in the fire area and fire was large enough to activate sprinklers. In homes (including apartments), wet-pipe sprinklers operated effectively 92% of the time. When wet-pipe sprinklers were present in the fire area in homes that were not under construction, the fire death rate per 1,000 reported structure fires was lower by 82%, and the rate of property damage per reported home structure fire was lower by 68%. In all structures, not just homes, when sprinklers of any type failed to operate, the reason most often given (64% of failures) was shutoff of the system before fire began.

Keywords: fire sprinklers, fire statistics, automatic extinguishing systems, automatic suppression systems

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. For more information about the National Fire Protection Association, visit www.nfpa.org or call 617-770-3000. To learn more about the One-Stop Data Shop go to www.nfpa.org/osds or call 617-984-7443.

Copies of this report are available from:

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NFPA No. USS14

Executive Summary

Automatic sprinklers are highly effective and reliable elements of total system designs for fire protection in buildings. According to the 2009 American Housing Survey, in 2009, 4.6% of occupied homes (including multi-unit) had sprinklers, up from 3.9% in 2007, and 18.5% of occupied home built in the previous four years had sprinklers.

Of reported 2007-2011 structure fires, an estimated 10% showed sprinklers present.* Sprinklers were reported as present in 57% of reported fires in health care properties. High-rise apartment buildings (47%), manufacturing facilities (48%), passenger terminals (51%), hotels and motels (52%), prisons and jails (53%), dormitories and barracks (53%), and high-rise office buildings (63%), all had sprinklers reported in roughly half or more of reported structure fires. In every other property uses, more than half of all reported fires were reported as sprinklers not present.

Sprinklers are still rare in educational properties (36% of fires), stores and offices (24%), public assembly properties (23%), and especially homes (6%), where most fire deaths occur. There is considerable potential for expanded use of sprinklers to reduce the loss of life and property to fire.

As defined in NFPA 13, section 3.4, a wet pipe sprinkler system has sprinklers attached to a piping system containing water so that water discharges immediately from sprinklers opened by heat from a fire, while a dry pipe sprinkler system has sprinklers attached to a piping system containing air or nitrogen under pressure so that sprinkler activation releases the air or nitrogen, allowing water pressure to open a valve and water to flow into the piping system and out the opened sprinklers.

With wet-pipe sprinklers the fire death rate per 1,000 reported home structure fires was lower by 82% and the rate of property damage per reported home structure fire was lower by 68%. For more on NFPA's Home Fire Sprinkler Initiative, go to http://www.firesprinklerinitiative.org.

Sprinkler systems are carefully designed to activate early in a real fire (responding to heat not smoke) but not to activate in a non-fire situation. Each sprinkler reacts only to the fire conditions in its area. Water release in a fire is generally much less than would occur if the fire department had to suppress the fire, because later action means more fire, which means more water is needed. Water release with no fire is rare compared to water release in response to a fire.

Sprinklers operated in 91% of all reported structure fires large enough to activate sprinklers, excluding buildings under construction and buildings without sprinklers in the fire area. When sprinklers operated, they were effective 96% of the time, resulting in a combined performance of operating effectively in 87% of all reported fires where sprinklers were present in the fire area and fire was large enough to activate them. The more widely used wet pipe sprinklers operated effectively 89% of the time, while dry pipe sprinklers operated effectively in 76% of cases.

* These estimates are projections based on the detailed information collected in Version 5.0 of the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS 5.0) and the NFPA's annual fire department experience survey. In this report, fires are excluded if they involve buildings under construction or failure or ineffectiveness because of a lack of sprinklers in the fire area. Because fires reported as confined fires are usually reported without sprinkler performance details or as fires too small to activate operating equipment, confined fires are not included in any analysis involving reliability or effectiveness of automatic extinguishing equipment. See Appendixes A and B for additional details of statistical methodology, including the distinction between confined and non-confined fires.

When sprinklers fail to operate, the reason most often given (64% of failures) was shutoff of the system before fire began, as may occur in the course of routine inspection or maintenance. Other leading reasons included manual intervention that defeated the system (17%), lack of maintenance (6%), and inappropriate system for the type of fire (5%). Only 7% of sprinkler failures were attributed to component damage.

When sprinklers operate but are ineffective, the reason usually had to do with an insufficiency of water applied to the fire, either because water did not reach the fire (44% of cases of ineffective performance) or because not enough water was released (30% of cases of ineffective performances). Other leading reasons were system component damage (8%), manual intervention that defeated the system (7%), lack of maintenance (7%), and inappropriate system for the type of fire (5%).

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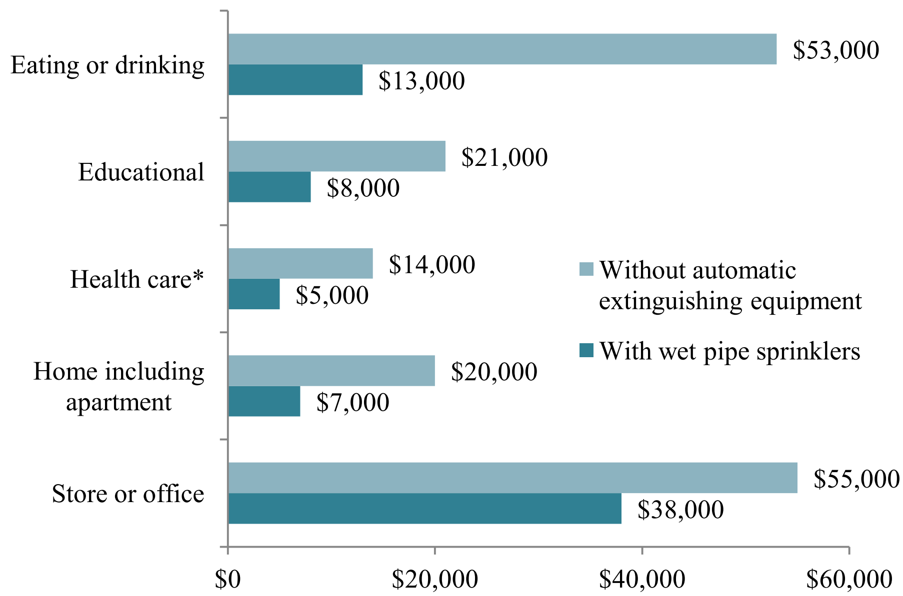
U.S. Experience with Sprinklers Fact Sheet

Sprinklers save lives and protect property from fires.

Compared to properties without automatic extinguishing equipment and specifying wet-pipe sprinklers

- The death rate per fire in sprinklered homes is lower by 82%.
- Direct property damage per fire in sprinklered homes is lower by 68%.

Damage per Fire With Wet Pipe Sprinklers versus Without Automatic Extinguishing Equipment, 2007-2011



*Health care includes hospitals, nursing homes, clinics, and doctor's offices.

Sprinklers are reliable and effective.

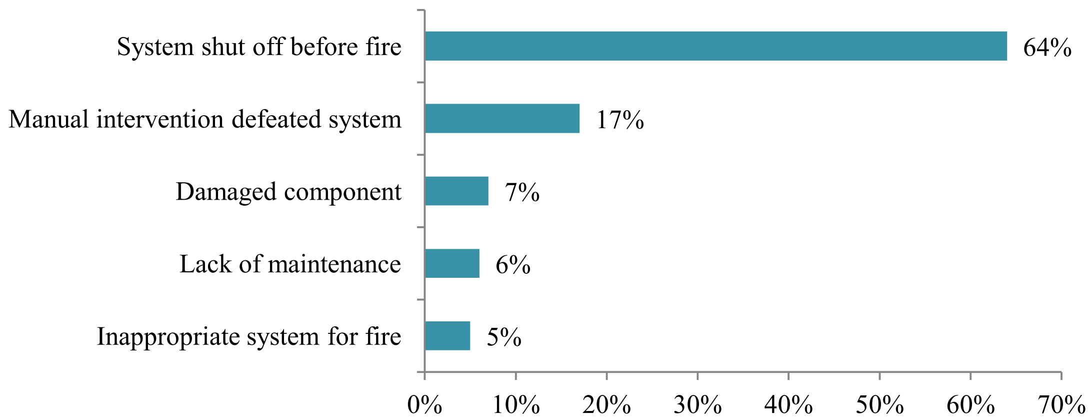
- In reported structure fires large enough to activate them, sprinklers operated in 91% of fires in sprinklered properties.
- Wet-pipe sprinklers operated in 92% of these fires vs. 81% for dry-pipe sprinklers.
- In reported structure fires large enough to activate them, sprinklers operated and were effective in 87% of fires in sprinklered properties.
- Wet-pipe sprinklers operated and were effective in 89% of fires vs. 76% for dry-pipe sprinklers.

NFPA's Fire Sprinkler Initiative: Bringing Safety Home seeks to encourage the use of home fire sprinklers and the adoption of fire sprinkler requirements for new construction.
See www.firesprinklerinitiative.org.

Statistics are based on 2007-2011 U.S. reported fires excluding buildings under construction and properties with no sprinklers in fire area. Almost no reported confined fires are large enough to activate operating sprinklers, and so confined fires are excluded from analysis of reliability and effectiveness.

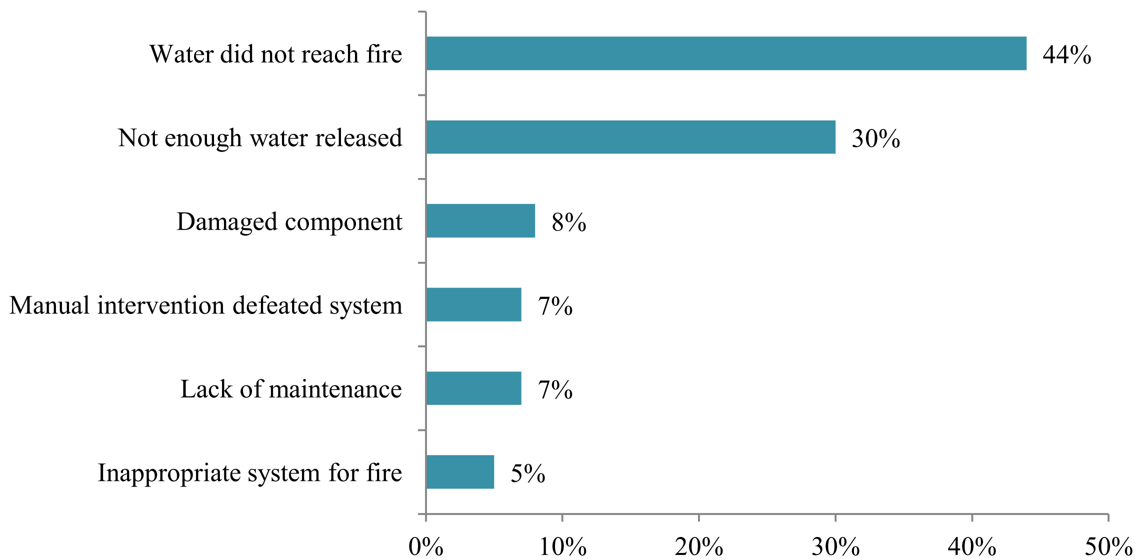
In 2007-2011 fires large enough to activate them, sprinklers operated in 91% of fires in sprinklered properties. The graph below is based on the other 9% in which sprinklers should have operated but did not.

Reasons When Sprinklers Fail to Operate, 2007-2011



In 2007-2011 fires where sprinklers operated, they were effective in 96% of the cases. The graph below is based on the other 4% in which the sprinkler was ineffective.

Reasons When Sprinklers Are Ineffective, 2007-2011



Usually only 1 or 2 sprinklers are required to control the fire.

- When wet-pipe sprinklers operated, 88% of reported fires involved only 1 or 2 sprinklers.
- For dry-pipe sprinklers, 73% involved only 1 or 2 sprinklers.

Statistics are based on 2007-2011 U.S. reported fires excluding buildings under construction and properties with no sprinklers in fire area. Almost no reported confined fires are large enough to activate operating sprinklers, and so confined fires are excluded from analysis of reliability and effectiveness.

NFPA's Fire Safety Resources

NFPA´s wealth of fire-related research includes investigations of technically significant fire incidents, fire data analysis, and the Charles S. Morgan Technical Library, one of the most comprehensive fire literature collections in the world. In addition, NFPA´s Fire Protection Research Foundation is a source of independent fire test data. Find out more at:

www.nfpa.org/research

Properly installed and maintained smoke alarms are necessary to provide a warning of any fire to all occupants. You can find out more information about smoke alarms here: NFPA Smoke Alarm Information

Home fire sprinkler systems provide even greater protection. These systems respond quickly to reduce the heat, flames, and smoke from a fire until help arrives. More information about home fire sprinklers may be found at www.firesprinklerinitiative.org

Simply put, smoke alarms and fire sprinklers save lives.

Research

Advocacy

Codes & Standards

Public Education

NFPA also develops and publishes, more than 300 consensus codes and standards intended to minimize the effects of fire, including:

NFPA 101: Life Safety Code®:

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.

NFPA13R Standard For The Installation of Sprinkler Systems in Low-Rise Residential Occupancies

For consumers: NFPA has consumer safety information regarding causes, escape planning, fire & safety equipment, and many other topics.

Sparky.org has important For Kids for kids delivered via fun games, activities, and cartoons.

For public educators: Resources on fire safety education programs, educational messaging, grants & awards, and many other topics.

Section 1. Presence of Sprinklers

Fire sprinklers are highly reliable and effective elements of total system designs for fire protection in buildings. They save lives and property, producing large reductions in the number of deaths per thousand fires, in average direct property damage per fire, and especially in the likelihood of a fire with large loss of life or large property loss.

In 2007-2011, sprinklers were reported present in only 10% of reported structure fires.

The left side of Table 1-1 indicates, by property use for 1980-1984 and 1994-1998, the number of structure fires per year where any type of automatic extinguishing equipment was present and the associated percentage of total structure fires. (The established generic name of "automatic extinguishing equipment" is misleading, because most such equipment is designed to control fires and not to fully extinguish them.) Prior to 1999, incident report coding did not distinguish different types of automatic extinguishing equipment and in particular did not distinguish sprinklers. The right side of Table 1-1 indicates, by property use for 2007-2011, the number of structure fires per year and the percentage of total structure fires where any type of automatic extinguishing equipment was present and where any type of sprinklers were present.[1]

The left side of Table 1-1 can be used to track trends in the usage of automatic extinguishing equipment by property use. Usage is up dramatically in most property use groups – department stores are a notable exception. For most property uses, nearly all automatic extinguishing equipment cited in fires is sprinklers. Exceptions are places with extensive use of wet or dry chemical systems to protect commercial cooking equipment – eating and drinking establishments (and the larger public assembly group they dominate) and grocery or convenience stores.

The right side of Table 1-1 can be used to examine differences in presence of sprinklers in fires in different property uses. However, only one type of equipment can be coded in any one fire incident, and it should be the type closest to the fire. It is possible that some or most of the fires reported with dry (or possibly wet) chemical equipment protecting a commercial cooking surface were in properties that also had sprinkler systems.

Of reported 2007-2011 structure fires in health care properties, an estimated 57% showed sprinklers present, with higher percentages for hospitals (63%) and nursing homes (69%) and a much lower percentage (not shown on Table 1-1) for the other health care properties, notably clinics and doctor's offices (35%).

Sprinklers were also reported as present in roughly half of reported fires in prisons and jails (53%), hotels and motels (52%), manufacturing facilities (48%), and high-rise apartment buildings (47%). In every other property use, more than half of all reported fires were reported as sprinklers not present.

[1] Some fires after 1999 are coded as confined fires, which are fires confined to cooking vessel, chimney or flue, furnace or boiler, incinerator, commercial compactor, or trash receptacle. Confined fires permit limited reporting with most data fields not required and usually left blank. Confined fires combine with very low sprinkler usage to make estimates for one- and two-family homes too volatile and uncertain to list separately, and so estimates are provided only for all homes (including apartments) combined.

Some of the highest usage percentages were for high-rise hotels (64%) and high-rise offices (63%). In general, high-rise properties show much more usage of fire protection systems and features than other properties of the some property use.[2]

The following properties where large numbers of people routinely are present show 37% or less of reported fires in properties with sprinklers present in 2007-2011:

- Every type of public assembly property except passenger terminals
- Educational properties
- Homes (including apartments)
- Rooming or boarding homes
- Every type of store except department stores
- Offices except high-rise offices

Most fires in storage properties are not in warehouses but are in garages, barns, silos, and small outbuildings. It is these types of buildings that drive the very low percentage (4%) of reported fires with sprinklers in all storage properties combined.

In 2007-2011, sprinklers were reported in only 6% of fires in homes (including apartments). Although the percentage of homes with some kind of automatic extinguishing equipment is up from 1% in 1980-1984 and 2% in 1994-1998 to 7% in 2007-2011, there is clearly great potential for expanded installation.

General Statistics on Usage

The 2007 and 2009 American Housing Surveys included a question about sprinkler presence inside homes.[3]

The two surveys showed that 3.9% of occupied year-round housing units had sprinklers in 2007, rising to 4.6% in 2009. Table 1-A shows 2007 and 2009 sprinkler usage percentages for a number of different categories of housing units.

Most of the usage percentages in Table 1-A rose by one-sixth to one-fourth between 2007 and 2009. The notable exceptions were occupied housing units in the Northeast, where the usage percentage rose by more than a third, and the occupied new construction category, where the usage percentage rose by more than half. In 2009, nearly one of every five occupied housing units built in the previous four years had sprinklers.

In the inventory of single-family detached homes, nearly 1.4 million homes had sprinklers in 2009 and nearly 300,000 of those dwellings with sprinklers had been added to the inventory since 2007.

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[2] John R. Hall, Jr., *High-Rise Building Fires*, NFPA Fire Analysis and Research Division, November 2011.

[3] *American Housing Survey 2007* and *2009*, U.S. Department of Commerce and U.S. Department of Housing and Urban Development, September 2008 and September 2010, Tables, 2-4, 2-25 (for 2007 survey) and special analysis provided by the survey report authors of statistics from the discontinued Table 2-25 (for 2009 survey).

The Home Fire Sprinkler Coalition, formed in 1996, developed a variety of educational materials about the benefits of home fire sprinklers. These materials address common questions and misconceptions. They may be accessed through their web site www.homefiresprinkler.org.

Table 1-A. Sprinkler Usage by Category of Housing, 2007 and 2009

Category of Housing	2007	2009
Occupied year-round housing	3.9%	4.6%
Occupied single-family detached homes	1.5%	1.9%
Occupied single-family homes, either detached or attached	1.9%	2.2%
Occupied housing units in all multi-unit buildings	10.6%	12.9%
Occupied housing units in buildings with 2-4 units	2.9%	3.4%
Occupied housing units in buildings with 5-9 units	5.8%	7.7%
Occupied housing units in buildings with 10-19 units	12.1%	14.8%
Occupied units in buildings with 20-49 units	16.3%	18.4%
Occupied housing units in buildings with 50 or more units	27.3%	32.4%
Occupied manufactured homes	0.9%	1.0%
Owner-occupied housing units	2.3%	2.7%
Renter-occupied housing units	7.2%	8.7%
Occupied housing units built within last 4 years	11.8%	18.5%
Occupied housing units in Northeast	3.3%	4.6%
Occupied housing units in Midwest	2.7%	3.5%
Occupied housing units in South	3.7%	4.4%
Occupied housing units in West	5.7%	6.2%
Housing units occupied by households below poverty level	4.6%	5.6%
Housing units occupied by households with older adult head	5.2%	5.7%

Source: *American Housing Survey 2007* and *2009*, U.S. Department of Commerce and U.S. Department of Housing and Urban Development, September 2008 and September 2010, Tables, 2-4, 2-25 (for 2007 survey) and special analysis provided by the survey report authors of statistics from the discontinued Table 2-25 (for 2009 survey). All safety equipment questions were deleted for the 2011 edition.

Because sprinkler systems are so demonstrably effective, they can make a major contribution to fire protection in any property. NFPA 101®, *Life Safety Code*, NFPA 1®, *Fire Code*, and NFPA 5000®, *Building Construction and Safety Code*, have required sprinklers in all new one- and two-family homes, all nursing homes, and many nightclubs since the 2006 editions. The 2009 edition of the *International Residential Code* also added requirements for sprinklers in one- and two-family homes, effective January 2011. This protection can be expected to increase in areas that adopt and follow these codes. NFPA is supporting adoption of these requirements through its Fire Sprinkler Initiative (see http:/www.firesprinklerinitiative.org).

Table 1-1. Presence of Sprinklers in Structure Fires

Property Use	Number of Structure Fires With Equipment Present and Percentage of Total Structure Fires in Property Use							
	Any Automatic Extinguishing Equipment						Any Sprinkler	
	1980-1984		1994-1998		2007-2011		2007-2011	
All public assembly	4,280	(13%)	4,380	(26%)	7,720	(53%)	3,410	(23%)
Variable-use amusement place	120	(8%)	140	(16%)	230	(19%)	190	(16%)
Religious property	50	(2%)	90	(5%)	280	(16%)	200	(12%)
Library or museum	80	(14%)	110	(28%)	240	(41%)	210	(37%)
Eating or drinking establishment	3,310	(16%)	3,240	(29%)	4,710	(63%)	1,680	(23%)
Passenger terminal	70	(20%)	60	(35%)	400	(52%)	390	(51%)
Educational property	1,620	(13%)	1,820	(24%)	2,370	(42%)	2,020	(36%)
Health care property*	6,920	(47%)	4,400	(68%)	3,810	(66%)	3,360	(57%)
Nursing home	2,250	(61%)	2,060	(76%)	2,050	(75%)	1,880	(69%)
Hospital	3,370	(47%)	1,650	(74%)	1,020	(78%)	830	(63%)
Hospital, clinic or doctor's office high rise					*190*	*(84%)*	*150*	*(65%)*
Hospital, clinic or doctor's office not high rise					*1,060*	*(61%)*	*890*	*(51%)*
Prison or jail	370	(10%)	430	(19%)	280	(57%)	260	(53%)
All residential	7,090	(1%)	11,110	(3%)	32,550	(8%)	29,430	(8%)
Home (including apartment)	5,120	(1%)	8,440	(2%)	25,620	(7%)	23,650	(6%)
Apartment high rise					*4,220*	*(51%)*	*3,880*	*(47%)*
Apartment not high rise					*17,520*	*(18%)*	*16,210*	*(17%)*
Hotel or motel	1,590	(15%)	1,690	(35%)	2,090	(58%)	1,870	(52%)
High rise					*350*	*(74%)*	*300*	*(64%)*
Not high rise					*1,740*	*(56%)*	*1,570*	*(50%)*
Dormitory or barracks	430	(16%)	620	(29%)	2,180	(57%)	2,020	(53%)
Rooming or boarding home	70	(4%)	230	(17%)	1,130	(40%)	1,050	(37%)
Board and care home	Not available		Not available		940	(51%)	860	(46%)
Store or office	5,510	(13%)	5,230	(21%)	5,800	(33%)	4,230	(24%)
Grocery or convenience store	1,160	(15%)	1,190	(27%)	1,880	(48%)	880	(23%)
Laundry or dry cleaning or other professional service	330	(8%)	310	(13%)	310	(21%)	300	(19%)
Department store	1,340	(44%)	1,100	(52%)	530	(47%)	470	(42%)
Office	1,240	(12%)	1,470	(25%)	1,190	(36%)	1,100	(33%)
High rise					*210*	*(67%)*	*200*	*(63%)*
Not high rise					*970*	*(33%)*	*890*	*(30%)*
Manufacturing facility	11,910	(44%)	6,400	(50%)	2,950	(56%)	2,530	(48%)
All storage	1,430	(2%)	1,090	(3%)	830	(4%)	770	(4%)
Warehouse excluding cold storage*	1,060	(13%)	740	(22%)	430	(34%)	400	(32%)
All structures	38,620	(4%)	37,100	(7%)	59,380	(12%)	48,460	(10%)

* "Health care property" includes other facilities not listed separately. In 1980-84 and 1994-98, this category excludes doctor's office and care of aged facilities without nursing staff (which are assumed to be residential board and care facilities). In 1980-1984 and 1994-1998, "warehouse" includes general warehouse, textile storage, processed food storage except cold storage and storage of wood, paper, plastics chemicals, and metals.

Notes: These are structure fires reported to U.S. municipal fire departments and so exclude fire 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.

Source: NFIRS and NFPA survey.

Section 2. Type of Sprinkler

In reported fires with sprinklers present, most sprinklers are wet pipe sprinklers. Table 2-1 shows the percentage of fires, excluding buildings under construction, by type of sprinkler, for each of the major property use groups and some subgroups.[4] Percentage calculations are based only on fires where sprinkler presence and type were known and reported. 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.

Overall, when some type of sprinkler was reported in 2007-2011 structure fires, wet pipe sprinklers were reported in 88% of the fires, dry pipe sprinklers in 9% of the fires, and other sprinklers in 3%.

As defined in NFPA 13, section 3.4, a wet pipe sprinkler system has sprinklers attached to a piping system containing water so that water discharges immediately from sprinklers opened by heat from a fire, while a dry pipe sprinkler system has sprinklers attached to a piping system containing air or nitrogen under pressure so that sprinkler activation releases the air or nitrogen, allowing water pressure to open a valve and water to flow into the piping system and out the opened sprinklers.

Wet pipe sprinklers out-numbered dry pipe sprinklers by roughly 10-to-1. The major property classes with the largest share for dry pipe sprinklers were passenger terminals (25%), all storage facilities (24%), and warehouses excluding cold storage specifically (20%).

[4] Some fires after 1999 are coded as confined fires, which are fires confined to cooking vessel, chimney or flue, furnace or boiler, incinerator, commercial compactor, or trash receptacle. Confined fires permit limited reporting with most data fields not required and usually left blank. Confined fires combine with very low sprinkler usage to make estimates for one- and two-family dwellings too volatile and uncertain to list separately, and so estimates are provided only for all homes combined.

Table 2-1. Type of Sprinkler Reported in Structure Fires Where Equipment Was Present in Fire Area, by Property Use 2007-2011 Structure Fires Reported to U.S. Fire Departments

Property Use	Fires per year with any type of sprinkler	Wet pipe sprinklers	Dry pipe sprinklers	Other sprinklers*
All public assembly	3,410	82%	8%	10%
Variable-use amusement place	190	87%	12%	1%
Religious property	200	91%	7%	1%
Library or museum	210	81%	13%	6%
Eating or drinking establishment	1,680	79%	7%	14%
Passenger terminal	390	74%	25%	1%
Educational property	2,020	89%	9%	2%
Health care property**	3,360	86%	11%	3%
Nursing home	1,880	89%	9%	2%
Hospital	830	89%	9%	2%
Prison or jail	260	90%	6%	4%
All residential	29,430	89%	9%	2%
Home (including apartment)	23,650	89%	8%	2%
Hotel or motel	1,870	90%	7%	3%
Dormitory or barracks	2,020	89%	9%	2%
Rooming or boarding home	1,050	88%	11%	0%
Board and care home	860	91%	8%	1%
Store or office	4,230	87%	10%	3%
Grocery or convenience store	880	84%	10%	6%
Laundry or dry cleaning or other professional service	300	84%	12%	4%
Department store	470	88%	11%	2%
Office	1,100	89%	8%	3%
Manufacturing facility	2,530	85%	12%	3%
All storage	770	75%	24%	2%
Warehouse excluding cold storage	400	79%	20%	1%
All structures ***	48,460	88%	9%	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 survey.

Section 3. Reliability and Effectiveness

Sprinklers operated in 91% of reported structure fires where sprinklers were present, excluding buildings under construction, partial installations, and small fires.
Table 3-1 shows:

- the number of structure fires per year where sprinklers were present,
- the percentage of fires where sprinklers operated,
- the percentage of operating equipment cases where sprinklers were effective, and
- the percentage of fires where sprinklers operated effectively (i.e., operated and were effective).

Table 3-1 also shows these statistics for specific types of sprinklers (specifically, for wet pipe and dry pipe sprinklers). For example, the percentage of fires where sprinklers operated was:

- 92% for wet pipe sprinklers, and
- 81% for dry pipe sprinklers.

For sprinklers that operated, sprinkler performance was deemed effective in 96% of the cases, and sprinklers operated effectively 87% of the time (96% times 91%).
The percentage of fires where sprinklers operated effectively was as follows for specific types of sprinklers:

- 89% for wet pipe sprinklers, and
- 76% for dry pipe sprinklers.

Wet pipe sprinklers are more reliable than dry pipe sprinklers and more effective when they operate, resulting in a higher percentage of effective operation.

A disadvantage of measuring sprinkler effectiveness by judgments made in incident reports is the ambiguity and subjectivity of the criterion of "effective," which has never been precisely defined, let alone supported by an operational assessment protocol that could be executed consistently by different people.

When sprinkler performance is deemed to be a failure (did not operate) or ineffective (operated but not effective), reasons for failure or ineffective can be reported:

- System shut off
- Not enough agent (water) discharged to control the fire
- Agent (water) discharged but did not reach the fire
- Inappropriate system for type of fire
- Fire not in area protected by the system
- System component(s) damaged
- Lack of maintenance, including corrosion or heads painted
- Manual intervention defeated the system
- "Other" reason
- Undetermined reason

Some combinations of coded entries are inconsistent (e.g., system operated but was not effective, and reason for ineffectiveness was systems shut off). The text box on Database Edits provides a detailed description of steps in the analysis designed to address these inconsistencies.

Database Edits

In order to estimate reliability and effectiveness, the database must first be edited to remove fires, buildings, and systems where operation cannot be expected, such as buildings under construction. Statistics on reliability and effectiveness exclude partial systems, whether identified by coding under sprinkler presence or identified by reason for failure and ineffectiveness as equipment not in area of fire. Not all partial systems will be so identified and the codes and standards for many types of sprinklers do not require coverage in all areas. For example, concealed spaces and exterior locations may not be required to have coverage.

The coding of reasons for failure or ineffectiveness has been used in this analysis to recode system performance entries. First, fires with reason for failure or ineffectiveness coded as sprinklers not in fire area are excluded from analysis because reliability and effectiveness cannot be judged in these situations. Second, the coding of performance as failure or ineffective is changed if that coding is inconsistent with the coded reason, as follows:

If Performance = Not Effective	And Reason =	Then Change to:
	System shut off	Performance = Failed to operate

If Performance = Failed to Operate	And Reason =	Then Change to:
	Not enough agent OR Agent didn't reach fire	Performance = Not effective

Finally, fires with reason for failure or ineffectiveness listed as "other" (unclassified), unknown, or blank are proportionally allocated over the known reasons. There is no way to know whether fires coded with "other" as reason for failure or ineffectiveness really had one of the coded reasons, had reason unknown, or had a known reason that was not one of the coded reasons.

The following reasons for failure or ineffectiveness may be difficult to translate into a particular one of the NFIRS 5.0 reasons, even though they are not necessarily distinct, separate reasons themselves:

- Specific design of sprinkler system proves inadequate to the size or location of fire, even though the type of sprinkler system is considered appropriate to the property use and hazard under applicable standards; or
- Poor or obsolete (no longer compliant with current standards and codes) design installation, which does not take the form of an inappropriate *type* of system or of damaged components.

These reasons for failure or ineffectiveness could be coded as inappropriate system, component damage, or lack of maintenance, even though circumstances do not fit these designations well. Alternatively, these reasons could be coded in terms of their effect on performance, as not enough water released or water did not reach fire. If there is not a good fit between circumstances and specific wording of reason for failure or ineffectiveness, or if the circumstances might fit two or more of the coded categories equally well, the report might use "Other".

Because the hard-to-code circumstances do not constitute a clearly distinct failure mode, the analysis approach used here of basing percentages on the known and classified responses is still reasonable. However, it is worth mentioning these two groups of circumstances in any discussion of reasons for failure or ineffectiveness, and this report will do so.

Nearly two-thirds (64%) of sprinkler failures occurred because the system was shut off. Table 3-2 provides the percentages of reasons for failure, after recoding, by type of sprinkler and property use in 2007-2011. Other or unclassified reason for failure is treated as an unknown and allocated.

For all types of sprinklers combined:

- 64% of failures to operate were attributed to the equipment being shut off,
- 17% were because manual intervention defeated the equipment,
- 7% were because a component was damaged,
- 6% were because of lack of maintenance, and
- 5% were because the equipment was inappropriate for the type of fire.

If manual intervention occurs before fire begins, one would expect that to be coded as system shut off before fire. If manual intervention occurs after sprinklers operate, one would expect that to constitute ineffective performance, not failure to operate. What is left is manual intervention after fire begins but before sprinklers operate, but we do not know whether that is the only condition associated with coding as manual intervention.

As noted in the bullets above, only 7% were because of a failing of the equipment rather than a failing of the people who designed, selected, maintained, and operated the equipment. If these human failings could be eliminated, the overall sprinkler failure rate would drop from the estimated 9% of reported fires to 0.6%. That is close to the sprinkler failure rate reported in the mid-1980s by Marryatt[5] for Australia and New Zealand, where high standards of maintenance were reportedly commonplace.

Training can sharply reduce the likelihood of three other causes of failure – system defeating due to manual intervention, lack of maintenance, and installation of the wrong system for the hazard.

Most cases of sprinkler ineffectiveness in non-confined fires were because water did not reach the fire (44%) or because not enough water was released (30%).
Table 3-3 provides distributions of reasons for ineffectiveness, by property class and type of automatic extinguishing equipment. In Table 3-3, two of the reasons for ineffectiveness are (extinguishing) agent did not reach the fire and not enough (extinguishing) agent was released. For sprinklers, the agent is water. In addition to the two reasons cited, other reasons for sprinkler ineffectiveness for all structures were damage to a system component (8%), defeating due to

[5] H.W. Marryatt, Fire: *A Century of Automatic Sprinkler Protection in Australia and New Zealand*, 1886-1986, 2nd edition, Victoria, Australia: Australian Fire Protection Association, 1988.

manual intervention (7%), lack of maintenance (7%), and inappropriate equipment for the type of fire (5%).

Insufficient (not enough) water can be released if there are problems with the system's water supply. This reason for ineffectiveness can also overlap with other reasons, such as inappropriate equipment (if, for example, the hazard has changed under the equipment and now requires a higher water flow density than is provided by the now inappropriate equipment) and defeating by manual intervention (if, for example, the sprinklers are turned off prematurely so that insufficient water reaches the fire). Insufficient water also could be one of the reasons that could be cited if a flash fire or a fire with several points of origin overwhelms the system or if an explosion reduces the water flow but does not cause complete system failure.

There are a number of different ways in which *water may not reach the fire*. One is shielded fires such as rack storage in a property with ceiling sprinklers only. Another is fire spread above exposed sprinklers, through unsprinklered concealed spaces, or via exterior surfaces. Another reason would be a deep-seated fire in bulk storage. A different kind of problem would be droplet sizes that are too small to penetrate the buoyant fire plume and reach the seat of the fire.

A blockage in the pipes (e.g., due to mussels) that reduces but may not completely interrupt the flow of water might be coded as insufficient water, water did not reach fire, or even lack of maintenance.

Even a well-maintained, complete, appropriate system requires the support of a well-considered integrated design for all the other elements of the building's fire protection. Unsatisfactory sprinkler performance can result from an inadequate water supply or unique building construction features. More broadly, unsatisfactory fire protection performance can occur if the building's design does not address all five elements of an integrated system – slowing the growth of fire, automatic detection, automatic suppression, confining the fire, and occupant evacuation.

Effectiveness should be measured relative to the design objectives for a particular system. For most rooms in most properties, sprinklers are designed to confine fire to the room of origin.

Some properties have some very large rooms in which the sprinkler installation is designed to confine fire to a design area that is much smaller than the entire room. These rooms could include large assembly areas; sales, showroom, or performance areas; and storage areas.

Table 3-A shows the percentage of fires, by property use, that begin in five types of rooms that *could* be large enough to have a design area smaller than the entire room. Many of these rooms will not be that large. All these rooms combined do not account for a majority of fires in any type of property, and only stores and offices and warehouses have more than about one-seventh of their fires in such rooms.

Table 3-A. Fires With Areas of Origin That Could Be Room Larger Than Sprinkler Design Area for Space Percent of Structure Fires Excluding Buildings Under Construction, Sprinklers Not in Fire Area, and Fires Coded as Confined Fires
2007-2011 Structure Fires With Sprinklers Present Reported to U.S. Fire Departments

Property Use	Large Assembly Area (At Least 100 People)	Sales, Showroom or Performance Area	Unclassified Storage Area	Shipping, Receiving or Loading Area	Storage Room Area, Tank or Bin	All Areas Combined
Warehouse excluding cold storage	0.2%	0.2%	13.2%	18.2%	8.5%	40.3%
Store or office	0.2%	10.2%	4.6%	3.6%	4.2%	22.8%
Public assembly excluding eating or drinking establishment	6.3%	1.4%	2.0%	0.3%	2.8%	14.8%
Manufacturing facility	0.1%	0.0%	2.7%	2.5%	2.9%	8.2%
Educational property	2.9%	0.5%	1.9%	0.3%	1.2%	6.8%
Eating or drinking establishment	1.3%	0.1%	1.9%	0.3%	1.9%	5.5%
Hotel or motel	0.5%	0.1%	1.5%	0.0%	1.5%	3.6%
Health care property*	0.2%	0.0%	1.0%	0.2%	0.9%	2.3%
Home (including apartment)	0.0%	0.1%	0.5%	0.0%	0.5%	1.1%

* Hospital, clinic, doctor's office, nursing home and development disability facility.

Note: Percentages sum left to right and may not equal totals in last column because of rounding. Fires reported as confined fires are excluded because such fires could not be large enough to exceed the sprinkler design area. Statistics are based on structure fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. Statistics exclude buildings under construction, partial systems, and fires with sprinklers not in fire area reported as reason for failure or ineffectiveness of automatic extinguishing equipment.

Source: NFIRS and NFPA survey.

Sprinklers are designed to confine a fire to the room of origin or the design fire area, whichever is smaller.
Therefore, the benefits of sprinklers will tend to come in the following scenarios:

- A fire that would otherwise have spread beyond the room of fire origin will be confined to the room of origin, resulting in a smaller fire-damaged area and less property damage.

- A fire that would otherwise have grown larger than the design fire area in a room larger than that area will be confined to the design fire area, resulting in a smaller fire-damaged area and less property damage.

- A fire will be confined to an area smaller than the room or the design fire area, even though that degree of success goes beyond the performance assured by the design, resulting in a smaller fire-damaged area and less property damage.

Table 3-4 provides direct measurement of sprinkler effect involving the first bulleted scenario above. For all structures combined, 51% have flame damage confined to room of origin when there is no automatic extinguishing equipment present. This rises to 86% of fires with flame damage confined to room of origin when any type of sprinkler is present.

As noted, for most rooms in most properties, effective performance is indicated by confinement of fire to the room of origin. Table 3-B shows that when an operating system is judged effective, flame is usually confined to the room of origin (86% for all structures). When sprinklers fail to operate or are ineffective, it is much less likely that fire was confined to the room of origin. Table 3-B suggests that the property uses with larger percentages of floor space devoted to very large rooms (e.g., manufacturing, storage) are more likely to have fire spread beyond the room of origin even though sprinkler performance was judged effective.

Table 3-B. Sprinkler Success in Confining Fire to Room of Origin vs. Sprinkler Performance by Property Use Group
2007-2011 Structure Fires Reported to U.S. Fire Departments Where Sprinklers Were Present in Fire Area, Fire Was Not Coded as Confined and Was Large Enough to Activate Sprinklers, and Building Was Not Under Construction

	Percentage of Fires Confined to Room of Origin		
Property Use	**Where Sprinklers Operated Effectively**	**When Sprinklers Failed to Operate**	**When Sprinklers Operated But Were Not Effective**
Public assembly	84%	64%	46%
Eating or drinking establishment	83%	67%	40%
Educational	93%	82%	22%
Health care property*	92%	82%	86%
Residential	92%	71%	40%
Home (including apartment)	91%	68%	37%
Hotel or motel	95%	75%	59%
Store or office	81%	65%	62%
Office	85%	75%	51%
Manufacturing facility	76%	62%	41%
Storage	73%	32%	42%
Warehouse excluding cold storage	71%	41%	60%
All structures**	86%	64%	46%

* Hospital, clinic, doctor's office, nursing home and development disability facility.

**Includes some properties not separately listed above.

Source: NFIRS and NFPA Survey.

Table 3-B also suggests that confinement of fire to room of origin is more likely when sprinklers fail to operate than when sprinklers operate but are not effective. This is not so surprising as it may appear. When sprinklers fail to operate, the reason almost always has nothing to do with the fire, and so the fire sizes may have the full mix of fire sizes found in that kind of property. When sprinklers operate but are ineffective, the reason often has to do with an insufficiency of water delivered to the fire, which means the fire has to be large enough not only to activate the sprinklers but to overpower them. That in turn suggests a larger average fire size for ineffective sprinklers than for failed sprinklers.

Dry pipe sprinklers that operate have more sprinklers operating than wet pipe sprinklers that operate.
Table 3-5 shows the number of sprinklers operating by type of sprinkler system. Five or fewer sprinklers operated in 95% of the wet pipe system activations and 88% of the dry pipe system activations.

Dry pipe systems that operate are less likely to open only one sprinkler than wet pipe systems that operate (55% vs. 74% of fires). The likely reason is the designed time delay in tripping the dry pipe valve and passing water through the piping to the opened sprinklers. The delay permits fire to spread, which can mean a larger fire, requiring and causing more sprinklers to activate.

Wet pipe sprinkler systems tend to have more sprinklers operating in fires in manufacturing facilities or warehouses than in other properties.
Table 3-6 shows the number of wet pipe sprinklers operating by property use group. In manufacturing facilities, 67% of the fires in properties where wet pipe sprinklers operated had two or fewer sprinklers operating, which means 33% of the fires in properties had at least three sprinklers operating. Similarly, 86% had five or fewer sprinklers operating, which means 14% had at least six sprinklers operating. By contrast, in public assembly properties and stores and offices where wet pipe sprinklers operated, 84-88% of fires had two or fewer sprinklers operating, which means only 12-16% of fires in properties had at least three sprinklers operating. Similarly, 94-96% had five or fewer sprinklers operating, which means only 4-6% had at least six sprinklers operating.

In homes (including apartments), 94% of fires had two or fewer sprinklers operating.

Effectiveness declines when more sprinklers operate.
When more than 1-2 sprinklers have to operate, this may be taken as an indication of less than ideal performance. Table 3-7 shows that the percentage of fires where performance is deemed effective decreases as the number of wet pipe sprinklers operating increases, falling from 98% effectiveness in fires when one sprinkler opens to 83% effectiveness when more than 10 sprinklers open. At the same time, the number of sprinklers operating should not be used as an independent indicator of effectiveness because sprinklers are deemed effective in most fires where sprinklers operate, no matter how many sprinklers operate. Furthermore, most sprinkler installations are designed for control, not extinguishment, and anticipate that multiple sprinklers will be needed for control in some fire scenarios.

Details on reasons for failure or ineffectiveness and how to address them.
The following potential reasons for failure or ineffectiveness are defined in the statistical database:

- System shut off (a reason for failure but not for ineffectiveness),
- Wrong type of (inappropriate) system for the type of fire,
- Manual intervention [defeated the system]
- Not enough agent discharged (a reason for ineffectiveness but not for failure),
- Lack of maintenance [including corrosion or heads painted],
- Agent discharged but did not reach fire (a reason for ineffectiveness but not for failure),
- System component damaged,
- Fire not in area protected [by the system] (excluded from analysis of failure and ineffectiveness)

Table 3-C shows how each reason contributes to failure and ineffectiveness.

Table 3-C. Reasons for Failure or Ineffectiveness as Number of 2007-2011 Structure Fires per Year and Percentages of All Cases of Failure or Ineffectiveness, for All Structures and Wet Pipe Sprinklers Excluding Buildings Under Construction, Sprinklers Not in Fire Area, and Fires Coded as Confined Fires

Reason	Failure		Ineffectiveness		Combined	
System shut off	1,638	(42%)	0	(0%)	1,638	(42%)
Manual intervention defeated system	568	(14%)	114	(3%)	682	(17%)
Water discharged but did not reach fire	0	(0%)	516	(13%)	516	(13%)
Not enough water discharged	0	(0%)	385	(10%)	385	(10%)
Lack of maintenance	196	(5%)	54	(1%)	251	(6%)
System component damaged	183	(5%)	67	(2%)	250	(6%)
Wrong type of (inappropriate) system for type of fire	161	(4%)	64	(2%)	225	(6%)
Total	2,746	(70%)	1,200	(30%)	3,946	(100%)

Source: Calculated from percentages and numbers in Total lines of Tables 3-2B and 3-3B.

The bulleted list above should add another category of potential reasons for failure or ineffectiveness which is similar to several of the identified reasons but sufficiently different from all of them that it may constitute some of the "other" or unclassified reported reasons for failure or ineffectiveness:

- Because of poor or obsolete design, manufacture, or installation, the sprinklers are not able to deliver sufficient water in time and in the right place to control the fire.

If the "other" category for reasons for failure or ineffectiveness is not being used primarily to mean unknown or multiple reasons from the identified reasons, then the rankings in Table 3-C might change, except for the dominant leading reason of system shut off, which would remain the leading reason in any case. If the "other" reason suggested above – poor or obsolete design, manufacturing, or installation – is a major part of the reported "other reasons, then most of those cases might fit best with the "wrong system" identified reason, which might thereby move from last place to second place. In other words, not too much emphasis should be placed on the relative shares and rankings of the reasons ranking below system shut off.

NFPA has compiled published incidents (see selected examples in Appendix C) that illustrate the different types of reasons for sprinkler failure or ineffectiveness. NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, describes procedures to address most of these reasons that involve maintenance of an existing sprinkler system. An exception is systems designed to NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* (the home sprinkler standard), for which maintenance, inspection, and testing requirements are much fewer, reflecting the greater inherent reliability of the simpler design. These requirements are included in the NFPA 13D standard. When the reasons involve a need to modify the sprinkler system, procedures to trigger those changes are found in NFPA 1, *Fire Code*, and NFPA 1620, *Standard for Pre-Incident Planning*.

System shut off

The NFPA incident compilation includes cases of systems shut off because of building status (e.g., vacant, being remodeled, still under construction) and cases of systems shut off because of system problems (e.g., leak in system, dirt in water supply for both building and system, damage from earlier forklift collision). NFPA 25 addresses all these circumstances under rules for dealing with impairments (Chapter 14). When the system is shut off or otherwise impaired, NFPA 25 requires use of a tag to provide a visible reminder that the system is out of service, close oversight of the schedule and steps required to correct the impairment, and appropriate practices to assure safety in the building while the impairment exists. NFPA 25 also addresses valve supervision using a tamper switch connected to a central alarm monitoring system.

Manual intervention defeated system

NFPA standards for specific occupancies or for fire service operations provide guidance for fire protection and firefighting in a sprinklered building. These rules address the best use of fire suppression equipment in combination with fire sprinklers and the need to confirm that fire conditions no longer pose a threat before shutting off sprinklers.

Agent (water) did not reach fire

A number of conditions can result in this problem, but the most obvious one is a shielded fire. An incident identified in Appendix C (in the section on large fires where water did not reach fire) involved a convention center where a covering, operating like a temporary ceiling, blocked the sprinklers from reaching the fire. Shielding can also occur if fire grows under furniture (as in a residential property or an office) or under equipment (as in a manufacturing facility) or in the lower portions of an array of objects (as in a store or warehouse).

An engineered solution to the problem is to place sprinklers under the shielding, as with in-rack sprinklers. The other principal alternative is to avoid arrangements where shielding and blocking are likely to occur. The periodic inspections needed to identify shielding and blocking situations and to correct such problems if discovered can be conducted as part of fire code inspections (e.g., in support of NFPA 1) or pre-incident planning (e.g., in accord with NFPA 1620.)

Not enough agent (water) discharged

The NFPA incident compilation identifies several cases of inadequate water flow; note that some are incidents where firefighters also found inadequate water flow for hydrants or hoses.

Inadequate water flow can also occur if the system design is no longer adequate for the hazard being protected. These incidents may also be reported as cases of inappropriate system.

NFPA 25 uses inspections and testing to address all sources of problems affecting water flow or delivered density, including standpipes, hose systems, fire service mains, fire pumps, and water storage tanks. If the problem is a system no longer appropriate for the hazard below it, NFPA 1 and NFPA 1620 are relevant, as discussed above under "inappropriate system".

NFPA 25 also provides a procedure for periodic investigation of pipes for obstructions (Chapter 13). Such obstructions can reduce water flow and result in a problem of not enough agent discharged.

Lack of maintenance

The NFPA compilation identifies an incident where a sprinkler was coated with cotton dust in a textile manufacturing plant and an incident where sediment built up in the system. NFPA 13 and NFPA 25 include requirements for special protection in settings or during activities with a high vulnerability to accumulation of dust, paint, or other substances, and NFPA 25 uses inspections to detect such accumulations when they occur.

More generally, there is the question of how to organize Inspection, Testing, and Maintenance (ITM) activities so as to strike the best balance between risk (of failure or ineffectiveness) and cost. A visual inspection or a test can indicate a problem that, left unaddressed, could lead to sprinkler failure or ineffectiveness. An act of maintenance can restore the system to target or greater reliability and effectiveness. At every stage there are probabilities that create residual risk or needless cost, such as the following:

- Likelihood that a real problem will not be identified versus likelihood that a problem will be reported when there is no real problem. This applies to visual inspection and testing.
- Likelihood that the threshold (e.g., how much "loading" of material on a sprinkler) is too high, resulting in problems left unaddressed that eventually lead to failure or ineffectiveness, or too low, resulting in costly maintenance that ends up being unnecessary.
- Likelihood that the frequency of inspection or testing is too high, leading to inspection-hours or tests that cost money but are not necessary to maintain high reliability and effectiveness, or too low, allowing problems to emerge and to remain long enough to prove decisive in a fire.

There are efforts underway to apply risk concepts to design inspection, testing and maintenance programs that balance risk and cost more explicitly and quantitatively. At this time, the main point is that it is too easy to oversimplify this issue into one of maintenance lacking or maintenance present. Differences in degree of maintenance or type of maintenance all matter, and all may make a large difference or a small difference in cost, reliability, effectiveness, and risk.

Inappropriate system for type of fire

"Inappropriate" system can refer to the wrong type of agent (e.g., water vs. chemical agent or carbon dioxide), the wrong type of system for the same agent (e.g., wet pipe vs. dry pipe), or the wrong design for the same system and agent (e.g., a design adequate only for Class I commodities vs. a design adequate for any class of commodities). The NFPA compilation identifies several cases where the system was inadequate for the hazard.

The NFPA 13, NFPA 13D and NFPA 13R standards for installation of automatic extinguishing equipment provide detailed requirements for selecting the right agent, the right system, and the right design, but this is all relative to conditions at the initial installation. The need for a change in system design can be identified during routine, periodic inspections in support of the local fire code or pre-incident planning. Section 13.3.3 of NFPA 1 requires the property owner or occupant to maintain the design level of performance and protection of the sprinkler system and to evaluate the adequacy of the installed system if there are any changes in occupancy, use, process, or materials. NFPA 1620 requires periodic review, testing, updating and refinement of the pre-incident plan. NFPA 1620 also states that a mismatch of sprinkler system with type or arrangement of protected commodities is a sprinkler system design deficiency that should be noted on the pre-incident plan.

System component damaged

In the NFPA compilation of incidents of failure or ineffectiveness, the incidents involving component damage consist entirely of fires where automatic extinguishing equipment was damaged by explosions or by ceiling, roof, or building collapse, the latter nearly always as a consequence of fire. System component damage is rarely cited as the reason for sprinkler failure or ineffectiveness, which is consistent with the idea that the components are very reliable, absent a severe external cause like an explosion. Explosions are more severe than the design fires considered by NFPA 13, NFPA 13D, and NFPA 13R. NFPA 25 uses inspections and tests to detect less severe component damage.

Fire not in area protected

Under fire incident coding rules, automatic extinguishing equipment is deemed to be present in a building only if it is present in the area of fire. Therefore, fires are removed from the operationality and effectiveness analysis in the report if equipment was deemed to have failed or been ineffective because of fire outside area protected.

However, some areas may be unprotected even in a system that is described as having complete coverage. NFPA 13 has provisions for sprinkler protection of concealed spaces and exterior locations, but coverage of these areas is required only in certain defined situations. The NFPA compilation includes several incidents involving partial coverage by any definition but also several incidents where coverage was described as complete but was not provided for areas of fire origin or of early fire growth in concealed or void spaces, on balconies or other outside locations, or above sprinklers in manufacturing or storage facilities.

This long-standing dilemma over how to describe a lack of coverage in concealed spaces and exterior locations has become more complicated with the emergence of specialized installation standards, such as NFPA 13D and NFPA 13R, that also exempt certain rooms from coverage.

Table 3-D shows the leading areas of fire origin for one- and two-family home fires coded as sprinklers present but failed or ineffective because of no sprinkler in the fire area.[6] In other words, sprinklers were present somewhere in the home but not in the area of origin. Percentage

[6] Fires with incident types indicating fire confined to cooking vessel, chimney or flue, boiler or fuel burner, compactor, incinerator, or trash are excluded from this table.

shares for all these areas of origin for one- and two-family home fires, regardless of sprinkler status, are also included for comparison.

Table 3-D. Leading Areas of Origin for Fires in One- or Two-Family Homes
In Which Sprinklers Failed or were Ineffective Because They Were Not in the Fire Area
Excluding Buildings Under Construction
2007-2011 Structure Fires Reported to U.S. Fire Departments

Area of Origin	Percent of Fires Where Wet-Pipe Sprinklers Were Present But Not Present in Fire Area*	Percent of All Fires*
Attic or concealed space above top story	13%	5%
Exterior balcony or unenclosed porch	11%	3%
Wall assembly or concealed space	9%	4%
Garage	8%	5%
Exterior roof surface	7%	1%
Laundry room or area	4%	5%
Exterior wall surface	4%	5%
Kitchen	3%	18%
Unclassified structural area	3%	3%
Other area of origin	38%	51%
Total	100%	100%

* Excludes fires coded as confined.
** Excludes dwelling garages coded as separate buildings.
Source: NFIRS and NFPA survey.

The listed concealed spaces and other structural areas, external areas, garages, and attics – that is, all the listed areas except for kitchens and laundry rooms – account for 55% of the non-confined fires where sprinklers are present but not in the fire area. These same areas accounted for only 26 % of non-confined fires in one- or two-family homes in general.

Table 3-1.
Automatic Extinguishing Equipment Reliability and Effectiveness When Fire Was Coded as Not Confined and Large Enough to Activate Equipment and Equipment Was Present in Area of Fire, by Property Use
2007-2011 Structure Fires

A. All Sprinklers

Property Use	Number of fires per year where sprinklers were present	Non-confined fires too small to activate equipment	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	3,410	560	2,210	640	91%	93%	84%
Eating or drinking establishment	1,680	300	990	390	91%	91%	83%
Educational property	2,020	440	1,400	180	87%	97%	84%
Health care property*	3,360	670	2,350	340	86%	98%	84%
All residential	29,430	2,500	23,010	3,920	94%	97%	91%
Home (including apartment)	23,650	1,630	18,890	3,120	95%	97%	91%
Hotel or motel	1,870	370	1,210	300	90%	97%	88%
Store or office	4,230	1,090	2,040	1,100	90%	97%	87%
Grocery or convenience store	880	250	430	190	90%	95%	85%
Department store	470	180	170	120	87%	98%	85%
Office	1,100	240	680	180	89%	97%	87%
Manufacturing facility	2,530	660	760	1,110	90%	94%	84%
All storage	770	150	280	340	79%	97%	76%
Warehouse excluding cold storage	400	80	110	200	84%	97%	82%
All structures**	48,460	6,440	34,000	3,020	91%	96%	87%

* 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 fail if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. Property use classes are shown only if they accounted for at least 120 projected fires per year appropriate for the calculation. Fires reported as confined fires are all treated as fires too small to activate operating equipment.

Source: NFIRS and NFPA survey.

Table 3-1. (Continued)
Automatic Extinguishing Equipment Reliability and Effectiveness When Fire Was Coded as Not Confined and Large Enough to Activate Equipment and Equipment Was Present in Area of Fire, by Property Use
2007-2011 Structure Fires

B. Wet Pipe Sprinklers Only

Property Use	Number of fires per year where sprinklers were present	Non-confined fires too small to activate equipment	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	2,810	480	1,770	550	92%	95%	88%
Eating or drinking establishment	1,330	250	750	330	93%	94%	88%
Educational property	1,810	390	1,250	170	87%	97%	84%
Health care property*	2,900	590	2,020	300	87%	98%	85%
All residential	26,280	2,240	20,370	3,670	95%	97%	92%
Home (including apartment)	21,060	1,470	16,670	2,920	95%	97%	92%
Hotel or motel	1,680	320	1,080	270	91%	97%	89%
Store or office	3,680	970	1,710	990	91%	97%	88%
Grocery or convenience store	740	220	340	170	90%	96%	87%
Department store	410	160	140	110	87%	97%	85%
Office	980	220	600	170	90%	98%	88%
Manufacturing facility	2,160	570	670	920	91%	94%	86%
All storage	570	120	200	260	85%	98%	83%
Warehouse excluding cold storage	320	70	80	170	86%	97%	84%
All structures**	42,520	5,680	29,690	7,150	92%	96%	89%

* 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 fail if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. Property use classes are shown only if they accounted for at least 110 projected fires per year appropriate for the calculation. Fires reported as confined fires are all treated as fires too small to activate operating equipment.
Source: NFIRS and NFPA survey.

Table 3-1. (Continued)
Automatic Extinguishing Equipment Reliability and Effectiveness When Fire was Coded as not Confined and Large Enough to Activate Equipment and Equipment Was Present in Area of Origin, by Property Use
2007-2011 Structure Fires

C. Dry Pipe Sprinklers Only

Property Use	Number of fires per year where sprinklers were present	Non-confined fires too small to activate equipment	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	2,510	220	2,110	190	88%	96%	85%
Homes	2,000	130	1,740	130	90%	95%	85%
Store or office	430	100	250	80	81%	96%	78%
Manufacturing facility	300	80	70	160	85%	90%	77%
All storage	180	30	80	80	60%	93%	55%
All structures*	4,530	620	3,250	660	81%	94%	76%

* 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 if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. Property use classes are shown only if they accounted for at least 80 projected fires per year appropriate to the calculation. Fires reported as confined fires are reported without sprinkler performance details or as all treated as fires too small to activate operating equipment.

Source: NFIRS and NFPA survey.

Table 3-2.
Reasons for Failure to Operate When Fire Was Coded as Not Confined and Large Enough to Activate Equipment and Equipment Was Present in Area of Fire, by Property Use Based on Estimated Number of 2007-2011 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	51%	13%	7%	13%	15%	61
Eating or drinking establishment	43%	11%	10%	21%	15%	34
All residential	59%	21%	8%	7%	4%	233
Home (including apartment)	64%	16%	9%	6%	5%	168
Store or office	62%	16%	11%	5%	6%	112
Manufacturing facility	65%	17%	7%	5%	5%	111
All structures*	64%	17%	7%	6%	5%	711

* 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. Figures reflect recodings explained in Introduction: Fires are excluded if the reason for failure or ineffectiveness is system not present in area of fire, unclassified or unknown. Fires are recoded from operated but ineffective to failed if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. 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. Property use groups are shown only if there were at least 10 fires per year involving failure to operate and 10 fires per year involving operation not effective. Fires reported as confined fires are all treated as fires too small to activate operating equipment. Fires reported with unclassified reason for failure, which accounted for 21% of fires with failure for all structures combined, are treated as cases of unknown reasons for failure.

Source: NFIRS and NFPA survey.

Table 3-2. (Continued)
Reasons for Failure to Operate When Fire Was Coded as Not Confined and Large Enough to Activate Equipment and Equipment Was Present in Area of Fire, by Property Use Based on Estimated Number of 2007-2011 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	55%	18%	7%	10%	10%	42
Eating or drinking establishment	50%	15%	14%	14%	7%	23
All residential	57%	24%	6%	8%	5%	202
Home (including apartment)	62%	19%	8%	6%	6%	146
Store or office	57%	19%	10%	6%	7%	92
Manufacturing facility	62%	20%	3%	7%	7%	81
All structures*	60%	21%	7%	7%	6%	549

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	80%	6%	9%	2%	2%	124

* 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. Figures reflect recodings explained in Introduction: Fires are excluded if the reason for failure or ineffectiveness is system not present in area of fire, unclassified or unknown. Fires are recoded from operated but ineffective to failed if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. 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. Property use groups are shown only if there were at least 10 fires per year involving failure to operate and 10 fires per year involving operation not effective. Fires reported as confined fires are all treated as fires too small to activate operating equipment. Fires reported with unclassified reason for failure, which accounted for 22% of wet pipe sprinkler fires with failure and 13% of dry-pipe sprinkler fires for all structures combined, are treated as cases of unknown reasons for failure.

Source: NFIRS and NFPA survey.

Table 3-3.
Reasons for Ineffectiveness When Fire Was Coded as Not Confined and Large Enough to Activate Equipment and Equipment Was Present in Area of Fire, by Property Use
Based on Estimated Number of 2007-2011 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. 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 if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. 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. Property use groups are shown only if there were at least 10 fires per year involving failure to operate and 10 fires per year involving operation not effective. Fires reported as confined fires are all treated as fires too small to activate operating equipment. Fires reported with unclassified reason for ineffectiveness, which accounted for 10% of fires with ineffective performance for all structures combined, are treated as cases of unknown reasons for ineffectiveness.

Source: NFIRS and NFPA survey.

Table 3-3. (Continued)
Reasons for Ineffectiveness When Fire Was Coded as Not Confined and Large Enough to Activate Equipment and Equipment Was Present in Area of Fire, by Property Use
Based on Estimated Number of 2007-2011 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. 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 if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. 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. Property use groups are shown only if there were at least 10 fires per year involving failure to operate and 10 fires per year involving operation not effective. Fires reported as confined fires are all treated as fires too small to activate operating equipment. Fires reported with unclassified reason for ineffectiveness, which accounted for 10% of wet pipe sprinkler fires with ineffective performance and 10% of dry pipe sprinkler fires for all structures combined, are treated as cases of unknown reasons for ineffectiveness.

Source: NFIRS and NFPA survey.

Table 3-4.
Extent of Flame Damage
for Sprinklers Present vs. Automatic Extinguishing Equipment Absent
2007-2011 Structure Fires

	Percentage of fires confined to room of origin excluding structures under construction, fires coded as confined fires, and sprinklers not in fire area		
Property Use	**With no automatic extinguishing equipment**	**With sprinklers of any type**	**Difference (in percentage points)**
Public assembly	58%	82%	24
Variable-use amusement or recreation place	65%	88%	23
Religious property	54%	83%	30
Library or museum	67%	87%	20
Eating or drinking establishment	58%	79%	21
Educational	77%	92%	15
Health care property*	79%	94%	15
Residential	54%	89%	35
Home (including apartment)	54%	88%	34
Hotel or motel	74%	93%	19
Dormitory or barracks	76%	94%	18
Store or office	56%	84%	29
Grocery or convenience store	59%	86%	27
Department store	56%	85%	29
Office building	60%	88%	27
Manufacturing facility	55%	79%	24
Storage	24%	68%	44
Warehouse excluding cold storage	39%	71%	32
All structures**	51%	86%	35

* 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. Calculations exclude fires with unknown or unreported extent of flame damage. 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.

Source: NFIRS and NFPA survey.

Table 3-5.
Number of Sprinklers Operating, by Type of Sprinkler
2007-2011 Structure Fires

	Percentage of structure fires where that many sprinklers operated			
Number of Sprinklers Operating	**Wet pipe**	**Dry pipe**	**Other type sprinkler**	**All sprinklers**
1	74%	55%	51%	72%
2 or fewer	88%	73%	64%	86%
3 or fewer	92%	80%	72%	91%
4 or fewer	94%	85%	79%	93%
5 or fewer	95%	88%	84%	95%
6 or fewer	96%	90%	87%	96%
7 or fewer	97%	91%	88%	96%
8 or fewer	97%	92%	91%	97%
9 or fewer	97%	92%	91%	97%
10 or fewer	98%	94%	93%	98%
20 or fewer	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 if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. 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, as are partial systems and fires reported as confined fires.

Source: NFIRS and NFPA survey.

Table 3-6.
Number of Wet Pipe Sprinklers Operating, by Property Use Group
2007-2011 Structure Fires

	Percentage of structure fires where the indicated number of wet pipe sprinklers operated					
Number of Sprinklers Operating	**Public assembly**	**Home**	**Hotel or motel**	**Store or office**	**Manufacturing facility**	**Warehouse excluding cold storage**
1	71%	84%	83%	66%	46%	49%
2 or fewer	88%	94%	95%	84%	67%	73%
3 or fewer	93%	96%	98%	90%	76%	81%
4 or fewer	95%	97%	98%	93%	83%	88%
5 or fewer	96%	98%	98%	94%	86%	89%
6 or fewer	97%	98%	99%	95%	89%	92%
7 or fewer	97%	98%	99%	96%	90%	92%
8 or fewer	98%	99%	99%	97%	91%	93%
9 or fewer	98%	99%	99%	97%	91%	94%
10 or fewer	98%	99%	99%	98%	93%	96%
20 or fewer	99%	100%	100%	99%	97%	98%

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 if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. 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, as are partial systems and fires reported as confined fires.

Source: NFIRS and NFPA survey.

Table 3-7.
Sprinkler Effectiveness Related to
Number of Sprinklers Operating
2007-2011 Structure Fires

	Percent of structure fires where sprinklers are effective			
		Wet pipe sprinklers		
Number of Sprinklers Operating	All sprinklers All structures	All structures	Manufacturing facility	Warehouse excluding cold storage
1	98%	98%	96%	100%
2	95%	95%	96%	97%
3 to 5	92%	93%	94%	96%
6 to 10	81%	80%	87%	96%
More than 10	83%	85%	86%	79%
Total	96%	96%	94%	97%

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 if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. 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 as are partial systems. Because fires reported as confined fires are reported without sprinkler performance details or as fires too small to activate operating equipment, confined fires are not included in any analysis involving reliability or effectiveness of automatic extinguishing equipment.

Source: NFIRS and NFPA survey.

Section 4. Impact of Sprinklers

A number of approaches can be and have been used to quantify the impact and value of sprinklers. These approaches may be grouped into the following three types:

- Reduction in life loss per fire or property loss per fire;
- Reduction in the likelihood of large fire size or severity, such as fire spread beyond room of origin, multiple deaths, or large property loss; and
- Qualitative judgments as "effective" or "satisfactory" by fire investigators or others completing incident reports, already discussed in the previous section.

Sprinkler Reduction in Loss of Life in Fire

For 2007-2011 home fires, the death rate per 1,000 fires was 82% lower with wet pipe sprinklers than with no automatic extinguishing equipment.
Table 4-1 shows fire death rate reductions for various property use groups. Only the statistics for all residential properties and for homes (including apartments) are based on enough fatal fires, both with and without sprinklers, for reasonable confidence in the results.

For properties other than homes, deaths tend to be extremely rare, with or without sprinklers. The associated rates of deaths per thousand fires will therefore be very sensitive to individual fires with large death tolls, fatal fires with unusual circumstances, the variability associated with analysis of confined fires, and fires with fatalities or other characteristics misreported.

Educational properties are not shown in Table 4-1 because fatal fires are nearly unheard of in such properties, with or without sprinklers. The last major multiple-death school fire (Our Lady of Angels) was a half-century ago, and in recent decades individual fire fatalities at schools have been limited to staff and juvenile firesetters.

The factors that make fatal injury possible even when sprinklers are present and operate would include the following, including those shown in Table 4-2:

1. Victims whose actions or lack of action add to their risk by prolonging their exposure to fire conditions, such as victims who
   (a) act irrationally;
   (b) go back into the building after safely escaping;
   (c) are unable to act to save themselves, such as people who are bedridden or under restraint; or
   (d) are engaged in firefighting or rescue;

2. Victims of fires that are beyond the design limits of the system, such as fires that were
   (a) so close that the victim is deemed "intimate with ignition" (a victim condition no longer shown in the data but most closely approximated by "victim in area of fire origin";

they constituted 97% of fatal victims when sprinklers operated vs. 51% of fatal victims when no automatic extinguishing equipment was present, in Table 4-2);
(b) very fast, such as explosions or flash fires; or
(c) outside the sprinkler-protected area, such as fires originating on exterior areas of the building; and

3. Victims who are or may be unusually vulnerable to fire effects, such as
   (a) older adults, age 65 or older (who constituted 59% of fatal victims when sprinklers operated vs. 30% of fatal victims when no automatic extinguishing equipment was present, in Table 4-2), or
   (b) people who are in poor health before fire begins.

In group 2 above, although we can no longer identify victims who were intimate with ignition, we can identify victims who were both in the fire area and involved with ignition. Those victims constituted 77% of fatal victims when wet pipe sprinklers operated vs. 39% of fatal victims when no automatic extinguishing equipment was present. "Involved with ignition" does not mean setting the fire. As Table 4-2 also shows, intentional fires account for 14% of fatal fire victims when no automatic extinguishing equipment was present, a much smaller share than the 39% of victims who were in the area of origin and involved in fire origin. When wet pipe sprinklers operated, the 6% of fatal victims who were killed by an intentional fire constituted a much smaller share than the 77% of victims who were in the area of origin and involved in fire origin.

Nursing homes are not shown in Table 4-1 because most of their fire fatalities are individual deaths of people with multiple characteristics from the above numbered list. Most victims are located near the point of fire origin and have characteristics that make them much less able to respond effectively to a threatening fire and possibly more vulnerable to fire effects. The value of sprinklers in nursing homes is primarily limited to prevention of multiple deaths, such as the 16 deaths in a 2003 Connecticut nursing home fire and the 14 deaths in a 2003 Tennessee nursing home fire, neither of which involved a sprinklered facility. Such fires are too rare to be picked up in the simple average death rate comparisons in Table 4-1.

Sprinkler Reduction in Loss of Property in Fire

For most property uses, the property damage rate per reported structure fire is 38-75% lower than in properties with no automatic extinguishing equipment when wet pipe sprinklers are present in structures that are not under construction, after excluding cases of failure or ineffectiveness because of a lack of sprinklers in the fire area.
Table 4-3 shows a smaller reduction for stores and offices (30%) and no reduction for hotels and motels and for warehouses.

As with death rates, loss rates can be very sensitive to individual fires with large losses, large loss fires with unusual circumstances, the variability associated with analysis of confined fires, and fire with losses or other characteristics misreported.

Warehouses and hotels and motels appear to illustrate these factors. Two incidents accounted for 60% of the 2007-2011 total estimated direct property damage in warehouse fires with wet pipe sprinklers present (excluding fires in buildings under construction and fires with sprinklers not in fire area as reported reason for ineffectiveness or failure). The two fires had reported losses of $50 million and $45 million, but neither fire was captured by NFPA's data base on large-loss fires, which is designed to capture any fire reported in news accounts or other sources as involving at least $5 million in loss. The larger fire was reported to have 600 sprinklers operating, but sprinkler operation was not reported. It would not be surprising if these two fires had loss amounts inadvertently inflated, which would explain why they were not captured by NFPA's large-loss fire data base, and the larger fire may have had number of sprinklers operating inadvertently inflated as well. If these two fires are removed, the analysis shows an 18% reduction in loss per fire with wet-pipe sprinklers.

One fire accounted for most (68%) of the 2007-2011 direct property damage in hotel and motel fires with wet pipe sprinklers present (and excluding buildings under construction and fires coded with sprinklers not in fire area as reason for failure or ineffectiveness). This fire was captured by NFPA's large-loss fires data base. It was a $100 million Nevada fire where fire began when hot work ignited exterior trim. The complete coverage sprinkler system was reported as effective, and the sprinklers that operated were credited with containing the fire on the 32nd (top) story. If this one fire had been excluded from their analysis, we would have calculated a 55% reduction in loss per fire with wet-pipe sprinklers.

In both cases, the influence of a small number of cases or errors and the limitations of gross statistics in these circumstances produce a misleading picture of the impact of sprinklers. It should also be noted that sprinklers are more common in warehouses that are larger and have higher values per square foot. This can mean that the average loss per fire in a sprinklered warehouse will not be a good estimate of the predicted average loss per fire if sprinklers were added to the unsprinklered warehouses, as our calculations implicitly assume. The use of average loss in unsprinklered warehouses as a proxy for average loss in sprinklered warehouses in the absence of sprinklers, as is done in this analysis, will produce a misleadingly low baseline for comparison and so a misleadingly low estimated reduction.

Sprinklers cannot be expected to prevent large loss if the large loss was attributable to partial coverage, explosion or flash fire, system shutoff, or the loss of the system to collapse or collision before or early in the fire. In addition, other circumstances can lead to a large loss:

- Sprinkler design may not be appropriate to the hazard being protected. In the simplest form, the contents may be capable of supporting a larger, more intense fire than the sprinkler system can handle. The problem may be insufficient sprinkler density or insufficient water flow, which in turn may reflect the system's design, its age and maintenance, or its supporting water supply. Unlike explosions and flash fires, fire loads can be addressed by appropriate design, installation, maintenance, and operation. Although the effectiveness statement could be phrased to require a fully code-compliant installation, fire incident reports rarely have enough detail to confirm code compliance, and large property-loss fires are less likely than large life-loss fires to receive the detailed fire investigations that could confirm such details.

- The nature or configuration of contents may be sufficient to create a large loss even when sprinkler performance is deemed successful. Some bulk goods can shield a deep-seated fire from sprinklers. Rack storage may shield fires from ceiling sprinklers, although in-rack sprinklers should be sufficient to address such problems. High-piled stock may block sprinklers or even permit fire spread on the tops of contents above the sprinklers. And some areas – such as clean rooms – have contents so sensitive and valuable that even a small fire can produce a large financial loss.

  Sprinklers should be designed appropriately for the hazard they protect. As an example of engineered design of sprinklers for a space with blocked-storage issues, see the final report from the Fire Protection Research Foundation project on a sprinkler design project for compact mobile shelving systems (go to http://www.nfpa.org, then to Research, then to Fire Protection Research Foundation, then to Reports and Proceedings, then to Suppression, then to Other Sprinkler Protection, then to the *Compact Mobile Shelving System Fire Testing Project Final Report*.

- A fire with a sufficient number of different points of origin can overwhelm any sprinkler system. Multiple points of origin can occur deliberately in an arson fire, but they can occur unintentionally or naturally, as when an outside fire spreads to numerous entry points in and on a building.

Environmental Benefits of Home Sprinklers

Because sprinklers keep fires smaller and use much less water than fire department hose streams to do so, there is a large favorable effect from sprinklers in the form of reduced fire-related water pollution and greenhouse gas emissions. See http://homefiresprinker.org/green-fire-sprinklers-education for a brief summary of findings from a recent study by FM Global research and a link to the full report of that study.

Table 4-1.
Estimated Reduction in Civilian Deaths per Thousand Fires
Associated With Wet Pipe Sprinklers, by Property Use
2007-2011 Structure Fires

Property Use	Without automatic extinguishing equipment	With wet pipe sprinklers	Percent reduction
All public assembly	0.6	0.0	100%
Residential	7.4	1.1	85%
Home (including apartment)	7.4	1.3	82%
Boarding or rooming house	9.6	1.5	84%
Hotel or motel	7.3	0.0	100%
Residential board and care home	5.7	0.7	88%
Dormitory or barracks	1.1	0.0	100%
Store or office	1.5	0.6	62%
Manufacturing facility	2.3	0.3	88%
Warehouse excluding cold storage	3.5	1.4	61%
All structures	6.3	0.8	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. Figures exclude fires with sprinkler status unknown or unreported, partial sprinkler systems not in fire area, and structures under construction; and 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 if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. 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.

Source: NFIRS and NFPA survey.

Table 4-2.
Characteristics of Fatal Victims
When Wet Pipe Sprinklers Operate vs. No Automatic Extinguishing Equipment
2007-2011 Structure Fires

Victim Characteristic	Number of fire fatalities per year and percent of total fire fatalities where victims had indicated characteristics: When wet pipe sprinklers operate, excluding sprinklers not in fire area		No automatic extinguishing equipment	
Victim in area of origin	20	(97%)	1,391	(51%)
And involved in fire origin	16	(77%)	1,059	(39%)
Not involved in fire origin	4	(20%)	331	(12%)
Intentional fire	1	(6%)	371	(14%)
Clothing on fire, whether or not escaping	4	(19%)	207	(8%)
Victim age 65 or older	12	(59%)	807	(30%)
Victim returned to fire, unable to act, or acted irrationally	5	(25%)	557	(20%)
Victim physically disabled	3	(17%)	420	(15%)
Victim asleep	3	(14%)	781	(29%)

Note: Statistics are based on structure fires reported in NFIRS Version 5.0 to U.S. municipal fire departments and so exclude fire 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.

Note: Here is an example of how to read this table: Nearly all (97%) the people who died in fires despite the presence of wet-pipe 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 51% of fatal victims in fires with no automatic extinguishing equipment present who were located in the area of fire origin.

Source: NFIRS and NFPA survey.

Table 4-3.
Estimated Reduction in Average Direct Property Damage per Fire Associated With Wet Pipe Sprinklers, by Property Use
2007-2011 Structure Fires

Property Use	Without automatic extinguishing equipment	With wet pipe sprinklers	Percent reduction
All public assembly	$47,000	$12,000	75%
Eating or drinking establishment	$53,000	$13,000	75%
Educational property	$21,000	$8,000	62%
Health care property*	$14,000	$5,000	65%
Residential	$20,000	$9,000	56%
Home (including apartment)	$20,000	$7,000	68%
Boarding or rooming house	$15,000	$5,000	69%
Hotel or motel	$31,000	$42,000	No reduction
Residential board and care home	$6,000	$3,000	57%
Dormitory or barracks	$4,000	$1,000	65%
Store or office	$55,000	$38,000	30%
Manufacturing facility	$145,000	$90,000	38%
Warehouse excluding cold storage	$128,000	$262,000	No reduction

*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. Figures exclude fires with sprinkler status unknown or unreported, partial sprinkler systems not in fire area, and structures under construction; and 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 if the reason for failure or ineffectiveness was system shut off. Fires are recoded from failed to operated but ineffective if the reason for failure or ineffectiveness was not enough agent or agent did not reach fire. Direct property damage is estimated to the nearest thousand dollars and has not been adjusted for inflation. 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.

Note: Most of the total loss involving sprinklered hotels and motels (68%) was projected from one Nevada fire that began on exterior trim and was stopped by sprinklers operating effectively on the top floor. There was no comparable fire in an unsprinklered hotel and so there was no proper basis for comparison between the two figures. Without that fire, the average loss per fire for sprinklered hotels and motels would have been lower by a factor of three, and we would have calculated a large reduction in average loss per fire due to sprinklers (55%).

Note: Most of the total loss involving sprinklered warehouses (60%) was projected from two fires that are not reflected in NFPA's data base on large-loss fires. It would not be surprising if these two fires had their reported losses inadvertently inflated. Without those fires, we would have calculated an 18% reduction in average loss per fire.

Source: NFIRS and NFPA survey.

Section 5. Water Damage from Sprinklers in the Absence of Fire

Sprinkler systems can release water in the absence of fire, but the best available evidence indicates that this is a small source of loss compared to fire losses. For home sprinklers in particular, the threat from non-fire water damage is negligible.

Sprinkler systems are carefully designed to activate early in a real fire but not in a non-fire situation. Each sprinkler reacts only to fire conditions in its area. Water release in a fire is generally much less than would occur if the fire department had to suppress the fire, because later action means more fire. A 2010 FM Global Research study of sprinkler versus hose stream water release, in a test space designed to represent an average home, found the following.[7] "Comparing the water usage between the two tests, it was found that in order to extinguish the fire, the combination of sprinkler and hose stream discharge from the firefighters was 50% less than the hose stream alone. Additional analysis indicates that the reduction in water use achieved by using sprinklers could be as much as 91% if the results are extrapolated to a full-sized home."

Unintentional release of water in a non-fire activation of a sprinkler appears to be less likely and much less damaging, according to the best available evidence, than is unintentional water release involving other parts of a building's plumbing and water supply, which tends to be both more frequent and more costly per incident.[8]

NFPA analyzed the number of reported emergency responses in 2003 by U.S. fire departments where the reason for the response was either (a) non-fire unintentional sprinkler activation or (b) non-fire sprinkler activation from a malfunction or failure of the system. The year 2003 was the last one for which the public release file of NFIRS included non-fire incidents. Four property use groups accounted for nearly three-fourths of the reported non-fire sprinkler incidents. See Table 5-A.

A sprinkler system can "activate" with no damaging release of water outside the sprinkler system. The most common example is a dry-pipe system that activates by flowing water into the pipes but does not release water outside the system. Such an activation would register in a centrally monitored system and could result in a fire department response.

To estimate the fraction of incidents where water is released, an analysis was conducted on uncoded narratives for 2007 non-fire sprinkler incidents from Austin, TX (thanks to Karyl Kinsey) and the states of Minnesota and Massachusetts (thanks to Nora Gierok and Derryl Dion). Table 5-B shows the results, separating incidents confirmed as no water outside the system and, among incidents where water release was possible, those with water release outside the system confirmed.

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[7] Christopher J. Wieczorek, Benjamin Ditch, and Robert G. Bill, Jr., *Technical Report: Environmental Impact of Automatic Fire Sprinklers*, FM Global Research Division, March 2010, p. ii.

[8] Walter W. Maybee, "A Brief History of Fire Protection in the United States, Atomic Energy Commission, 1947-1975", paper presented to the NFPA Fall Meeting, 1978. Paper is not limited to or focused on power plants and like facilities.

Table 5-A. Non-Fire Sprinkler Activations by Major Property Use Group, 2003

Property Use	Reported incidents	
Commercial properties (public assembly, stores and offices)	15,900	(36%)
Manufacturing facilities	6,800	(15%)
Homes (one- or two-family dwellings, apartments)	4,700	(11%)
Warehouses excluding cold storage	4,100	(9%)
Other property use groups	12,500	(28%)
Total	44,000	(100%)

Note: Projections from NFIRS to national estimates are based on non-fire emergency responses estimated by Michael Karter from the 2003 Fire Loss Experience Survey.

Source: Unpublished analysis by Jennifer D. Flynn, NFPA Fire Analysis and Research Division, January 2008.

Table 5-B. Non-Fire Sprinkler Activations by Likelihood of Water Release and Major Property Use Group

Type of Activation (Based on:)	Commercial properties (726 incidents)	Manufacturing facilities (206 incidents)	Homes (292 incidents)	Warehouses excluding cold storage (165 incidents)
No Water Released	50%	55%	50%	50%
Definitely no water released except dry pipe system charging or release to drain or outside	(45%)	(48%)	(46%)	(44%)
Activation with no mention of water flow outside system	(5%)	(7%)	(4%)	(6%)
Possibly Water Released	50%	45%	50%	50%
Break or damage to component	(29%)	(30%)	(27%)	(38%)
Activation with mention of water flow release outside system	(8%)	(4%)	(14%)	(5%)
Leak	(5%)	(2%)	(2%)	(1%)
Freezing	(7%)	(6%)	(6%)	(6%)
Nearby heat	(2%)	(2%)	(1%)	(1%)
Total	100%	100%	100%	100%
Confirmed water release outside system	16%	7%	21%	12%

Source: Analysis of uncoded narratives from reported incidents in Austin (TX), Minnesota, and Massachusetts in 2007.

If the confirmed water release percentages shown in Table 5-B are applied to the non-fire sprinkler incidents in Table 5-A, and the resulting water-damage incidents are compared to the 2003-2006 annual average number of fires where sprinklers were present in the same properties, then one can obtain a basis for comparison. Non-fire sprinkler incidents with confirmed water release outside the system, as a percentage of fire incidents where sprinklers operated, were as follows:

- 34% for commercial properties,
- 13% for manufacturing facilities,
- 5% for homes (including apartments), and
- 25% for warehouses excluding cold storage.

While the NFIRS reports do not include any estimates of dollar damage, only a handful of incidents mentioned extensive water damage. It seems likely that the average damage per non-fire sprinkler incident is considerably less than the average damage per fire incident in sprinklered properties. Even without any such adjustment, the percentages above are comparable to the estimate of 25% made by Marryatt based on mid-1980s data from sprinkler installations in Australia and New Zealand.[9]

Also, the Minnesota and Massachusetts incidents that dominate the combined data base probably reflect a bigger problem with freezing conditions than is true for the country as a whole. Roughly half of the commercial property confirmed water release incidents and roughly half of the warehouse incidents involved either freezing as a cited factor or a month of occurrence during December to February. Therefore, these two percentages would probably be somewhat lower if data with representative weather conditions were available.

Whatever the actual rate for these incidents, many of them can be readily prevented by better design or safer practices. Common factors in component breaks are:

- Exposure to freezing conditions,
- Damage from forklifts or other large vehicles,
- Misuse of sprinklers, notably their use as hangers or as a base for anchoring hangers,
- Damage by construction or similar workers,
- Vandalism or horseplay in the vicinity of sprinklers, and
- Damage from impact by large doors.

Non-fire activations can also be prevented by better design or safer practices. Common factors in such activations are:

- Proximity to very high levels of ambient heat, like that produced by certain manufacturing processes, or
- Testing or maintenance not conducted according to standard, resulting in water surge or alarm activation

[9] H.W. Marryatt, Fire: *A Century of Automatic Sprinkler Protection in Australia and New Zealand, 1886-1986*, 2nd edition, Victoria, Australia: Australian Fire Protection Association, 1988, p. 435.

Section 6. Other Issues Related to Home Fire Sprinklers

Myths About Sprinklers

Much of the resistance to wider use of sprinklers stems from a cluster of concerns that are not so much issues as myths. Most Americans have had little contact with sprinkler systems outside of their portrayal in movies and television shows, where sprinklers all too often are portrayed inaccurately.

One myth has to do with the likelihood or severity of water damage, which was discussed in Section 5 and is especially small for home fire sprinklers.

A second myth has to do with aesthetics. People outside the fire community may think of the exposed pipe and sprinkler arrays that are common in some large manufacturing facilities. Inconspicuously mounted sprinklers, which are already common in offices and hotels and are available for homes, need to be better publicized.

A third myth has to do with the risk of death, serious injury or significant property damage in fire. This was the principal reason cited by people without smoke alarms 30 years ago, when home smoke alarms were still rare, to explain why they did not have smoke alarms. If sprinklers are an excellent solution to a problem you (wrongly) think you do not have, then that would naturally reduce your interest in sprinklers and your sense of their value.

A fourth myth has to do with the affordability of sprinklers. Sprinklers are not inexpensive, although their effectiveness, documented earlier, means most people will find them cost-effective. This often can be incorporated into reduced insurance costs and incentives applied by community planners in new developments.

A 2008 study, conducted by Newport Partners under sponsorship of the Fire Protection Research Foundation, developed comprehensive and all-inclusive cost estimates for 30 diverse house plans in 10 communities.[10] Cost per sprinklered square foot ranged from $0.38 to $3.66, with an average (mean) of $1.61 and a median of $1.42. Variables associated with higher cost systems included:

- Extensive use of copper piping instead of CPVC or PEX plastic;
- On-site water supply (such as well water) instead of municipal water supply;
- Local requirements to sprinkler areas, like garages or attics, where coverage is not required under NFPA 13D;
- Local sprinkler ordinances in effect for less than five years, or too brief a time for market acceptance, increased competition, and resulting lower prices to take hold; and
- Local sprinkler permit fees that are higher than the norm.

[10] Newport Partners, *Home Fire Sprinkler Cost Assessment – Final Report*, Fire Protection Research Foundation, Quincy, MA, September 2008, pp. iv and 6.

A 1977 survey done for the U.S. Fire Administration, back when only 22% of U.S. homes had smoke alarms, found that 74% of households with smoke alarms were very concerned about fire compared to only 45% of households that had no smoke alarms and no intention of obtaining smoke alarms. For households without smoke alarms, whether or not they intended to obtain smoke alarms, the leading reason cited for not having obtained one was no perception of need (don't need one – 16%; no interest in one – 16%) and the second leading reason was cost (too expensive – 23%; not worth the money – 1%). These are the same reasons, in the same order, cited today by people not intending to obtain home fire sprinklers today.[11]

In survey after survey, we find that people's perceptions and reasoning align for consistency with their actions. It is impossible today to believe that a large segment of the public once objected to smoke alarms on the basis of cost, but early in their adoption, it was true. The more people learn about home fire sprinklers, the more they are attracted to them, and there is no reason to expect this trend to stop.

In fact, there is evidence that many homeowners are getting past these dated perceptions and moving on to more fact-based and positive views of home fire sprinklers. The Home Fire Sprinkler Coalition sponsored a December 2005 survey by Harris Interactive®.[12] Among the findings were that 45% of homeowners considered a sprinklered home more desirable than an unsprinklered home, that 69% believe a fire sprinkler system increases the value of a home, that 38% say they would be more likely to purchase a new home with sprinklers than one without, and that 43% would be more likely to have home fire sprinklers installed if the cost could be included in the mortgage. These read like the emerging perceptions of a nation that sees value for the cost of home fire sprinklers and sees ways to handle that cost within their home-buying budget.

Costs and Benefits of Sprinklers

Ever since the late 1970s, when traditional sprinkler technology and design were modified to operate effectively to protect lives in the smaller spaces of a typical home, there have been cost-benefit studies intended to direct and support national policy decisions on the value and need for home fire sprinklers. Similar analyses have been performed for home smoke alarms, fire-safe cigarettes, and mattresses and upholstered furniture with improved fire performance. Cost-benefit studies of home sprinklers have been conducted all over the world.

Enough such studies have now been performed that it is possible to identify certain recurring erroneous or controversial choices and assumptions in most of these studies.

1. Sprinkler benefits are often under-estimated.

Sprinklers produce large reductions in deaths per thousand fires and in direct property damage per fire. However, sprinkler usage in homes is still so limited that there is not enough data on fires in single family homes with and without sprinklers. The best approach is to use data on all housing units, including multi-unit housing, because the spaces and causes of fires are very

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[11] Based on 2007 slide presentation of results of NAHB National Survey, conducted August 14-15, 2006, by Public Opinion Strategies, #06811.

[12] See a summary of findings in a press release at http://www.homefiresprinkler.org/release/HarrisPoll.html.

similar, and even the sprinkler design standards have similar differences from the traditional sprinkler standard. Some cost-benefit analyses have instead estimated benefits indirectly by estimating the fraction of fires where sprinklers will *definitely* activate. This approach produces a conservatively low estimate of sprinkler impact because it assigns none of the uncertainty of the calculation to the credit of sprinklers.

Some cost-benefit analyses ignore all sprinkler impacts except the impact on death rates. Even if the principal rationale for home sprinklers is life safety, a proper cost-benefit analysis should capture all likely benefits just as it should capture all likely costs. In particular, the impact on property damage is a substantial part of the predictable benefit of sprinkler usage.

Impacts on civilian injuries, firefighter deaths and injuries, and indirect loss (such as the cost of temporary housing) are less substantial and less certain; it is less essential to include these impacts in order to have a proper estimate of benefits. This is even more true for controversial trade-offs that are sometimes proposed, such as higher allowable housing density (which means smaller minimum allowable lot sizes and smaller minimum allowable building separation distances.) It is better not to include benefits like these in a base case cost-benefit analysis, although it may be useful to include them in a sensitivity analysis.

In statistical analyses of property damage, the available data typically documents damage due to fire and omits damage due to water or firefighting. Some cost-benefit analyses attempt to add losses due to water damage from sprinklers in response to fire. These estimates are inappropriate for a couple of reasons. Sprinkler water damage, when it occurs, is far more than offset by reduced damage from water from fire hoses. If firefighting water damage is included in the calculation, it should be as an additional *benefit* from sprinklers.

2. Sprinkler costs are often over-estimated.

The base cost for home sprinklers is the installed cost per square foot. Many cost-benefit analyses have used exaggerated base costs. The extra cost may arise from the inclusion of design elements – such as copper piping, backflow preventers, or water demand charges – that are not required by a standard home sprinkler installation. The extra cost may also reflect exaggerated labor costs, labor hours, profit margins, and markups estimated by people who are setting estimates to avoid the work in question, not to compete for it.

Recurring costs (such as inspection and maintenance) also tend to be exaggerated because the estimates do not reflect the substantial differences between the needs of a standard design for homes and the needs of a standard design for a traditional commercial system. An NFPA 13D system does not require professional inspection or maintenance.

Water damage from non-fire activations are also included as a recurring cost in many cost-benefit analyses. These cost estimates tend to be highly speculative because, until recently, there has been no statistical data to anchor the estimates in reality. Special-study statistical analysis by NFPA (presented and discussed in Section 5) provides that missing data and shows that damage from non-fire water releases is much less, relative to annual fire damage, than had been widely assumed. Non-fire water damage is especially low for home sprinklers.

3. Cost and benefit estimates often fail to fully reflect the characteristics of an NFPA 13D standard design for home sprinklers.

Installed costs per square foot, the need for and cost of maintenance, water usage, the frequency of non-fire water releases, and the speed of reaction and impact on fire loss (human and property), all are significantly different and more favorable with standard home installations. A cost-benefit analysis that does not properly reflect the characteristics of the equipment it seeks to evaluate cannot be accurate.

4. In accounting for time, many cost-benefit analyses ignore or under-value out-year sprinkler benefits.

Sprinklers are a fire safety strategy where all or nearly all the costs occur at the outset while the benefits are spaced out over the life of the system. Cost-benefit analyses normally employ a study period of fixed duration. Sprinklers will operate effectively as installed for more than 50 years. Use of a shorter period for analysis is equivalent to inappropriately under-estimating the benefits of sprinklers. Even if sprinkler costs are incorporated into a home mortgage and spaced out over the life of the mortgage, sprinkler benefits will last decades longer.

A related issue is the controversy over whether to apply a discount rate to future lives saved. The rationale for the use of discount rates is based on the obvious preference people have for a dollar to spend today over a dollar to spend next year. However, the extension of discount rates to something like human life is not straightforward and remains controversial. The use of a discount rate where one should not be used or the use of an exaggerated rate will reduce the present value of out-year benefits and so under-estimate sprinkler benefits.

5. Baseline conditions used to evaluate sprinklers are often unrealistic.

A cost-benefit analysis needs to compare costs and benefits with home sprinklers to costs and benefits in a baseline situation. The baseline does not have to be the status quo, but if it is different, then its characteristics, costs and benefits need to be realistically and appropriately developed.

Several cost-benefit analyses have chosen to use a baseline of universal working smoke alarms. This is not the status quo. Many smoke alarms are not working, and it would require significant technology upgrades and/or universal distribution of very effective educational programs to achieve universal operationality. Use of this alternative as a baseline for comparison without incorporation of the significant costs required to achieve the condition is at best seriously misleading and at worst deceptive.

The perception that sprinklers cost too much or cost more than they are worth is so widespread that, unfortunately, many intelligent, well-meaning fire safety professionals do not look closely enough at a series of calculations that claim to confirm the point. Most fire safety policy questions are complex and involve the balancing of various benefits and costs. Fire safety professionals should make sure that they apply the best science and the best data to every policy question. When open-minded fire safety professionals meet that standard on the question of home sprinklers, they see that home sprinklers are a good choice.

Section 7. Concluding Points

Fire sprinklers are highly reliable and effective elements of total system designs for fire protection in buildings. They save lives and property, producing large reductions in the number of deaths per thousand fires, in average direct property damage per fire, and especially in the likelihood of a fire with large loss of life or large property loss.

Excluding fires too small to activate a sprinkler and cases of failure or ineffectiveness because of a lack of sprinklers in the fire area, wet pipe sprinklers operated in 92% of reported structure fires and operated effectively in 89% of fires. Three out of five (60%) of the failures occurred because the system had been shut off.

There are certain fire situations where even a complete sprinkler system will have limited impact: (a) Explosions and flash fires that may overpower the system; (b) Fires that begin very close to a person (e.g., clothing ignition) or unusually sensitive and expensive property (e.g., an art gallery) where fatal injury or substantial property loss can occur before sprinklers can react; and (c) Fires that originate in unsprinklered areas (e.g., concealed wall spaces) or adjacent properties (e.g., exposure fires), which may grow to unmanageable size outside the range of the sprinkler system. These situations can arise when (a) sprinkler standards are based on design fires less severe than explosions or flash fires, as is the case for explosions in the NFPA 13, NFPA 13D, and NFPA 13R standards; (b) sprinkler objectives are defined in terms of a design fire area larger than the distance implied by a victim intimate with ignition; or (c) sprinkler standards exclude certain potential areas of fire origin from their definition of complete coverage, which is typically but not always the case.

Sprinkler systems are so effective that it can be tempting to overstate just how effective they are. For example, some sprinkler proponents have focused too narrowly on the reliability of the components of the sprinkler system itself. If this were the only concern in sprinkler performance, then there would be little reason for concern at all, but human error is a relevant problem.

On the other hand, human error is not a problem unique to sprinklers. In fact, all forms of active and passive fire protection tend to show more problems with human error than with intrinsic mechanical or electrical reliability.

It is important for all concerned parties to (a) distinguish between human and mechanical problems because they require different strategies; (b) include both as concerns to be addressed when deciding when and how to install, maintain, and rely on sprinklers and other automatic extinguishing systems; (c) strive to use performance analysis in assessing any other element of fire protection; and (d) remember that the different elements of fire protection support and reinforce one another and so must always be designed and considered as a system.

Because sprinkler systems are sophisticated enough to require competent fire protection engineering and function best in buildings where there is a complete integrated system of fire protection, it is especially important that proper procedures be used in the installation and maintenance of sprinkler systems. This means careful adherence to the relevant standards:

- 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 Residential Occupancies Up to and Including Four Stories in Height*; and
- NFPA 25, *Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems*.

Because sprinkler systems are so demonstrably effective, they can make a major contribution to fire protection in any property. NFPA 101®*, Life Safety Code*; NFPA 1, *Fire Code*; and NFPA 5000®, *Building Construction and Safety Code*, have required sprinklers in all new one- and two-family homes, all nursing homes, and many nightclubs since the 2006 editions. The 2009 edition of the *International Residential Code* also added requirements for sprinklers in one- or two-family dwellings, effective January 2011. This protection can be expected to increase in areas that adopt and follow these revised codes.

For more on NFPA's Fire Sprinkler Initiative, go to http://www.firesprinklerinitiative.org.

For relevant research on sprinklers, go to http://www.nfpa.org, then to Research, then Fire Protection Research Foundation, then Reports and Proceedings, then Suppression.

Section 8. Summary by Property Use

This section summarizes key facts for each of several property use groups.

Homes* (Including Apartments)

- In 2007-2011, 6% of reported home structure fires** indicated some type of sprinkler was present (89% wet pipe, 8% dry pipe, 2% other).

- The 2009 American Housing Survey reported that 5% of occupied year-round housing units had sprinklers. The percentage was higher for housing units in multi-unit buildings (13%) than for single family homes (2%).

- Wet pipe sprinklers operated in 95% of fires and operated effectively in 92% of fires.*** When failure occurred, leading reasons were system shutoff (62%) and manual intervention defeated system (19%). When operating equipment was ineffective, leading reasons were water did not reach fire (43%), not enough water released (33%), and component damaged (10%).

- Only one or two sprinklers operated in 94% of reported fires where wet pipe sprinklers operated.

- In homes, deaths per thousand reported fires were 82% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

- In homes, direct property damage per reported fire was 68% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

* Home includes single family homes, duplexes, rowhouses, apartments, flats, and manufactured homes.

** Excluding buildings under construction.

*** Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, fuel burner or boiler, commercial compactor, incinerator, or trash.

Source: 2007-2011 NFIRS and NFPA survey except where noted.

Hotels and Motels

- In 2007-2011, 52% of reported hotel or motel structure fires* indicated some type of sprinkler was present (90% wet pipe, 7% dry pipe, 3% other).
- Wet pipe sprinklers operated in 91% of fires and operated effectively in 89% of fires.**
- Only one or two sprinklers operated in 95% of reported fires where wet pipe sprinklers operated.
- In hotels and motels, deaths per thousand reported fires were 100% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

* Excluding buildings under construction.

** Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, fuel burner or boiler, commercial compactor, incinerator, or trash.

Source: 2007-2011 NFIRS and NFPA survey except where noted.

Public Assembly Properties

- In 2007-2011, 23% of reported public assembly structure fires* indicated some type of sprinkler was present (82% wet pipe, 8% dry pipe, 10% other). In properties with more than one type of automatic extinguishing equipment present, only the type closest to the fire is reported, which means sprinklers may also have been present in some of the 30% of public assembly structure fires where some type of automatic extinguishing equipment other than sprinklers was reported present.

- Wet pipe sprinklers operated in 92% of fires and operated effectively in 88% of fires.** When failure occurred, leading reasons were system shutoff (55%) and manual intervention defeated system (18%). When operating equipment was ineffective, leading reasons were water did not reach fire (66%) and not enough water released (26%).

- Only one or two sprinklers operated in 88% of reported fires where wet pipe sprinklers operated.

- In public assembly properties, deaths per thousand reported fires were 100% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing systems present.

- In public assembly properties, direct property damage per reported fire was 75% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

* Excluding buildings under construction.

** Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, fuel burner or boiler, commercial compactor, incinerator, or trash.

Note: Public assembly properties include eating or drinking establishments, places of worship, theaters, libraries and museums, passenger terminals, and fixed or variable use entertainment properties, including stadiums, arenas, and concert halls.

Source: 2007-2011 NFIRS and NFPA survey except where noted.

Eating or Drinking Establishments

- In 2007-2011, 23% of reported eating or drinking establishment structure fires* indicated some type of sprinkler was present (79% wet pipe, 7% dry pipe, 14% other). In properties with more than one type of automatic extinguishing equipment present, only the type closest to the fire is reported, which mean sprinklers may have been present in some of the 40% of eating and drinking establishment structure fires where some type of automatic extinguishing equipment other than sprinklers was reported present.

- Wet pipe sprinklers operated in 93% of fires and operated effectively in 88% of fires.** When failure occurred, leading reasons were system shutoff (50%) and manual intervention defeated system (15%). When operating equipment was ineffective, leading reasons were water did not reach fire (66%) and not enough water released (34%).

- In eating or drinking establishments, direct property damage per reported fire was 75% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

* Excluding buildings under construction.

** Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, fuel burner or boiler, commercial compactor, incinerator, or trash.

Source: 2007-2011 NFIRS and NFPA survey except where noted.

Educational Properties

- In 2007-2011, 36% of reported educational property structure fires* indicated some type of sprinklers was present (89% wet pipe, 9% dry pipe, 2% other).

- Wet pipe sprinklers operated in 87% of fires and operated effectively in 84% of fires.**

- In educational properties, direct property damage per reported fire was 62% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

* Excluding buildings under construction.

** Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, fuel burner or boiler, commercial compactor, incinerator, or trash.

Source: 2007-2011 NFIRS and NFPA survey except where noted.

Health Care Properties

- In 2007-2011, 57% of reported health care property structure fires* indicated some type of sprinkler was present (86% wet pipe, 11% dry pipe, 3% other).

- Wet pipe sprinklers operated in 87% of fires and operated effectively in 85% of fires.**

- In health care properties, direct property damage per reported fire was 65% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

- The category of health care properties includes a number of specific property types that were excluded or not specifically identified in NFIRS prior to 1999. The excluded properties are doctor's offices. The properties not specifically identified are:
  - Ambulatory care facility
  - Development disability facility
  - Alcohol or substance abuse recovery center
  - Hospice
  - Hemodialysis unit

  Some properties that were specifically identified prior to 1999 are not specifically identified now:
  - Sanatorium or sanitarium
  - Institution for deaf, mute, or blind
  - Institution for physical rehabilitation

* Excluding buildings under construction.

** Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, fuel burner or boiler, commercial compactor, incinerator, or trash.

Source: 2007-2011 NFIRS and NFPA survey except where noted.

Stores and Offices

- In 2007-2011, 24% of reported store and office structure fires* indicated some type of sprinkler was present (87% wet pipe, 10% dry pipe, 3% other).

- Wet pipe sprinklers operated in 91% of fires and operated effectively in 88% of fires.** When failure occurred, leading reasons were system shutoff (57%) and manual intervention defeated system (19%). When operating equipment was ineffective, leading reasons were not enough water released (35%), water did not reach fire (34%), and manual intervention defected system (19%).

- Only one or two sprinklers operated in 84% of reported fires where wet pipe sprinklers operated.

- In stores and offices, deaths per thousand reported fires were 62% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

- In stores and offices, direct property damage per reported fire was 30% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

* Excluding buildings under construction.

** Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, fuel burner or boiler, commercial compactor, incinerator, or trash.

Source: 2007-2011 NFIRS and NFPA survey except where noted.

Manufacturing Facilities

- In 2007-2011, 48% of reported manufacturing facility structure fires* indicated some type of sprinkler was present (85% wet pipe, 12% dry pipe, 3% other).

- Wet pipe sprinklers operated in 91% of the fires and operated effectively in 86% of the fires.** When failure occurred, leading reasons were system shutoff (62%) and manual intervention defeated system (20%). When operating equipment was ineffective, leading reasons were water did not reach fire (36%) and not enough water released (31%).

- Only one or two sprinklers operated in 67% of reported fires where wet pipe sprinklers operated.

- In manufacturing facilities, deaths per thousand reported fires were 88% lower when wet pipe sprinklers were present, compared to fires with automatic extinguishing equipment present.

- In manufacturing facilities, direct property damage per reported fire was 38% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

* Excluding buildings under construction.

** Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, fuel burner or boiler, commercial compactor, incinerator, or trash.

Source: 2007-2011 NFIRS and NFPA survey except where noted.

Warehouses Excluding Cold Storage

- In 2007-2011, 32% of structure fires in warehouses (excluding cold storage) reported some type of sprinkler was present (79% wet pipe, 20% dry pipe, 1% other).

- Wet pipe sprinklers operated in 86% of fires and operated effectively in 84% of fires.**

- Only one or two sprinklers operated in 73% of reported fires where wet pipe sprinklers operated.

- In warehouses excluding cold storage, deaths per thousand reported fires were 61% lower when wet pipe sprinklers were present, compared to fires with no automatic extinguishing equipment present.

* Excluding buildings under construction.

** Estimates of reliability and effectiveness are based only on fires and installations where the fire should have activated and been controlled by an operational system, therefore excluding buildings under construction, fires with sprinklers not in fire area reported as reason for failure or ineffectiveness, fires reported as too small to activate equipment, and fires reported as confined to cooking vessel, chimney or flue, fuel burner or boiler, commercial compactor, incinerator, or trash.

Source: 2007-2011 NFIRS and NFPA survey except where noted.

Appendix A.
How National Estimates Statistics 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 sent to all municipal departments protecting populations of 50,000 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.

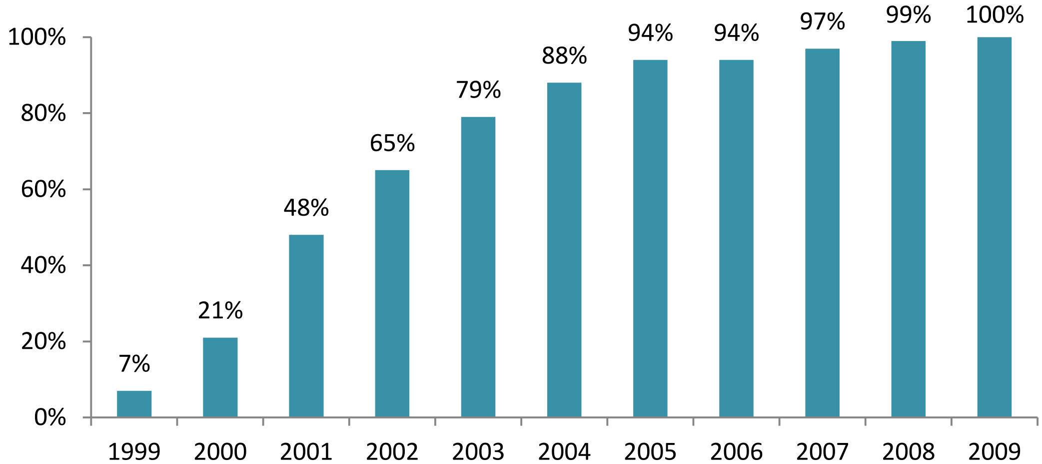
Scaling ratios are obtained by comparing NFPA's projected totals of residential structure fires, non-residential structure fires, vehicle fires, and outside and other fires, and associated civilian deaths, civilian injuries, and direct property damage with comparable totals in NFIRS. Estimates of specific 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.

Figure A.1. Fires Originally Collected in NFIRS 5.0 by Year



From 1999 data on, analyses are based on scaling ratios using only data originally collected in NFIRS 5.0:

<u>NFPA survey projections</u>
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.

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.

Some analyses of structure fires show only non-confined fires. In these tables, percentages shown are of non-confined structure fires rather than all structure fires. This approach has the advantage of showing the frequency of specific factors in fire causes, but the disadvantage of possibly overstating the percentage of factors that are seldom seen in the confined fire incident types and of understating the factors specifically associated with the confined fire incident types.

Other analyses include entries for confined fire incident types in the causal tables and show percentages based on total structure fires. In these cases, the confined fire incident type is treated as a general causal factor.

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.*

In the formulas that follow, the term "all fires" refers to all fires in NFIRS on the dimension studied. The percentages of fires with known or unknown data are provided for non-confined fires and associated losses, and for confined fires only.

Cause of Ignition: This field is used chiefly to identify intentional fires. "Unintentional" in this field is a specific entry and does not include other fires that were not intentionally set: failure of equipment or heat source, act of nature, or "other" (unclassified)." The last should be used for exposures but has been used for other situations as well. Fires that were coded as under investigation and those that were coded as undetermined after investigation were treated as unknown.

Factor Contributing to Ignition: In this field, the code "none" is treated as an unknown and allocated proportionally. For Human Factor Contributing to Ignition, NFPA enters a code for "not reported" when no factors are recorded. "Not reported" is treated as an unknown, but the code "none" is treated as a known code and not allocated. Multiple entries are allowed in both of these fields. Percentages are calculated on the total number of fires, not entries, resulting in sums greater than 100%. Although Factor Contributing to Ignition is only required when the cause of ignition was coded as: 2) unintentional, 3) failure of equipment or heat source; or 4) act of nature, data is often present when not required. Consequently, any fire in which no factor contributing to ignition was entered was treated as unknown.

In some analyses, all entries in the category of mechanical failure, malfunction (factor contributing to ignition 20-29) are combined and shown as one entry, “mechanical failure or malfunction.” This category includes:

21. Automatic control failure;
22. Manual control failure;
23. Leak or break. Includes leaks or breaks from containers or pipes. Excludes operational deficiencies and spill mishaps;
25. Worn out;
26. Backfire. Excludes fires originating as a result of hot catalytic converters;
27. Improper fuel used; Includes the use of gasoline in a kerosene heater and the like; and
20. Mechanical failure or malfunction, other.

Entries in “electrical failure, malfunction” (factor contributing to ignition 30-39) may also be combined into one entry, “electrical failure or malfunction.” This category includes:

31. Water-caused short circuit arc;
32. Short-circuit arc from mechanical damage;
33. Short-circuit arc from defective or worn insulation;
34. Unspecified short circuit arc;
35. Arc from faulty contact or broken connector, including broken power lines and loose connections;
36. Arc or spark from operating equipment, switch, or electric fence;
37. Fluorescent light ballast; and
30. Electrical failure or malfunction, other.

Heat Source. In NFIRS 5.0, one grouping of codes encompasses various types of open flames and smoking materials. In the past, these had been two separate groupings. A new code was added to NFIRS 5.0, which is code 60: “Heat from open flame or smoking material, other.” NFPA treats this code as a partial unknown and allocates it proportionally across the codes in the 61-69 range, shown below.

61. Cigarette;
62. Pipe or cigar;
63. Heat from undetermined smoking material;
64. Match;
65. Lighter: cigarette lighter, cigar lighter;
66. Candle;

67 Warning or road flare, fuse;
68. Backfire from internal combustion engine. Excludes flames and sparks from an exhaust system, (11); and
69. Flame/torch used for lighting. Includes gas light and gas-/liquid-fueled lantern.

In addition to the conventional allocation of missing and undetermined fires, NFPA multiplies fires with codes in the 61-69 range by

$$\frac{\text{All fires in range 60-69}}{\text{All fires in range 61-69}}$$

The downside of this approach is that heat sources that are truly a different type of open flame or smoking material are erroneously assigned to other categories. The grouping "smoking materials" includes codes 61-63 (cigarettes, pipes or cigars, and heat from undetermined smoking material, with a proportional share of the code 60s and true unknown data.

Equipment Involved in Ignition (EII). NFIRS 5.0 originally defined EII as the piece of equipment that provided the principal heat source to cause ignition if the equipment malfunctioned or was used improperly. In 2006, the definition was modified to "the piece of equipment that provided the principal heat source to cause ignition." However, much of the data predates the change. Individuals who have already been trained with the older definition may not change their practices. To compensate, NFPA treats fires in which EII = NNN and heat source is not in the range of 40-99 as an additional unknown.

To allocate unknown data for EII, the known data is multiplied by

$$\frac{\text{All fires}}{\text{(All fires – blank – undetermined – [fires in which EII =NNN and heat source <>40-99])}}$$

In addition, the partially unclassified codes for broad equipment groupings (i.e., code 100 - heating, ventilation, and air conditioning, other; code 200 - electrical distribution, lighting and power transfer, other; etc.) were allocated proportionally across the individual code choices in their respective broad groupings (heating, ventilation, and air conditioning; electrical distribution, lighting and power transfer, other; etc.). Equipment that is totally unclassified is not allocated further. This approach has the same downside as the allocation of heat source 60 described above. Equipment that is truly different is erroneously assigned to other categories.

In some analyses, various types of equipment are grouped together.

Code Grouping	EII Code	NFIRS definitions
Central heat	132	Furnace or central heating unit
	133	Boiler (power, process or heating)
Fixed or portable space heater	131	Furnace, local heating unit, built-in
	123	Fireplace with insert or stove
	124	Heating stove
	141	Heater, excluding catalytic and oil-filled
	142	Catalytic heater
	143	Oil-filled heater
Fireplace or chimney	120	Fireplace or chimney
	121	Fireplace, masonry
	122	Fireplace, factory-built
	125	Chimney connector or vent connector
	126	Chimney – brick, stone or masonry
	127	Chimney-metal, including stovepipe or flue
Fixed wiring and related equipment	210	Unclassified electrical wiring
	211	Electrical power or utility line
	212	Electrical service supply wires from utility
	213	Electric meter or meter box
	214	Wiring from meter box to circuit breaker
	215	Panel board, switch board or circuit breaker board
	216	Electrical branch circuit
	217	Outlet or receptacle
	218	Wall switch
	219	Ground fault interrupter
Transformers and power supplies	221	Distribution-type transformer
	222	Overcurrent, disconnect equipment
	223	Low-voltage transformer

	224	Generator
	225	Inverter
	226	Uninterrupted power supply (UPS)
	227	Surge protector
	228	Battery charger or rectifier
	229	Battery (all types)
Lamp, bulb or lighting	230	Unclassified lamp or lighting
	231	Lamp-tabletop, floor or desk
	232	Lantern or flashlight
	233	Incandescent lighting fixture
	234	Fluorescent light fixture or ballast
	235	Halogen light fixture or lamp
	236	Sodium or mercury vapor light fixture or lamp
	237	Work or trouble light
	238	Light bulb
	241	Nightlight
	242	Decorative lights – line voltage
	243	Decorative or landscape lighting – low voltage
	244	Sign
Cord or plug	260	Unclassified cord or plug
	261	Power cord or plug, detachable from appliance
	262	Power cord or plug-permanently attached
	263	Extension cord
Torch, burner or soldering iron	331	Welding torch
	332	Cutting torch
	333	Burner, including Bunsen burners
	334	Soldering equipment
Portable cooking or warming equipment	631	Coffee maker or teapot
	632	Food warmer or hot plate
	633	Kettle
	634	Popcorn popper
	635	Pressure cooker or canner
	636	Slow cooker

637	Toaster, toaster oven, counter-top broiler
638	Waffle iron, griddle
639	Wok, frying pan, skillet
641	Breadmaking machine

Equipment was not analyzed separately for confined fires. Instead, each confined fire incident type was listed with the equipment or as other known equipment.

Item First Ignited. In most analyses, mattress and pillows (item first ignited 31) and bedding, blankets, sheets, and comforters (item first ignited 32) are combined and shown as "mattresses and bedding." In many analyses, wearing apparel not on a person (code 34) and wearing apparel on a person (code 35) are combined and shown as "clothing." In some analyses, flammable and combustible liquids and gases, piping and filters (item first ignited 60-69) are combined and shown together.

Area of Origin. Two areas of origin: bedroom for more than five people (code 21) and bedroom for less than five people (code 22) are combined and shown as simply "bedroom." Chimney is no longer a valid area of origin code for non-confined fires.

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
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
U	Undetermined (restored to coding 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	System did not 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

Appendix C: Selected Incidents

The following published incidents are detailed examples reinforcing the need for proper inspection and testing maintenance programs and reflect the analysis discussed in the reliability and effectiveness section of the report. The collection may not be representative of all fires in terms of relative frequency or specific circumstances.

Included are short articles from the “Firewatch” column in *NFPA Journal* and incidents from the large-loss and catastrophic fires report. It is important to remember that this is anecdotal information. Anecdotes show what can happen; they are not a source to learn about what typically occurs.

NFPA’s Fire Incident Data Organization (FIDO) identifies significant fires through a clipping service, the Internet and other sources. Additional information is obtained from the fire service and federal and state agencies. FIDO is the source for articles published in the “Firewatch” column of the *NFPA Journal*.

LARGE FIRES IN WHICH SPRINKLERS HAD BEEN SHUT OFF BEFORE FIRE

State: Massachusetts
Dollar Loss: $26,000,000
Month: July 2007
Time: 4:14 am

Property Characteristics and Operating Status:
This three-story, irregularly-shaped former mill building was used by 56 mercantile businesses and covered 350,000 square feet (32,500 square meters). It was of unprotected ordinary construction. The building was closed at the time of the fire.

Fire Protection Systems:
There was no smoke detection equipment present. There was a full-coverage combination wet-and dry-pipe sprinkler system. A sprinkler valve in the area of ignition was padlocked shut, allowing the fire to quickly overwhelm the rest of the system. The fire department was not notified that the system was shut down.

Fire Development:
Investigators believe the fire started after welding was done in the basement the day before, without a permit from the fire department.

Contributing Factors and Other Details:
Several code noncompliance issues, such as the welding and shutting down the sprinkler system, contributed to the fire. Four hundred firefighters from 78 fire departments in two states responded to this fire. Nine firefighters were injured. The loss was estimated at $16,000,000 to the structure and $10,000,000 to the contents.

Stephen G. Badger, 2008, "Large-Loss Fires in the United States in 2007", *NFPA Journal* Fire Analysis and Research, Quincy, MA.

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
Maryland $11,000,000 May, 2005 7:00 p.m.	This storage complex consisted of a one-story vacant warehouse of unprotected ordinary construction and a second warehouse of unprotected noncombustible construction and covered 100,000 square feet (9,290 square meters). The site was closed.	There was no detection equipment present. There was a complete coverage dry-pipe sprinkler system present. The system was not operational, as it had been shut down when building became vacant.	This was an incendiary fire. The fire caused a complete collapse of the older brick building and fire damage to the steel storage building.	Four firefighters were injured. The loss was $10,000,000 to the structure and $1,000,000 to the contents.

Stephen G. Badger, 2006, "Large-Loss Fires for 2005", *NFPA Journal*, November/December, 68.

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
Colorado $15,000,000 April, 1999 2:58 p.m.	This two-story single-family home had a ground-floor area of more than 5,000 square feet (464 square meters). The type of construction wasn't reported. No one was home when the fire broke out.	The house had an automatic detection system of unknown type and coverage, which operated. It also had a residential set-pipe sprinkler system, but it had been shut down during remodeling.	A light fixture in a closet ignited structural members. No details on the fire's subsequent growth and spread were reported. No injuries were reported.	None reported.

Stephen G. Badger and Thomas Johnson, 2000, "1999 Large-Loss Fires and Explosions", *NFPA Journal*, November/December, 93.

LARGE FIRES IN WHICH INAPPROPRIATE SYSTEM WAS USED FOR TYPE OF FIRE

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development:	Contributing Factors and Other Details
Arizona $100,000,000 August, 2000 4:58 p.m.	The fire broke out in a warehouse containing a home and garden supply company and a pharmaceuticals distribution company. The construction and height of the structure weren't reported. Employees were working in one of the companies when the fire broke out.	No information was available on automatic detection equipment. A sprinkler system, whose type and extent of coverage weren't known, wasn't adequate for the stored merchandise.	Due to litigation, officials are releasing no information on the fire's development.	None reported.

Stephen G. Badger, 2001, "Large-Loss Fires of 2000", *NFPA Journal*, November/December, 61.

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development:	Contributing Factors and Other Details
Pennsylvania $6,000,000 August, 1999 5:57 p.m.	This approximately 50-foot (15.2 meters) steel manufacturing building was of unprotected, noncombustible construction with a ground-floor area of 20,000 square feet (1,858 square meters). Although the plant was closed for the night, maintenance workers were inside.	The plant didn't have any automatic detection equipment, but it did have a partial coverage wet-pipe sprinkler system. The sprinklers were ineffective because of missing heads and the fact that the system wasn't designed for this hazard. The system outside the area did help stop the fire spread.	Investigators haven't determined the cause of this fire, but they believe it started in a dip-tank area. Six firefighters were injured fighting the blaze.	The poorly maintained sprinkler system wasn't designed for the hazard involved, and heads were missing.

Stephen G. Badger and Thomas Johnson., 2000, "1999 Large-Loss Fires and Explosions", *NFPA Journal*, November/December, 85-86.

LARGE FIRES IN WHICH SPRINKLERS HAD COMPONENT DAMAGE

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
Indiana $10,000,000 September, 2005 11:59 p.m.	This outdoor furniture and cushion manufacturing plant was of unprotected ordinary construction and had a ground floor area of 279,000 square feet (25,919 square meters). The height was not reported. The plant was in full operation.	There was no detection equipment present. There was a complete coverage combination wet- and dry-pipe sprinkler system. The system operated but risers were heavily damaged by a roof collapse.	The fire broke out in a woodworking area. The ignition sequence is still under investigation.	Over the years, the building had many add-ons and multiple roofs that firefighters had to work through to reach to the fire.

Stephen G. Badger, 2006, "Large-Loss Fires for 2005", *NFPA Journal*, November/December, 70.

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
Missouri $5,000,000 October, 2005 2:42 p.m.	This two-story food preparation plant was under construction. It was of protected noncombustible construction. The ground floor area was not reported. Workmen were on location with ongoing construction.	There was unreported coverage smoke detection equipment present. The system had been shut off due to construction work. There was an unreported coverage wet-pipe sprinkler system present. The system was damaged during the explosion and it did not operate.	An explosion and fire occurred when a natural gas valve was installed in the kitchen area and left in the open position and uncapped. The source of ignition is still under investigation.	One person died and 15 were injured in the explosion.

Stephen G. Badger, 2006, "Large-Loss Fires for 2005", *NFPA Journal*, November/December, 69-70.

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
Minnesota $10,000,000 March, 2001 5:08 a.m.	Two-story wood products manufacturing plant of unprotected wood frame construction was in full operation at the time the fire broke out. The ground floor area was not reported.	There was no automatic detection equipment present. A dry-pipe sprinkler system was present. The extent of coverage was not reported. A ceiling collapse preceding the fire damaged the system, rendering it ineffective.	A roof collapse caused by a heavy snow load is believed to have caused wires to spark and ignite dust that had accumulated above the ceiling. The fire then spread to pallets of wood product.	None reported.

Stephen G. Badger, November, 2002, "Large-Loss Fires in the United States 2001", 13-14.

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
Washington $7,000,000 December, 1999 3:23 a.m.	This 12-foot (3.7 meter) retail tool store was of unprotected, ordinary construction with a ground-floor area of 102,000 square feet (9,475.8 square meters). The store of origin, which was one of six businesses in the strip mall, covered a ground-floor area of 32,400 square feet (3,010 square meters). The store was closed.	No information was reported on automatic detection equipment. The entire strip mall had a shared wet-pipe sprinkler system, which had been disabled in the store of origin by a prior forklift incident. The sprinkler in the adjoining business helped control fire spread. There was also a dry-pipe system in a dry storage area.	Cardboard boxes containing plastic tarps failed and fell from rack storage, landing within a foot (.03 meters) of a heater. The propane heater was set up to help dry out the stock made wet by the sprinkler incident earlier in the day. The heater ignited the boxes and the blower pushed the burning embers into other storage. No injuries were reported.	With the sprinkler system disabled, there was no water flow alarm to notify the fire department, allowing the fire to burn a long time before the neighboring business' sprinkler activated.

Stephen G. Badger and Thomas Johnson, 2000, "1999 Large-Loss Fires and Explosions", *NFPA Journal*, November/December, 91.

LARGE FIRES WHERE SPRINKLERS HAD LACK OF MAINTENANCE

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
South Carolina $8,000,000 March, 2005 6:53 a.m.	Four-story textile manufacturing plant of heavy timber construction covering 67,500 square feet (6,271 square meters) was in full operation at the time this fire broke out.	There was a complete coverage detection system of an unreported type. This system was out of service for an unreported reason at the time of the fire. A complete coverage wet-pipe sprinkler system was present. The system operated but was ineffective due to lack of maintenance. The sprinkler heads were coated with cotton dust. There were pressurized water and ABC extinguishers present, which the employees used to extinguish the fire in a baler.	A fire originating in a baler was believed extinguished by the employees. The cause was not reported. When firefighters arrived and investigated they found the fire had extended to the second floor. Firefighters attempted an interior attack, but conditions deteriorated rapidly and walls started to collapse, so all firefighters were withdrawn to a defensive attack.	Three firefighters were injured. Holes in the floor on the second story allowed the fire to extend to the second story. Losses totaled $5,000,000 to the structure and $3,000,000 to the contents.

Stephen G. Badger, November, 2002, "Large-Loss Fires in the United States 2001", 14.

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
California $6,000,000 July, 1999 7:25 p.m.	This four-story furniture showroom of protected, non-combustible construction covered a ground-floor area of approximately 44,000 square feet (4,087.5 square meters). The showroom was closed but construction workers were in the building.	The building had no automatic detection system but did have a partial-coverage sprinkler system. Sprinklers helped control fire spread on the second and third floors but weren't effective on the fourth floor because of sediment in the system. Firefighters found sediment blocking several heads. The building also had portable extinguishers and a stand pipe system. Investigators believe that workers used the extinguishers.	Molten slag came in contact with furniture during welding operations and ignited a fire. The fire spread out the second-floor windows and into the third floor. Flames then breached a ceiling and entered the fourth floor where there was a flashover. No injuries were reported.	Sediment blocked sprinklers on the fourth floor.

Stephen G. Badger and Thomas Johnson, 2000, "1999 Large-Loss Fires and Explosions", *NFPA Journal*, November/December, 92.

LARGE FIRES IN WHICH WATER DID NOT REACH FIRE
(BECAUSE SPRINKLERS HAD OBSTRUCTED WATER FLOW)

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
Arizona $8,000,000 December, 2004 7:33 p.m.	This two-story convention center was of protected non-combustible construction. The ground floor area was not reported. The center was fully operating at the time of the fire.	There was a smoke detection system present that operated and alerted the occupants. The coverage was not reported. There was a wet-pipe sprinkler system present. The system did activate with over 30 heads flowing water.	Heat from a halogen light ignited walnut dust used in filming a collapse scene in a mine for a movie. The fire ignited polyurethane beams and walls of a cave and extended to the cave roof. A covering over the movie set prevented water from the sprinkler from reaching the seat of the fire but the sprinkler flow did prevent the fire's spread beyond the set.	Original reports were that one worker was missing. A primary search was initiated but the worker was located unharmed. Visibility was zero as firefighters attempted an initial fire attack. Firefighters were warned initially of loose rattlesnakes at the movie set. The snakes were corralled by an animal handler and posed no threat to the firefighters and harmed no one.

Stephen G. Badger, 2005, "Large-Loss Fires for 2004", *NFPA Journal*, November/December, 49.

LARGE FIRES IN WHICH SPRINKLERS DID NOT DISCHARGE ENOUGH WATER

Fire in drying oven causes significant loss, Oregon
A large food-processing plant was the site of a significant fire loss when debris build-up on gas burners dislodged and ignited dust and food products.

A dry-pipe sprinklers system providing full coverage to the building failed to operate during the fire and efforts by employees to control the fire were unsuccessful. The single-story, steel-frame building measured 400 feet (121 meters) in length and 200 feet (60 meters) in width. It had metal walls, a metal roof and two food dryers with a dividing wall between them inside the building. The three-section dryers had multiple doors allowing access to the blower section on the bottom, conveyor in the middle, and gas-fired burners and ventilation on the top section. Fire protection included multiple portable fire extinguishers and a fire pump and sprinkler system fed by a water storage reservoir. The plant was operating at the time of the fire.

An employee observed smoke in a section of the building and found a fire burning in the middle section of one of the food dryers. For nearly 10 minutes, employees tried to extinguish the fire using portable fire extinguishers and water-spray equipment that was not designed for fire protection. A 911 call from the employees alerted the fire department, which arrived 27 minutes after alarm.

Firefighters extinguished the fire and limited damage to just two sections of the oven, and the onions in the oven. There was, however, smoke damage throughout the building.

Investigators examined the equipment and found debris covering the gas-fired burners that had fallen off or was dislodged and then ignited. Evidence of previous fires was also noted as employees reported product often ignites within the oven but is usually easily extinguished.

Damage to the building, which was valued at more than $12 million with contents of $300,000, had losses estimated at $3 million and $130,000 in content loss. Investigators also found the fire pump room covered in an oily residue and the fuel tank to the fire pump empty. Some 256 sprinklers fused during the fire, but were ineffective due to a lack of water being pumped from the reservoir. Two employees suffered smoke inhalation during extinguishment attempts.

Kenneth J. Tremblay, 2007, “Firewatch,” *NFPA Journal*, November/December 22.

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
Iowa $250,000,000 February, 2000 7:02 a.m.	One-story machinery storage warehouse of unprotected non-combustible construction covering 990,000 square feet (91,974 square meters) was in full operation at the time the fire broke out.	There was no automatic detection equipment. A system was in the process of being installed. A wet-pipe sprinkler system was present. The extent of the coverage was not reported. This system activated but was not effective because of a water flow problem. The cause of the problem is still being investigated.	A fire of unknown cause broke out in the shipping/receiving area of this warehouse. Responding firefighters reported a large column of smoke from a distance away. With the sprinkler system activated, firefighters made an interior attack. Walls without openings within the warehouse hindered firefighters in reaching the fire. When large areas of the roof began to collapse and high rack storage failed, firefighters withdrew to a defensive attack.	Five firefighters were injured. The water supply was far below the fire flow requirements. A tanker shuttle was set up to assist until late in the day when the water problems were corrected.

Stephen G. Badger, November, 2002, “Large-Loss Fires in the United States 2001”, *NFPA Journal*, 17.

Location, Dollar Loss, Date, Time	Property Characteristics and Operating Status	Fire Protection Systems	Fire Development	Contributing Factors and Other Details
Oregon $8,501,000 March, 2004 8:21 a.m.	This one-story petroleum recycling plant was of heavy-timber, construction and covered 186,900 square feet. The plant was in full operation at the time.	No information was reported on any detection equipment. There was a complete coverage dry-pipe sprinkler system present. The system operated, but its rate of application was insufficient to control the fire.	A spark from an oxy/acetylene cutting torch fell into an open sludge-oil pit and ignited the contents instantaneously. The fire grew out of control quickly despite the activation of the sprinkler system. The fire spread through several businesses inside the building.	Firefighters reported insufficient water pressure in hydrants originally. Two firefighters were injured. Damage to the structure was estimated at $3,000,000 and $5,501,000 to the contents.

Stephen G. Badger, 2005, "Large-Loss Fires for 2004", *NFPA Journal*, November/December, 47.

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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1.0 Introduction

In most public buildings and many other locations, fire and building codes require fire extinguishers. Extinguishers are typically bright red and highly visible to the occupants. Questions surround the placement of fire extinguishers in areas where the general, untrained population may use them. If a small or incipient fire were to break out, would the untrained individual be able to operate the extinguisher? That is a central question debated by the fire-protection community every time a protection designer considers the selection and placement of portable fire extinguishers.

Currently, some fire protection professionals hypothesize that an ordinary person ("amateur") untrained in the operation of a fire extinguisher will not use the device effectively. Furthermore, these same professionals often speculate that, even if an untrained person chose to operate the fire extinguisher, he or she would be unable to do so safely. Such questions result, in part, due to a lack of research on the many elements of the interaction between amateurs and fire extinguishers. An extensive search of the archival published literature failed to uncover any tests specifically aimed at people's ability to use a fire extinguisher.

The purpose of this study was to collect data from a random sampling of the general population on an ordinary person's ability to use a fire extinguisher safely and effectively. For the purposes of this study, an ordinary person is defined as an untrained, novice, or amateur user of a fire extinguisher. Specifically this study addresses the following questions and data points:

Question 1. What is an amateur's ability to use a fire extinguisher with respect to four aspects describing this ability: usage, technique, safety, and extinguishment simulation– without prior training?

Usage – Ability of a random sampling of the population to operate a fire extinguisher.

Data points collected:

- Percentage able discharge the agent on the fire?
- Average pre-discharge time?
- Percentage that reads the label before usage?

Technique – What percentage of the same random sampling of the population who use good techniques of extinguishment?

Data points collected:

- Aims at the base of the fire?
- Uses a back and forth sweeping motion?
- Continues spraying agent after the fire appeared to be extinguished?

Safety - What percentage of the population completes the task safely?

Data points:

- Stands a safe distance away from the fire?
- Doesn't turn his/her back on the fire?

Extinguishment Simulation – What percentage of the population is able to control and extinguish a fire?

Data Points:

- Percentage who are able to simulate extinguishment of the fire?
- Average time to extinguish a simulated Class A fire?

Question 2. With a minimal amount of training, how much would the participant improve his/her performance on the four aspects: usage, technique, safety, and extinguishment simulation?

During the 1980s a series of tests were conducted at the Underwriters Laboratories[1]. These tests were not designed to determine a person's ability to use a fire extinguisher, but to develop revisions to the UL test standard for portable fire extinguishers (1). During 1979, 1985, and 1996, the National Association of Fire Equipment Distributors (NAFED) collected data on incidents of use of portable fire extinguishers in industrial or building environments. The data from 1979 showed that 5,076 out of 5,400 fires (94%) reported were extinguished solely by one or more portable fire extinguishers. The data from 1985 showed that 1,049 out of 1,153 (91%) fires were extinguished solely by one or more portable fire extinguishers. The data from 1996 showed that 2,154 out of 2,267 fires (95%) were extinguished solely by one or more portable fire extinguishers. Of all the fires extinguished, it is unknown whether the person using the extinguisher had any formal training. The fires extinguished were a Class A, Class B, and a mixture of fire classes. The study concluded that portable fire extinguishers had an "extraordinary success rate" (2).

In 2010, D. Bruck and I. Thomas investigated "Interactions Between Human Behavior and Technology: Implications for Fire Safety Science." One part of the study examined the ability of adults above the age of 60 to use a fire extinguisher on a small fire. This study concluded that 18 out of 23 (78%) of the participants were able to extinguish a fire with a fire extinguisher in a moderate amount of time (3). The average time for extinguishment for the fire was 38 seconds with a standard deviation of 16.3 seconds (3). Of the five participants who were not able to extinguish a fire, three were able to extinguish the fire after failing the first part of the experiment's protocol. The study by Mr. Bruck and Mr. Thomas provides valuable insight on how older people use fire extinguisher equipment. As stated in their study, older adults have altered reflexes and cognition abilities that limit their reaction time.

Raymond Ranellone, a WPI graduate, conducted an investigation in 2010 called "Fire Extinguishers in Academic Settings." (4) His research involved tracking detailed news reports of incidents in which a fire extinguisher was used in an academic setting from 2001-2010 (4). Specifically, his project used Google Alerts to estimate the number of incidents in which "fire extinguishers were beneficial in providing life safety and property protection…" (4). The report documented that fire extinguishers do provide "life safety and property loss prevention." A close look at a fire incident reporting system showed that, when a fire extinguisher is used effectively, it goes largely unreported, as there is no need for further action by anyone.

A literature search was also performed that showed "to date, no study has addressed these concerns that are facing many fire protection professionals in their everyday design considerations, yet all major authors of fire, life safety, and building codes require them in many occupancies." (5) The National Fire

[1] Note: The 1984 edition of UL 711 was a revision; UL 711 was established long before then and is used to evaluate relative effectiveness of various extinguishers by using repeatable, live fire testing. The 1984 Edition of UL 299 made major changes to the design of the extinguishers, including new operating instructions and other changes based on live fire testing with novices.

Protection Association's Standard 10, Standard for Portable Fire Extinguishers, is one of the most commonly "incorporated by reference" source on the inspection, testing, and maintenance for these devices and addresses many topics on the matter. A search in the NFPA online code subscriptions using EKU's library search engine shows that this standard is referenced in at least 103 NFPA documents as of March 2, 2012 (5). The International Code Council's International Fire Code section 906 and International Building Code section 906 require the placement of fire extinguishers in many occupancies, save for few exceptions, and incorporate NFPA 10 for requirements of testing, inspection, and maintenance. The same applies to the Occupational Safety and Health Administration's Regulations in both general industry and construction as found in 1910.157, Fire Extinguishers, and many others, which also incorporates NFPA 10 by reference. As such, NFPA 10 is considered the authoritative document on the topic.

NFPA 10, 2010 edition Annex D addresses several areas related to this study, and although not mandatory, every annex to such a document must be carefully considered by the individual applying the code to the built environment. First, D.1.1.1 recognizes three types of users — those trained in extinguisher use, such as responders and employees, and two additional groups of novice users – untrained private owners and untrained members of the general public. It was the latter group, the general public novices, whom the authors of this study sought to observe.

Section D.1.2.1 in NFPA 10 recognizes five basic steps to the operation of a fire extinguisher:

1. Recognition of a device as a fire extinguisher
2. Selection and suitability of a fire extinguisher
3. Transport of a fire extinguisher to the fire
4. Actuation of the fire extinguisher
5. Application of the extinguishing agent to the fire

This study assessed the abilities of untrained individuals in all the listed areas, except number 2. This is in no way intended to minimize the importance of selecting a suitable extinguisher, but simply was not within the scope of the present study.

The United States Department of Labor and Occupational Safety and Health Administration (OSHA) has outlined a series of strict standards for the placement, use, maintenance, and testing of portable fire extinguishers provided for the use of employees. In its guidelines, "Should employees evacuate or be prepared to fight a small fire?" there is a table on options a business can take depending on its circumstances. The options range from "total evacuation with no fire extinguishers required" to "certain or all employees being able to use a fire extinguisher. (6)

The Fire Protection Engineering Department at Worcester Polytechnic Institute (WPI) and the Fire and Safety Engineering Technology Program at Eastern Kentucky University (EKU) jointly conducted a study of 276 participants. Participants between ages 18 and 76 were asked to extinguish a controlled propane fire using the BullEx Intelligent Training System (ITS) before and after some limited training. After the trials they were surveyed on their comfort level and knowledge of fire safety.

2.0 Background

The following background information provides *a Brief History on Fire Extinguishers* that will provide context on past fire extinguishers and many of the common chemical agents used today in fire extinguishers. The *Types of Fire* section details briefly the classifications of fire and classifications on the fire extinguishers used to extinguish them. Finally, the *BullEx I.T.S.* and *Smart Extinguishers* section provides details on the systems used by WPI and EKU for this research.

2.1 A Brief History of Fire Extinguishers

From hand pumps to bucket chains to portable fire extinguishers, fire extinguishing devices have been around for a long time. Can these devices be considered fire extinguishers? According to *Merriam-Webster*, a fire extinguisher is "a portable or wheeled apparatus for putting out small fires by ejecting extinguishing chemicals." (7) In 1723, German Chemist Ambrose Godfrey-Hanckwitz built the first fire extinguisher. (8; 9) His invention was a "cask of fire-extinguishing liquid containing a pewter chamber of gunpowder." (9) Notably his invention was used with great efficiency in stopping a fire in London, according to *Bradley's Weekly Messenger* on November 7, 1729. (9; 8)

However, it was not until 1818 that the modern fire extinguisher was invented by British Captain George William Manby. His invention, nicknamed "Extincteur," consisted of "a copper vessel of 3 gallons (13.6 litres) of pearl ash (potassium carbonate) solution contained within compressed air." (10; 9) The soda-acid extinguisher was invented in 1866 by Francois Carlier of France. His fire extinguisher mixed water and sodium bicarbonate with tartaric acid that produced a stream of carbon dioxide (CO_2) gases. Almon M. Granger also invented a soda-acid extinguisher in the U.S. in 1881. The soda-acid extinguisher used "the reaction between sodium bicarbonate solution and sulphuric acid to expel pressurized water onto a fire." (9; 11)

The Russian Aleksandr Loren invented the first chemical foam fire extinguisher in 1904. Similar to how the soda-acid fire extinguisher worked, the chemical reaction between water, foam of licorice root, and sodium bicarbonate would expel the CO_2-rich foam onto the fire. (9; 8; 11)

In 1910, the Pyrene Manufacturing Company of Delaware patented the use of carbon tetrachloride (CTC) on fires and in 1911 deployed this agent in their own fire extinguisher. This fire extinguisher utilized a "brass or chrome container with integrated hand pump, which was used to expel a jet of liquid towards the fire." (9) One unique aspect of this fire extinguisher was the ability to be refilled with CTC. However, CTC is toxic and converts into phosgene gas, which is most commonly found today in chemical weapons. (9) In essence, the hazards to occupants were just as great as that posed by the fire and by products of combustion.

Bell Telephone Company encouraged the invention of the next fire extinguisher. Bell needed an "electrically non-conductive chemical for extinguishing the previously difficult to extinguish fires in telephone switchboards." (9) In 1924, Walter Kidde Company invented the carbon dioxide fire extinguisher to meet Bell's need. The carbon dioxide fire extinguisher was a tall metal cylinder that held 7.5 lbs. of $CO_{2.}$ (9)

In 1954, DuPont and the U.S. Army created Halon 1301, or bromotrifluoromethane. (9) This chemical agent "opened a new era in...industrial fire protection." (12) Though Halon 1301 is not a type of fire extinguisher, this chemical agent is an incredible extinguishment tool. This miracle chemical attacks fires without harming sensitive electronics. Halon 1301 was used widely across Europe and the U.S. up to the 1980s, when speculation began that Halon 1301 caused ozone depletion. Now heavily restricted, Halon 1301 and its other iterations have phased out in favor of more environmentally friendly options. (12; 9)

Over the past century, fire extinguishers have naturally evolved from the common bucket to today's sophisticated portable fire extinguisher. This evolution implies that fire extinguishers have been a useful tool for trained or untrained individuals for close to 300 years.

2.2 Types of Fire and Extinguisher Classification

There are five different types of fire classifications, labeled A, B, C, D, and K. NFPA 10, Standard on Portable Fire Extinguishers, dictates the color, pictograph, and other components of these markings. A fire can be classified in more than one class. A campfire that uses lighter fluid to ignite can be classified as a Class A and B fire until the lighter fluid is completely burned away. (14) The following pictures used in the figures were taken from the New York City Fire Department's website [http://www.nyc.gov/html/fdny/html/home2.shtml], but are representative of those being used throughout the United States.

Figure 1: Class A Fire Symbol

Class A fires are those that are fueled by materials that, when burned, leave a residue in the form of ash. (15)
Examples: paper, wood, cloth, rubber, certain plastics

Figure 2: Class B Fire Symbol

Class B fires are those that involve flammable liquids or gasses. (15)
Examples: gasoline, paint thinner, kitchen grease, propane, acetylene

Figure 3: Class C Fire Symbol

Class C fires are those that are energized by electrical wiring or equipment. When the electricity to the equipment is cut, the classification changes to the other types of fire. (15)
Examples: motors, computers, circuit breakers

Figure 4: Class D Fire Symbol

Class D fires are those that involve "combustible metals." (15)
Examples: magnesium, titanium, sodium

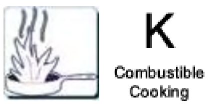

Figure 5: Class K Fire Symbol

Class K fires are those that involve cooking oils and fats used in cooking appliances. (15)
Examples: vegetable oils, animal oils, fats

For this study, a Class A fire is simulated for extinguishment using the BullEx Intelligent Training System. It should be noted that Class A fires are complex fires that involve many variables. A fairly detailed discussion of Class A fires can be found in NFPA 12A, Standard on Halon 1301 fire extinguishing systems, 2009 Edition, Annex I, Fire Extinguishment. Section I.2 reads in part:

> **I.2 Fires in Solid Materials**. Two types of fires can occur in solid fuels: one in which volatile gases resulting from heating or decomposition of the fuel surface are the source of combustion; and another in which oxidation occurs at the surface of, or within, the mass of fuel. The former is commonly referred to as "flaming" combustion, while the latter is often called "smoldering" or "glowing" combustion. The two types of fires frequently occur concurrently, although one type of burning can precede the other. For example, a wood fire can start as flaming combustion and become smoldering as burning progresses. Conversely, spontaneous ignition in a pile of oily rags can begin as a smoldering fire and break into flames at some later point.

This excerpt provides the background for discussion on the complexity of Class A fires and extinguishment with portable fire extinguishers. Portable fire extinguishers are installed in buildings to be used on small fires during their incipient stage. Typically, the incipient stage of a Class A fire includes flaming combustion at the surface of the fuel and will not include smoldering (deep seated) combustion because significant heat buildup is needed that can only occur over a prolonged period of time (not at the beginning stages of a fire).

The discussion in NFPA 12A continues:

> Flaming combustion, because it occurs in the vapor phase, is promptly extinguished with low levels of Halon 1301. In the absence of smoldering combustion, it will stay out.

Although the excerpt references the extinguishing agent Halon 1301, the concept can be used in a discussion of other extinguishing agents and portable fire extinguishers. A reasonable assumption is that the flaming combustion of an incipient fire can also be promptly extinguished with other more potent extinguishing agents applied with portable fire extinguishers. Once extinguished, these fires will stay out due to the absence of smoldering combustion.

2.3 BullEx Intelligent Training System

The BullEx Intelligent Training System (ITS) is a tool for training ordinary people how to properly and effectively use a fire extinguisher. The ITS uses sensor technology to determine if the trainee demonstrates the proper technique to extinguish a fire. The proper technique to extinguish a fire using the BullEx ITS is described later in the methods section.

On the front of the unit, there are four sensors that detect the sound of compressed air and water vapor being discharged from the Smart Extinguisher. These sensors are connected to a microprocessor that controls the flow of propane to the burner. (16) The system responds to different scenarios depending on how the user performs. For example, if the participant is aiming above or below the base of the flames, the system will dim the flames but not fully extinguish them. If the participant aims at one side of the flames only, it will extinguish on that side but increase in intensity on the other.

The Bull-Ex ITS consists of four parts: the unit, a propane fuel source, an electrical source, and a controller. The unit is 28 3/4” x 18” x 13”, is made out of stainless steel, and has four 40 kHz ultrasonic sensors on the front. (16) Fueled by a conventional 20-lb. propane tank, the system produces 500,000 Btu/h. (16) The entire system is powered by a 12V DC battery pack that draws up to 6 amps. The final part of the unit, the controller, controls the fire. (16) The controller has settings for a Class A, B, or C fire. For each setting, the fire can be assigned a difficulty ranging from 1 to 4, with 1 being the easiest and 4 the hardest. (16)

Figure 6: BullEx ITS Activated

The system has five safety features that prevent accidental injury to the participant or trainer.

1. The controller has an emergency stop/deadman switch on the controller. The switch needs to be fully depressed and held for the system to run. If the switch is released or controller disconnected while testing, the system will immediately shut off. (16)
2. A bump/tilt sensor. If the system is no longer level, the unit will issue a loud beep and will need user input to reset the system. (16)
3. An auto-ignition pilot light that continuously sparks until there is ignition. (16)
4. An auto-off after 25 seconds of full-flame evolution. (16)
5. The system cannot be started unless a key-code entry is entered at start up. If an incorrect code is entered, the system will force the user to reassemble the unit before allowing the code to be input again. (16)

2.3 BullEx Smart Extinguishers

BullEx Smart Extinguishers are training extinguishers used to deploy agent on the controlled propane fire. The extinguisher comes in a variety of sizes to represent different types of fire extinguishers. The fire extinguishers are differentiated by how many discharges it has before refilling. This is marked either by 5X or 7X, standing for five or seven discharges before refilling respectively. (16) 5X extinguishers are filled with four liters of water. 7X extinguishers need six liters of water. All extinguishers are filled with 100 PSI of regular air. (16) This is marked by the Schrader valve on the extinguisher. The extinguishers have approximately 15 seconds of discharge time of the agent before the pressure inside the extinguisher is too low. (15)

BullEx Smart Extinguishers mimic actual fire extinguishers in their size, shape, and weight. Most fire extinguishers can be described as metal cylinders filled with an agent to be deployed at high pressure on a fire. The agent is deployed from the extinguisher by the depression of the lever, allowing the pressurized air and water to escape (13).

Figure 7: BullEx Smart Extinguisher filled and ready for use.

3.0 Methods

This section details the study methodologies used for selecting participants, setting up the BullEx ITS, conducting the experiments, recording on each of the four aspects, and surveying the participants after the trials. The methods used during the study are discussed by topic. The *Participant Selection* section details information on the types of participants selected in the study. The *Set Up* section provides information concerning the materials used on how the BullEx system was set up in the WPI Fire Lab and EKU test site. *The Experiment* describes how the trials were carried out along with information defining the four aspects of fire extinguishers and their variables. Finally, the *Survey* details the final steps of experiment and how the survey was administered. A copy of the survey form given to participants can be found on page 18.

3.1 Participant Selection

The most effective way to test an amateur's ability to operate a fire extinguisher is to use a random sample of the population near the testing site. For WPI, the testing site is located in Higgins Laboratory in Worcester, MA WPI's random sampling of the population consisted of a diverse group of participants, including undergraduate and graduate students, faculty and staff at WPI. At EKU, the sample came from faculty and staff only employed at EKU's main campus in Richmond, KY, as well as the remote campuses in Corbin, Manchester, and Danville, KY.

3.2 Set Up

The BullEx ITS testing protocol set up was duplicated at both investigating locations, save for the type of location itself. At WPI, the location was in the WPI Fire Labs. The test areas for EKU's data collection mimicked the set up as described below, but occurred at several locations consisting of the main and several remote campuses. An outdoor location at the site of each EKU test was chosen to provide protection from wind gusts and vehicular traffic.

The complete system was assembled and disassembled following the BullEx guidelines. The BullEx ITS unit was placed in the middle of the identified test area free of any debris or unassociated items. To one side of the unit, a gas source and power source was located. There was a distance of at least four feet between the system and any object, wall or bench.

Two Bull-Ex Smart Extinguishers 7x were placed 10 feet away from the front of the propane training system. Each extinguisher was filled with six liters of water and pressurized to 100 PSI.

After the BullEx ITS base unit was placed in the center of the test areas, the quick-connect propane hose was connected to the rear of the ITS base unit. The other end of the hose was attached to the propane tank. The male end of the black controller cable was inserted into the ITS, and the female end inserted into the handheld controller. The yellow power cable was inserted into the rear of the ITS base unit. The other end of the power cable was inserted into the 12 V battery pack. The battery pack had an industrial-grade extension cable inserted into the battery pack and wall circuit. The ITS unit was leveled by adjusting the position and adjustable feet. The unit was then filled with water until it overflowed the overflow cut-outs. The sensor guard was then removed and placed eight feet away in front of the unit. The propane valve was opened and soapy water solution was added on all connections on the propane hose and unit to check for leaks.

The head assemblies of the BullEx Smart Extinguishers were removed and placed gently on the table to prevent damage. Six liters of water were measured out and slowly added into the fire extinguisher. The head assemblies were then placed back inside the fire extinguisher and screwed on hand-tight. They were carried to the air pressure valve and filled with 100 PSI or until no sound of filling was heard. This was marked by the sound of no rushing bubbles inside the fire extinguisher. The single metal pin was inserted into the tank so that the loop was beside the valve. The pin was perpendicular to the floor when the BullEx plastic break-away tamper tab was inserted around the top part of the handle and tightened so the pin could not move freely. The extinguisher was placed off to the side one foot away from where the participant was asked to stand.

The startup sequence was entered into the controller and the ITS was started up to make sure all systems were working on a setting of Class A Level 2. The system ran for 15 seconds before the switch was let go and testing could begin.

3.3 The Experiment

WPI and EKU employed the same experimental procedure and data-recording procedure. This was achieved by common test protocol and data-collection spreadsheet. Each participant was provided a date and a location for the test. When participants arrived, they were directed to read through the Institutional Review Board Approved Informed Consent Agreement for Participation. After they reported that they fully understood the form and signed it, they were given a safety briefing. Only one participant was permitted in the testing area at a time. For Trial 1, the participant stood 10 feet away from the system and was read a short introduction to the study and what to do:

> Hello, today you are participating in our study on fire extinguishers. There is a fire extinguisher to your left (POINT TO BULLEX EXTINGUISHER). We will be remotely lighting the fire. When you see the flames from the BullEx ITS (POINT TO BULLEX ITS), we will ask you to grab the extinguisher and use it to extinguish the fire we have created. Please stay behind the safety line at all times (Point at safety line). There is a label on the extinguisher to answer any questions. We are now ready to start the study. The BullEx System takes a few seconds to warm up so I will give you a verbal “Go” when you may look at the fire extinguisher and use it to extinguish the fire to the best of your abilities.

The area was checked once more to ensure the safest possible testing environment. After pressing down the BullEx ITS ignition key, the fire lit and the investigator gave a verbal “Go” when the fire reached full intensity. Two stopwatches were used to record the pre-discharge time and the total time it took to discharge agent. At any time, the test was stopped when the subject stopped discharging agent, the fire extinguisher ran out of compressed air, or there was a safety violation.

In this experiment, the BullEx ITS worked as a constant test source, as it was able to reproduce the same intensity fire for every simulation. When the BullEx ITS had reached full flame evolution or intensity, the system emitted a beep and began recording time until extinguishment. When the beep was heard by the investigator, he/she gave the verbal "Go." The ITS continued to simulate a Class A fire until the participant was able to extinguish the simulated fire. For a participant to extinguish the fire, the water spray from the Smart Extinguisher would be recognized as an acoustic signature by the BullEx ITS. Depending on the signature made by the water spray, the system would be able to understand the trajectory of the agent and vary the heights of the flames by metering the flow of propane. The fire was considered extinguished when the controller displayed an extinguishment time.

The participants were observed and measured on the two main questions posed at the start of this paper. The two main questions can be broken down into four aspects, each with a set of variables.

3.3.1 Usage

Percent Discharged: The percentage of subjects who were able to expel the agent onto the simulated fire.

Pre-Discharge Time: The time from when the subject was told to start until the time when the agent was discharged from the fire extinguisher, measured in seconds. This time involves the subject picking up the fire extinguisher, reading the label if he/she choose to do so, breaking the seal, removing the pin, and applying pressure to the level to expel the agent.

Read the Label: The percentage of subjects who read the label of the fire extinguisher before or during the individual trial.

3.3.2 Technique

Percent Aimed at Base of the Fire: The percentage of subjects who consistently aimed at the base of the fire as they discharged agent.

Swept Back and Forth: The percentage of subjects that used a proper sweeping motion when applying agent to the fire. The proper sweeping motion is detailed as a moderate sweep of the agent across the entire fire from both left to right or right to left and back again.

Continued to Apply Agent: The percentage of subjects that continued to apply agent after the fire was no longer visible and the BullEx ITS indicated extinguishment.

3.3.3 Safety

Stood a Safe Distance Away from the Fire: The percentage of subjects that did not cross the eight-feet safety line.

Back to Fire: The percentage of subjects who physically turned their backs to the fire. This is measured by observing the subject and noting whether their shoulders were parallel with the sides of the BullEx ITS.

3.3.4 Extinguishment Simulation

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.

3.4 Survey

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%

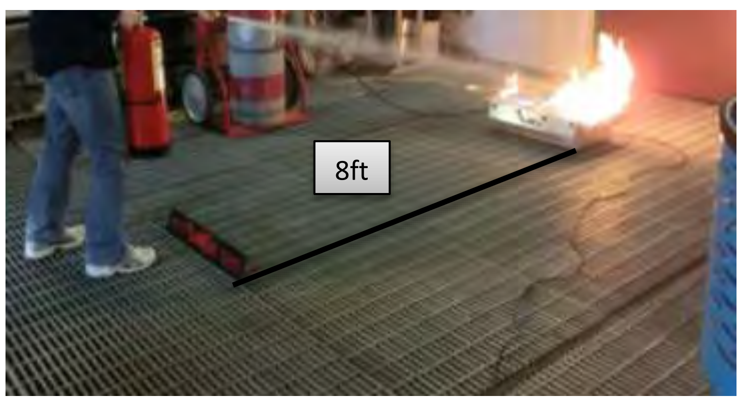

Figure 16: Participant standing just over 8ft away from the BullEx ITS

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