EVALUATION OF DRAFTSTOPPING WITHIN TYPE V COMBUSTIBLE CONCEALED ATTIC SPACES

Prepared for:

Florida Building Commission
and
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1. EXECUTIVE SUMMARY

The University of Florida has contracted Koffel Associates, Inc., on behalf of the Florida Building Commission, to evaluate attic draftstopping for the State of Florida in relation to the International Building Code (IBC). This evaluation will focus on the applicable code requirements, installation practices, and firefighting provisions.

This version of the report is for a pre-final submission on June 2, 2014. This report is now 100% complete.

2. PROJECT SCOPE

The scope of this project is to evaluate draftstopping in concealed combustible attic spaces. Draftstopping is required in concealed spaces in Type V (combustible) construction to subdivide attic spaces. Draftstopping (draftstop) is defined by the International Building Code as: "a material, device or construction installed to restrict the movement of air within open spaces of concealed areas of building components such as crawl spaces, floor/ceiling assemblies, roof/ceiling assemblies and attics."

The primary focus of the evaluation will be Group R-2 (apartments). Requirements pertaining to Group R-1 (hotels) and other use groups will also be discussed. When of Type V construction, Group R-2 buildings are typically limited to two to five stories in height depending on the type of construction.

The evaluation will consist of three components, which include a literature review, field assessment, and gap assessment. The literature review will include a review of current code requirements, code history, non-IBC approaches, technical literature, incident data, and firefighting challenges. The field assessment includes observations from a five-day field survey to verify both existing buildings and buildings under construction. The gap assessment will determine if additional information is required to complete the evaluation.

The scope was limited strictly to reviewing the attic draftstopping provisions of the codes. However, other code requirements will be discussed, as necessary, such as sprinkler protection, fire alarm, and penetration protection.

2.1 Special Consideration

The field assessment was conducted in the greater Orlando area as arranged by volunteers on behalf of the Florida Building Commission. This field assessment could leave the volunteers and the facilities evaluated open for scrutiny by the Florida Building Commission or local fire marshals. Thus, in this report, Koffel Associates, Inc. has kept any items observed generic and without reference to the facility's name when discussing the field assessment. Koffel Associates will maintain confidentiality throughout this project.

Koffel Associates has noted all major items observed to the owner of the facility. Our surveys do not relieve the Owner of responsibility for compliance with the requirements of the applicable codes, whether observed by us or not. The Owner is still solely responsible for code compliance.

3. CODE REFERENCES

The following codes and standards are used for this analysis:

- International Building Code (IBC), 2012 Edition
- Florida Building Code (FBC), 2010 Edition
- NFPA 13, Standard for the Installation of Sprinkler Systems, 2010 Edition
- NFPA 13R, Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies, 2010 Edition
- NFPA 13R, Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies, 2013 Edition
- NFPA 72, National Fire Alarm and Signaling Code, 2010 Edition

The primary reference of this evaluation will be the IBC, 2012 Edition, as Florida will use this code as the basis for the next edition of their building code. Note that the IBC and FBC are very similar. Any differences between the codes related to the code requirements addressed herein will be noted.

All terminology used in this report will be as defined by the IBC. For example, draftstopping can also be referred to as "draft stop," "fire block," or "fire stop." These other terms may be common in the field, but the code has different definitions for this terminology. In addition, this terminology has changed over time and is present in the legacy codes.

4. LITERATURE REVIEW

The literature review includes an analysis of current code requirements, code history, non-IBC approaches, technical literature, incident data, and firefighting challenges. Each item is discussed in the sections below.

4.1 Current Code Requirements

The current code requirements for attic draftstopping are in IBC Section 718.4. Draftstopping is required as summarized below for combustible attics:

- Group R-2
  - Required if three or more dwelling units
  - Draftstopping must be installed to subdivide concealed combustible attic spaces into areas not exceeding 3,000 sq ft or above every two dwelling units, whichever is smaller
    - Where a corridor also serves as a dwelling unit separation, draftstopping is only required above one of the corridor walls.
- Group R-1
  - Required in all buildings
  - Draftstopping must be installed in line with dwelling units

        - Where a corridor also serves as a dwelling unit separation, draftstopping is only required above one of the corridor walls.
- Other Groups
    - Required in all buildings
    - Draftstopping must be installed to subdivide concealed combustible attic spaces into areas not exceeding 3,000 sq ft

Draftstopping materials must comply with the following:

- Must extend to the underside of the roof sheathing
- Draftstopping materials must not be less than
    - 0.5-inch gypsum board
    - 0.375-inch wood structural panel
    - 0.375-inch particleboard
    - 1-inch nominal lumber
    - cement fiberboard
    - batts or blankets of mineral wool or glass fiber
    - other approved materials adequately supported.
- The integrity of draftstops must be maintained.
- Openings in the partitions must be protected by self-closing doors with automatic latches.

Per the IBC Commentary, draftstopping in attics is required for the following reasons:

- It is intended to separate the buildings horizontally
- It acts as a barrier to smoke and gases
- It is designed to prevent considerable damage from fire spread.

4.2 Penetrations and Joints

There are currently no specific requirements for the draftstopping to be provided with penetration or joint protection. This protection includes through-penetration firestop systems, approved fire-resistant joint systems, or some other approved means. The draftstopping must only be constructed tight to the roof and the integrity needs to be maintained.

4.3 Sprinkler Protection

Draftstopping is not required if the attic is protected by an approved, supervised automatic sprinkler system. Per IBC Section 903.2.8, a sprinkler system must be provided in all Group R fire areas. An NFPA 13R sprinkler system is allowed per IBC Section 903.3.1.2. NFPA 13R does not require sprinklers to be installed in concealed combustible spaces, including attics. Thus, attics in Type V construction are not typically sprinkler protected and still require draftstopping, even if sprinklers are provided in the apartment units below as allowed by NFPA 13R.

Note that NFPA 13 requires most combustible concealed spaces to be sprinkler protected. However, NFPA 13 is not required to be applied to Group R buildings of four stories or less, or five-level pedestal buildings as discussed below.

4.4 Pedestal Buildings

Based on IBC Table 503 with the sprinkler modifications of IBC Section 504.2, Type VB construction (non-rated) allows Group R-2 buildings of three stories in height and Type VA construction (1-hr rated) allows four stories. Additionally, IBC Section 510.4 allows a Group S-2 parking garage beneath Group R if the parking garage is open or constructed of Type I (noncombustible) construction. Thus, a Type VA building is allowed to have five levels and still be classified as four stories in height because of the following:

- 510.4 Parking beneath Group R. Where a maximum one story above grade plane Group S-2 parking garage, enclosed or open, or combination thereof, of Type I construction or open of Type IV construction, with grade entrance, is provided under a building of Group R, the number of stories to be used in determining the minimum type of construction shall be measured from the floor above such a parking area. The floor assembly between the parking garage and the Group R above shall comply with the type of construction required for the parking garage and shall also provide a fire-resistance rating not less than the mixed occupancy separation required in Section 508.4.
- The FBC does make one modification to include: "The number of stories to be used in determining the height in stories in accordance with Section 903.2.11.3 shall include the parking garage as a story."

This type of arrangement is commonly referred to as a "pedestal" building.

4.4.1 Sprinkler Protection for Pedestal Buildings

An NFPA 13R sprinkler system only applies to four-story buildings. However, with Type VA construction and a pedestal arrangement, an NFPA 13R system can still be used in a five-level pedestal building as the building height is classified as being four stories. Additionally, all editions of NFPA 13R evaluated for this project include Paragraph A.1.1 which reads:

> *"The height of a building above grade plane is determined by model building codes, which base the height on the average height of the highest roof surface above grade plane. For further information on the building height story limits, see model building codes."*

Additionally, the commentary and Handbook of the 2013 Edition of NFPA 13R supports that the pedestal does not count as a story. *NFPA 101®*, The *Life Safety Code®*, Chapter 4 also supports that the pedestal does not count as a story.

NFPA 13R is based on testing that has demonstrated the ability of residential sprinkler systems to control fires that have growth rates similar to those involving residential furnishings. NFPA 13R was limited to Group R occupancies in four-story buildings because fire burns upward much faster than it burns horizontally. The four-story limit was selected by the Committee as a reasonable limit given the types of Group R occupancies already in existence, such as garden apartments. The Committee also chose the four-story criteria due to firefighting access provision and as this was the height at which standpipe systems were typically required by the building code.

Thus, there is precedence to allow five-story pedestal buildings with NFPA 13R sprinkler protection and no sprinkler protection in the attics. Draftstopping is also still required in the attic.

4.4.2 Fire Alarm

IBC Section 907.2.9 sets the requirements for fire alarm systems in Group R-2 occupancies. All fire alarm systems must be in accordance with NFPA 72. A manual fire alarm system is typically required if a sleeping unit is located three or more stories above the lowest level of exit discharge, a sleeping unit is located one or more stories below the highest level of exit discharge, or the building contains more than 16 dwelling units. The manual fire alarm system is not required if the building is sprinkler protected to NFPA 13 or NFPA 13R.

Smoke alarms are also required in the following locations:

- On the ceiling or wall outside of each separate sleeping area in the immediate vicinity of bedrooms
- In each room used for sleeping purposes
- In each story within a dwelling unit, including basements but not including crawl spaces and uninhabitable attics

These smoke alarms are required to be interconnected within the dwelling unit. However, connection to the main fire alarm system is not required.

4.4.3 Maintenance

There are currently no specific requirements for inspection, testing, or maintenance of draftstopping at the time of construction or in an existing building. There are only generic requirements for it to be kept in place.

4.5 Legacy Code History

The requirement for draftstopping appeared in the 1927 Edition of the Uniform Building Code (UBC), which was also the first edition of the code. The UBC was published by the International Council of Building Officials (ICBO). This edition required the following:

- "All attic spaces or spaces between ceiling and the underside of roofs shall be divided into horizontal areas of not more than twenty-five hundred (2,500) square feet with tight one-inch (1") partitions of matched wood or of approved incombustible materials. All openings through these partitions shall be protected by self-closing doors of the same thickness and materials as the partition."

The requirement exists in the current edition of the IBC. However, the UBC changed the area to 3,000 sq ft in 1970. Various clarifications on the construction materials also changed between the editions.

The other two legacy codes were the Standard Building Code by the Southern Building Code Congress International (SBCCI) and The BOCA National Building Code by the Building Officials and Code Administrators International (BOCA). Note that the BOCA National

Building Code was originally the BOCA Basic Building Code before the rights to use the "National Building Code" was acquired by BOCA. These codes had requirements that were almost exactly the same as the UBC and have been in the codes since the first editions.

See Appendix A for copies of the legacy codes.

4.5.1 Basis for the Legacy Code Requirements

There is currently no documented basis for the legacy code requirements. The 1971 Edition of Fire Protection through Modern Building Codes, by the American Iron and Steel Institute, provides the best explanation of these requirements. In addition to discussing how draftstopping is intended to separate the building horizontally, the following concepts are discussed:

- Almost any size opening will allow fire spread, since all that is necessary to transmit fire from one point to another is simply the passage of hot gases. An opening no larger than the cross section of a pencil is sufficient to permit fire-generated hot gases to move through and thus spread the fire.
- Even with good firefighting, fire and smoke are likely to be communicated through concealed spaces in the construction, especially as the internal construction cannot be fully assured.
- In Type V construction, despite protection by fire-resistive ceilings or wall finishes, there is the ever present danger of a fire originating behind the protective finish, or that enough heat will get behind the finish to ignite the combustible construction materials and thus cause fire spread.
- In the plenum area of protected wood joist floor and ceiling assemblies, temperatures, recorded less than one-half hour after the start of the standard fire test, were high enough to ignite the joists. What this means is: the interior of a fire-resistance-rated combustible floor and ceiling assembly may not only burn during the course of a fire in the space below, but it would in all probability, continue to burn, possibly unnoticed, even after openly burning material has been extinguished. This is the prime reason for draftstopping combustible wall, partition, floor, and roof constructions. By so doing, the spread of fire may be kept within circumscribed building areas.

It is possible that the original 2,500 sq ft requirement comes from old requirements of NFPA 13 for sprinkler subdivision. However, Koffel Associates could not verify this correlation. The 1922 Edition of NFPA has generic requirements for design areas and there is no reference to 2,500 sq ft.

4.5.2 Penetrations and Joints

In older buildings, it is common to find penetrations open or just stuffed with mineral wool or even combustible materials. What are not the current requirements for penetration protection, which include through-penetration firestop systems and approved fire-resistant joint systems, first started to appear in prominence in the legacy codes in the 1980's. These requirements were to address this gap in the code after some major fires of this time period, such as the Browns Ferry and MGM Grand fire in Las Vegas. The IBC, upon its first edition in 2000, started to expand on these requirements. In the current IBC, penetration protection and joint system protection must now be applied to fire-resistance rated building elements, such as fire walls, fire

barriers, fire partitions, and shaft enclosures. However, these concepts have never applied to draftstopping throughout the code cycles.

4.6 Non-IBC Approaches

The following are some non-IBC approaches to protection of concealed combustible spaces in the United States of America:

- NFPA 13 – Concealed spaces entirely filled with noncombustible insulation do not require sprinkler protection per Section 8.15.1.2.7.
    - This concept assumes that the combustible structural members would not be exposed, thereby reducing the likelihood of ignition.
- NFPA 13 – Concealed spaces where rigid materials are used and the exposed surfaces have a flame spread index of 25 or less, and the materials have been demonstrated not to propagate fire more than 10.5 ft when tested in accordance with ASTM E 84, Standard Test Method of Surface Burning Characteristics of Building Materials, or ANSI/UL 723, Standard for Test for Surface Burning Characteristics of Building Materials, extended for an additional 20 minutes in the form in which they are installed, do not require sprinkler protection per Section 8.15.1.2.10.
- NFPA 13 – Concealed spaces in which the exposed materials are constructed entirely of fire retardant–treated wood as defined by NFPA 703, Standard for Fire Retardant-Treated Wood and Fire-Retardant Coatings for Building Materials, do not require sprinkler protection per Section 8.15.1.2.11.
- NFPA 5000 – Building materials having a flame spread index of Class A are exempted. Requires similar materials to IBC and areas not to exceed 3,000 ft^2 (280 sq m).

Some of the above items are not directly related to draftstopping. However, these items do represent methods to protect attics.

The following are some international approaches to draftstopping:

- Canada – requires separation to 3,230 sq ft (300 sq m) with similar materials to the IBC. The area may be increased to 6,460 sq ft (600 sq m) with a Class A interior finish rating.
- England (Approved Document B) – requires separation in-line with any compartmentation below up to the roof. Allows similar materials to the IBC, but does "recommend" a 30-minute rating. Lists allowed opening as follows: access doors, pipes, cables, conduits, openings with a fire damper, ducts that are fire-resisting or fitted with a fire damper.
- Sultanate of Oman – requires separation to 3,230 sq ft (300 sq m) with similar materials to the IBC. Also allows the void to be filled with a "fire prevention" material.

Most of these requirements are very similar to the current IBC requirements. A lot of the International codes mirror the American requirements.

4.7 Technical Materials

There is limited documentation available on materials and testing of draftstopping. Koffel Associates could not find any that was pertinent to this project. There are two reasons for this lack of documentation. The first reason is that the codes define the draftstopping requirements by referring to common building materials, without providing performance requirements. The other reason is that the draftstopping code requirements have under-gone very few major code changes over the years.

4.7.1 Calculated Fire Resistance

The IBC Section 722 provides calculated fire-resistance ratings for materials that have an inherent fire-resistance rating, but may not be specifically justified by documented data. Examples of these ratings are generic lightweight concrete or gypsum board. The materials allowed to serve as draftstopping materials are documented with the following calculated fire-resistance ratings:

- 0.5-inch gypsum board
  - 10 minutes from Table 722.2.1.4(2) (not Type X)
  - 25 minutes for Type X
- 0.375-inch wood structural panel
  - 5 minutes from Table 722.6.2(1)
- 0.375-inch particleboard
  - 5 minutes from Table 722.6.2(1)
- 1-inch nominal lumber
  - 20 minutes from Table 722.6.2(2)
- Cement fiberboard
  - no rating specified
- Batts or blankets of mineral wool or glass fiber
  - 15 minutes from Table 722.6.2(1) (only if part of another assembly)

These calculated fire-resistance ratings are very minimal. Note that these fire-ratings can be increased by 20 minutes if the materials above are supported by wood studs on the non-exposed sides. Most fire-resistance rated construction requires a minimum of 30-minutes.

4.7.2 Attic Sprinklers

Attic sprinklers are a type of sprinkler specifically designed to protect attic spaces. Attic sprinklers can be used instead of standard sprinklers and have been a "more recent" development in sprinkler protection. Attic sprinklers are considered special application sprinklers, allowed by NFPA 13, and are listed. A typical attic sprinkler is spaced a maximum of every 6 ft, covers a roof span up to 60 ft, and protects up to 400 sq ft. A typical attic sprinkler has a minimum operating pressure of 9.6 to 22.6 psi and a minimum flow of 13 to 38 gpm, depending on roof span and slope. These sprinklers are intended to provide superior fire protection in attic spaces and cost savings by eliminating branch line materials and the associated installation labor.

By comparison, a typical residential sprinkler has a minimum operating pressure of 7 to 16.7 psi and a minimum flow of 13 to 20 gpm, depending on area of coverage.

4.8 Incident Data

There is limited documentation available on incident data for demonstrating the effectiveness of draftstopping. Koffel Associates found very little information pertinent to this project. Most of the incident data that is available only related to attic fires. Most of this incident data did not confirm the presence or absence of draftstopping. This lack of data specifying draftstopping was present even in NFPA's National Fire Incident Reporting System (NFIRS).

These statistics also do not include information on fires that started within an occupied space and then spread into the attic. These scenarios are far more common.

Two primary sources for incident data were analyzed. One source was the Florida Division of State Fire Marshal, Bureau of Fire Prevention. The other source was the NFPA report, "Structure Fires Starting in the Attic, With and Without Automatic Extinguishing Systems, by Occupancy Type" by Marty Ahrens from September, 2013.

4.8.1 Florida Data

Appendix B contains the incident data from the Florida Division of State Fire Marshal, Bureau of Fire Prevention, from 2011 to 2013 for multifamily dwellings of three to four stories. This data indicates that most fires were started by electrical arcing or lighting strikes. These types of fires resulted in no injuries or deaths. The data indicates that fires caused by lightning strikes were costly, on the average $87,500, but rare, on the average of two per year.

The interesting item to note is that in only one of the fourteen fires were the occupants alerted by smoke detection. The code currently requires no automatic smoke detection in these spaces.

4.8.2 NFPA Data

Appendix C contains the NFPA report, "Structure Fires Starting in the Attic, With and Without Automatic Extinguishing Systems, by Occupancy Type." This report contained two sets of data, one from 2003-2011 and the other from 1980-1998.

The information in this report indicated that the fires involving sprinkler protection resulted in a 25% increase in the amount of the damage to buildings as compared to buildings without sprinkler protection for "apartment or multi-family dwelling" fires. This seems counter intuitive. Explanations include that the sprinkler protected buildings are more valuable as a whole and sprinkler water flow may cause water damage below the fire. Note that accidental activations were not included in these statistics.

This data also confirmed, as did the data from the Florida Division of State Fire Marshal, Bureau of Fire Prevention, that injuries and deaths from these types of fires are rare, even without sprinkler protection.

This NFPA incident data estimated 732 fires in attics of "apartment or multi-family dwellings" between 2003-2011, which equates to 82 fires per year. In 2012, NFPA estimated 97,000 apartment fires. Thus, attic fires represent a small percentage (less than 1%) of the fire problem in apartments.

4.9 Firefighting

There is limited documentation available on firefighting in buildings with and without draftstopping. Most of the information available only related to attic fires. Some of the views expressed in this section are opinions of personnel at Koffel Associates who have firefighting experience.

4.9.1 Firefighting with Voids in General

Fire in any type of combustible void space is difficult for firefighters, whether it be underneath the floor, through a shaft, or in the attic. Large open void spaces are inherent in combustible structures. These void spaces provide an abundance of fuel and air for a fire to grow quickly. Fuels in a void space could consist of wood joists, utilities, or even plastic products, such as PVC piping or insulation. Here are some of the dangers a void space fire may present:

- More challenging to access for manual suppression
- Hidden fire resulting in delayed detection
- Increased fuel load
- Rapid fire spread
- Accumulation of fire gases
- Increased backdraft potential
- Direct degradation to structure
- Early structural failure

4.9.2 Firefighting in Attics Fires

Void space fires can only be extinguished if the fire breaks out of the void space or the firefighters gain access to it. Standard approaches to firefighting in attics include pulling down the ceiling below or removing the roof to gain access. Standard methods for removing the roof include physically cutting a hole in the roof at or near the fire. The entire length of the roof can also be cut (known as “trench” cutting), which attempts to make a fire break in the building for the fire to vent itself. The procedures for removing both the ceiling or roof are difficult to perform and personnel resource intensive. One possible tactic is to use a piercing nozzle from an aerial apparatus directly through the roof.

Firefighters must do the work above while trying to keep the fire compartmented, which involves not cutting through fire walls, fire barriers, or draftstopping directly. Not cutting through these items is difficult as a firefighter cannot often see these items below.

The very fact that attics are high off the ground makes firefighting difficult. A standard firefighter ground ladder is 24 ft. Larger ladders between 35 and 45 ft are also available. However, in a 4-story structure of 5-level pedestal building, these ground ladders may not reach. These heights will require aerial apparatus, which if available, can often be difficult to position to access a fire.

It is difficult for firefighters to access the attics directly both due to these spaces being difficult to enter and then difficult in which to maneuver. Even if better access was provided for firefighting, the firefighters would still have to manage with balancing on the joists, low clearances, and other obstructions.

"Brannigan's Building Construction for the Fire Service," now published through NFPA, is a good source for understanding firefighting aspects of building construction. This book concurs with many of the points above. This book also discusses the chance of explosions from the buildup of hot gases, although, the frequency of these types of explosions are unknown. These explosions may or may not be caused by backdraft or flashover. This book even goes on to note that there are no testing standards for draftstopping.

5. FIELD ASSESSMENT

Koffel Associates completed the surveys for this evaluation on May 5-9, 2014. These surveys were conducted in the greater Orlando area as arranged by volunteers from the Florida Building Commission.

5.1 Overview

The following buildings of Type V construction were surveyed:

1) Seven R-2 Apartments under construction
2) Five existing R-2 Apartments
3) Two existing R-2 Hotels
4) Two existing Business buildings

An existing R-2 Hotel of Type II construction and an R-2 Apartment under construction of Type III construction were also surveyed during this work. These two buildings were only surveyed as Koffel Associates was unaware of the construction type until arriving on-site. They are included in this report as valuable information was observed.

At each R-2 Apartment property, two to three buildings were observed. A summary of our findings can be found in Appendix D and pictures can be seen in Appendix E.

5.2 Observations for Type V Construction

The following were major general observations during the surveys:

1) Plywood (wood structural panel) is the most common draftstopping material (See Pictures 01 through 03).
2) The only other draftstopping material observed was gypsum (See Pictures 04 and 05).
3) Very few of the buildings had any type of penetration or joint protection.
4) Most draftstopping was installed parallel to the trusses. The only case where it was more efficient to install perpendicular to the trusses was where each truss was installed in two sections (due to size and site constraints) and a corridor ran the entire length of the building perpendicular to the trusses (See Pictures 06 and 07).

The following were major observations for the R-2 Apartments:

1) Only 1 of the 7 buildings under construction had draftstopping that was deficient. This deficiency appeared to be from lack of details provided on the permit drawings (See Picture 08).
2) Two of the 7 buildings under construction were draftstopped along every unit separation, even though this is currently not required.
3) Five of the 7 buildings under construction had draftstopping that was aligned with the corridors or unit separation walls, rather than evenly dividing the building into 3,000 sq ft sectors.
4) All of the existing buildings were draftstopped along every unit separation, even though this was historically not required.
5) Two of the 5 existing buildings had minor deficiencies (See Pictures 10 through 12). However, these could be compensated by the fact the draftstopping was over-designed.
6) Every building surveyed had draftstopping parallel with the corridors.

The following were major observations for other uses:

1) The two existing R-2 Hotels were both sprinkler protected in the attics, though this is not required.
2) The two existing R-2 Hotels had draftstopping in the attics, though this was not required due to the sprinkler protection. However, it was not maintained in one of the properties.
3) One of 2 Business buildings was observed without draftstopping.
4) The Business building with draftstopping had major deficiencies (See Picture 13).

5.3 Observations for Other Construction Types

The existing R-2 Hotel of Type II construction had a wood truss roof. It was sprinkler protected in the attic. However, draftstopping was still provided, even though it was not required. Additionally, this draftstopping was not maintained.

The R-2 Apartment under construction is of Type III construction with exterior walls of fire-retardant-treated wood (See Picture 14). This arrangement is allowed by IBC Section 602.3. Normally, Type III buildings have non-combustible exterior walls. Type III construction with exterior walls of fire-retardant-treated wood is difficult to construct as the exterior wall must be load bearing and cannot be tied into any of the studwork internal to the building. This arrangement appeared to be constructed correctly at the property observed except for at a concrete fire wall, which would create an exterior wall (See Picture 15). The fire wall also appeared to be constructed incorrectly as it was not independent of the attached concrete parking garage.

The R-2 Apartment under construction of Type III construction also used interstitial sprinklers. This specialty type of sprinkler requires draftstopping to 1,000 sq ft per the listing of the sprinkler (See Picture 16). However, this draftstopping was deficient as it was not continuous.

5.3.1 Miscellaneous

The following items were noted during the surveys:

1) Draftstopping is often desired over unit separations to mitigate security concerns.
2) Lightning strikes can create both instantaneous fires and smoldering (slow-developing) fires (See Pictures 17 and 18).
3) Terracotta roofs appear to be common in Florida.
4) There were few properties constructed before 1990 in the region where the surveys were conducted.
5) The draftstopping was designed by the architects and approved in permit submission.
6) The contractors in the field did not attempt to modify the draftstopping in the field, even when acknowledging it was over-designed.
7) The average cost estimate for installing one 60-ft long draftstop in new construction with plywood is about $1,000. The cost for four to five draftstops in one building is about $5,000.
8) The building department is responsible for permitting and inspection of the draftstopping in the field. The building department often only inspects the draftstopping at substantial completion.
9) Fire marshals are not usually involved in permitting and not responsible for reviewing draftstopping. However, fire marshals are more likely to inspect the properties more often both during construction and during the life of the building.
10) Existing R-2 Apartment observed had high occupancy rates of 95 to 100 percent as noted by the management companies.
11) Existing R-2 Apartment observed was not aware of major work occurring in the attics, even by local utilities or cable provider, as noted by the management companies.

6. DISCUSSION

This section will discuss major items in the report.

6.1 Literature Review

The following major items should be noted of the literature review:

1) The materials currently allowed to serve as draftstopping are common building materials and have a small calculated fire-resistance rating. More robust materials could be considered.
2) NFPA 13R versus NFPA 13 sprinkler protection for five-level pedestal buildings should be clarified in the next edition of the Florida Building Code if the Florida Building Commission wants to deviate from the national code.
3) There is currently no documented basis for the legacy code requirements.
4) The requirements for penetration protection, which include a through-penetration firestop system, and fire-resistant joint systems, are “more recent” code requirements and have expanded since the first edition of the IBC. However, these concepts were never applied to draftstopping throughout the code cycles.
    a. Consideration can be given to some form of penetration and/or joint protection for draftstopping.

5) There are two possible alternates to draftstopping as documented in NFPA:
    a. NFPA 5000 exempts attics with a flame spread index of Class A.
    b. NFPA 13 does not require sprinkler protection in areas filled with noncombustible insulation or fire retardant wood.
6) International codes are very similar to the IBC requirements.
7) There is limited documentation available on materials and testing of draftstopping.
8) Attic sprinklers provide a possible solution for making attic sprinkler protection more practical and to reduce costs.
9) Incident data from the Florida Division of State Fire Marshal, Bureau of Fire Prevention, indicates that most fires were started by electrical arcing or lighting strikes.
    a. Lighting protection options could merit further research.
10) There are no requirements for automatic detection in attic spaces. Based on the incident data reviewed from the Florida Division of State Fire Marshal, Bureau of Fire Prevention, there appear to be delays in occupant notification for attic fires.
    a. Additional automatic detection options could merit further research.
11) Per NFPA incident data, attic fires represent a very small percentage of fires in apartments.
12) Fighting a fire in an attic is difficult for the fire service. Based on current construction methods, there appears to be few options to improve firefighting in attics with draftstopping.
    a. The prevalence of terracotta roofs in Florida increase difficulties in Florida. Terracotta cannot be cut by the fire department and must be removed (often with a sledge hammer) before access can be gained to the roof itself.

6.2 Field Investigation

The following major items should be noted of the field investigation:

1) The draftstopping observed was generally in excellent condition in the R-2 Apartments, except for one building under construction.
2) Ten of the 12 R-2 Apartments had draftstopping that was parallel to the trusses and/or corridors. In these cases, the draftsopping was aligned with the corridors or/and unit separation walls, rather than evenly dividing the building into 3,000 sq ft sectors.
    a. This arrangement can be considered good practice as the draftstopping can be consider an extension of the fire-resistance rated barriers below. This arrangement also makes it easier for the fire department to predict where the draftstopping will be.
3) The draftstopping observed was generally in poor condition in the Group B occupancy buildings.
4) Plywood (wood structural panel) is the most common draftstopping material.
5) Very few of the buildings have any type of penetration or joint protection.
6) Type III construction with exterior walls of fire-retardant-treated wood must be permitted and inspected carefully. This includes reviews of all structural drawings by fire protection reviewers.
7) Building officials and fire marshals should better coordinate permitting and inspection duties, which should include cross-training in disciplines.

Items 1 and 2 were not anticipated results of this evaluation. It is a general assumption that draftstopping is poorly installed and maintained. This assumption could be an exaggeration of the actual problem. Additionally, the properties surveyed had characteristics supporting good draftstopping based on that they were newer buildings, the buildings have low turn-over rates, were fully managed properties, and limited work was noted in them. This survey could result in more deficiencies in a more established and dynamic urban area. More deficiencies could be found in older buildings. Note that the oldest building surveyed was constructed in 1993. Additionally, only rented apartments were observed and no condominium units.

We did note major deficiencies in the Group B occupancy buildings, but these buildings are not in the same risk factor as Group R-2. Additionally, we observed draftstopping not being maintained in buildings in which draftstopping was installed, but not required.

6.3 Summary

Limited conclusions can be derived from this investigation. Limited information is available as only a small percentage of fires start in the attic and the draftstopping is constructed out of common building materials. Intuitively, increasing the level of draftstopping, such as providing penetration/joint protection or constructing a full 1-hr fire barrier, would increase the performance of draftstopping in a fire. However, the increase in performance may not be necessary and could be difficult to predict if the fire burns under the draftstopping.

Additionally, requiring sprinkler protection in the attics is an obvious method of mitigation. However, the cost versus just providing draftstopping is prohibitive. For example, it costs about $5,000 to install five draftstops in a typical new building. However, $5,000 is the equivalent cost for just a dry-pipe valve. In addition, consideration can be given to providing a limited sprinkler system; for example, one attic sprinkler every 3,000 sq ft. A single attic sprinkler could be considered equivalent to a water curtain. This would provide limited protection, but would provide notification of a fire in attic as attic fires are not often discovered immediately.

7. GAP ASSESSMENT

The most definitive follow-up item that could be derived from this report is for a code change to limit the materials to Type X gypsum. This code change would be based on the fire performance of Type X gypsum over the current material allowed and a minimal difference in cost. Based on the calculated fire-resistance ratings, plywood is rated for 5-minutes and Type X gypsum is rated for 25-minutes, which could represent a five-fold increase in fire performance. This additional fire performance will give the fire department additional time to respond to the fire.

Based on costs in RS Means and unit prices on building supplier websites, the installation cost of plywood versus Type X are minimal. The cost comparison even appears to favor gypsum installation. See Appendix F for RS Means cost data. These costs would also be significantly less than the cost to sprinkler protect the attics.

7.1 Other Assessments

Koffel Associates also has the following recommendations for further evaluation in order of recommended priority:

1) Prepare a code change as follows: "Draftstopping must be installed parallel to the trusses and aligned with the unit separation walls, unless provided above a corridor wall."
2) Survey any attic fires to determine if the draftstopping delays the fires.
    a. This would require a large amount of coordination with the local fire department. It may not be possible due to litigation concerns.
    b. $3,000, including expenses, for Koffel Associates to survey the building and prepare a report.
3) Research options for a limited sprinkler system in attic in lieu of draftstopping.
4) Surveying buildings in a more established and dynamic urban area. Examples would be in Miami, Tampa, and Jacksonville. This could also be coupled with surveys outside of Florida. An example would be the DC/Baltimore metro areas.
5) Research ways of mitigating lightning strike fires and whether additional protection is necessary.
6) Conduct full-scale testing of draftstopping. For example, create a 6,000 sq ft mock-up of an attic. Perform four tests to include the following scenarios: no draftstopping, with draftstopping, draftstopping with penetration/joint protection, and with limited sprinkler protection.
    a. This type of testing would be costly; approximately $100,000 per test if performed through a testing laboratory. However, there may be ways to reduce this cost.

8. CONCLUSION

We believe this report provides a comprehensive evaluation of draftstopping in Florida.

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APPENDIX A

COPIES OF LEGACY CODES

BUILDING STANDARDS

UNIFORM BUILDING CODE

1927 Edition

PREPARED BY

International Conference of Building Officials

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clearance for the piping. Where a partition containing such piping runs parallel to the floor joists, the joists underneath such partitions shall be doubled and spaced to permit the passage of such pipes and shall be bridged with solid bridging. Where plumbing, heating or other pipes are placed in or partly in a partition necessitating the cutting of the soles or plates, a metal tie not less than one-eighth (1/8) inch thick and one and one-half (1 1/2) inches wide shall be fastened to the plate across and to each side of the opening with not less than four (4) sixteen-penny (16-d.) nails.

(g) Openings in stud partitions and walls shall be framed around with double studs at each side and double headers across the top resting on the short stud at each end. The double header shall be placed on edge and shall be trussed above for all openings over four (4) feet in width or where more than two (2) studs are cut away.

(h) Wood lath, furring or framing shall be placed not less than two (2) inches from any chimney and not less than four (4) inches from the back of any fireplace.

(i) Where wood partitions and masonry walls join, bolts ten (10) inches long with two-inch by five-inch by one-fourth inch (2″ × 5″ × 1/4″) iron plate washers shall be built into the masonry wall opposite each line of fire blocking and near the top, top plate or ribbon in each partition. The projecting end of the bolt shall pierce the partition and be securely fastened thereto.

Roof Framing

Sec. 2508. (a) Valley rafters shall be not less than one and five-eighths by five and one-half inches (1 5/8″ × 5 1/2″) in size.

(b) Flashings shall be placed around all openings in and extensions of mechanical appliances or equipment through the roof.

(c) Anchors for joists and rafters shall be provided where they enter masonry walls and also where they are parallel to masonry walls as specified for joists in Section 2506 (f).

Framing Details: Trusses

Sec. 2509. (a) Wood trusses and truss framing shall have all joints accurately cut and fitted together so that each bearing is true and drawn tight to the full bearing. All such trusses shall be properly secured in place by lateral bracing.

(b) Washers of sufficient size to distribute the loads properly shall be used in connection with rods or metal members. Before a truss is loaded, the tension rods shall be well tightened.

(c) Timber trusses shall be securely anchored to the wall at points of bearing.

Fire Stops

Sec. 2510. (a) Fire stops shall be provided at all intersections of interior and exterior walls with floors, ceilings and roof in such a manner as to effectively cut off communication by fire through hollow concealed spaces and prevent both vertical and horizontal drafts.

(b) Furred walls shall have fire stopping placed immediately above and below the junction of any floor constructiion with the walls or shall be fire-stopped the full depth of the joist.

(c) All stud walls or partitions shall have a continuous row of bridging or fire stopping which shall form a complete and effective separation in the entire width of partition at that point, placed in such a manner that there shall be no concealed air spaces greater than seven (7) feet in any dimension. Fire stops shall be the full width of the studding and sufficiently stiff to act as lateral bracing for the individual studs.

(d) Stair stringers shall be fire-stopped at least once in the middle portion of each run, and shall be fire-stopped by a header beam at the top and bottom, so as to effectively prevent the passage of fire. Full width fire clocking shall be placed between studs along and in line with the run of stairs adjoining such partitions.

(e) When sliding doors are pocketed in partitions, such pockets shall be completely fire-stopped at end, sides, top and bottom.

(f) All spaces between chimneys and wood framing shall be solidly filled with refuse mortar, loose cinders or other incombustible material placed in incombustible supports.

(g) All fire-stopping as required in this Section shall be not less than two (2) inches in thickness and not less in width than the enclosed space within the partition except as provided in paragraph (f) hereof for chimneys.

(h) All attic spaces or spaces between ceilings and the underside of roofs shall be divided into horizontal areas of not more than twenty-five hundred (2500) square feet with tight one-inch (1″) partitions of matched wood or of approved incombustible materials. All openings through these partitions shall be protected by self-closing doors of the same thickness and materials as the partition.

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1970 Edition

Volume I

Attics: Access, Area Separations and Ventilation

Sec. 3205. (a) **Access.** An attic access opening shall be provided in the ceiling of the top floor of buildings with combustible ceiling or roof construction. The opening shall be located in a corridor or hallway of buildings of three or more stories in height, and readily accessible in buildings of any height.

The opening shall be not less than twenty-two inches by thirty inches (22″ x 30″).

Thirty-inch (30″) minimum clear head room shall be provided above the access opening.

Attics with a maximum vertical clear height of less than thirty inches (30″) need not be provided with access openings.

For ladder requirements see Uniform Building Code, Volume II, Mechanical.

(b) **Area Separations.** Enclosed attic spaces formed of combustible construction shall be divided into horizontal areas not exceeding 3000 square feet by partitions extending from the ceiling to the roof.

Such partitions shall be not less than one-half-inch (½″) thick gypsum wallboard, or one-inch (1″) nominal thickness tight-fitting wood, ⅜-inch thick plywood, or approved noncombustible material adequately supported.

Openings in the partitions shall be protected by self-closing doors constructed as required for the partitions.

> **EXCEPTION:** Where the entire attic is equipped with an approved automatic fire-extinguishing system, the attic space may be divided into areas not to exceed 9000 square feet.

(c) **Ventilation.** Where determined necessary by the Building Official due to atmospheric or climatic conditions, enclosed attics and enclosed rafter spaces formed where ceilings are applied direct to the underside of roof rafters, shall have cross ventilation for each separate space by ventilating openings protected against the entrance of rain and snow. The net free ventilating area shall be not less than 1/150 of the area of the space ventilated, except that the area may be 1/300 provided at least 50 per cent of the required ventilating area is provided by ventilators located in the upper portion of the space to be ventilated at least three feet (3′) above eave or cornice vents with the balance of the required ventilation provided by eave or cornice vents.

Smoke and Heat Venting

Sec. 3206. (a) **When Required.** Smoke and heat vents shall be installed in accordance with the provisions of this Section as follows:

1. In Groups G and F Occupancies over 50,000 square feet in single floor area.

2. In Group E Occupancies over 15,000 square feet in single floor area.

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such finish does not exceed 0.025 of an inch in thickness, and is applied directly to a non-combustible base.

*For interior finish and decoration for Group E, Assembly Occupancy, see Section 512.3.

SECTION 705 — FIRESTOPPING

(a) Firestopping shall be provided in all walls and partitions to cut off all concealed draft openings both horizontal and vertical, and to form an effectual fire barrier between stories and between the upper story and the roof space.

(b) Walls, including masonry walls furred with combustible material, and stud partitions shall be effectively firestopped with non-combustible material at floors, ceilings, and roofs, except in those parts of a building which are framed with wood, the firestopping may be of wood not less than two (2) inches in nominal thickness. See Section 1703.

(c) All openings around exposed pipes or power shafting shall be filled with approved non-combustible material, or shall be closed off by close-fitting metal caps at the ceiling and floor line, and on each side of a wall or partition.

(d) All openings for belts and conveyors shall be provided with approved slotted doors, or be otherwise closed off. Belts shall not pass through fire-walls.

(e) No firestopping shall be covered or concealed until inspected by the Building Official.

(f) In combustible roof construction, where ceilings or concealed spaces occur, such spaces shall be divided into horizontal areas of not more than three thousand (3,000) square feet (except one and two family dwellings) with tight partitions of non-combustible material or of approved wood construction consisting of one-half inch exterior plywood or of not less than two thicknesses of one (1) inch nominal lumber with joints broken.

(g) All openings through these partitions shall be protected by self-closing doors of approved construction meeting the partition requirements.

(h) Except in 1 and 2-family dwellings, when stairs are of wood or of combustible construction, the space between stair stringers shall be firestopped at top and bottom, and firestopping shall also be provided between studs, along and in line with run of stair adjoining such partition.

(i) Floors and roof constructed of combustible materials shall be firestopped at walls and partitions where openings occur. When wood joists run parallel to a wall, the space between the wall and the nearest joist shall be not less than two and one-half (2½) inches and shall be solidly filled with non-combustible material.

above the sidewalk. Retractable awnings shall be securely fastened to the building and shall not extend closer than twelve (12) inches from the curb line. They shall be equipped with a mechanism or device for raising and holding the awning in a retracted or closed position against the face of the building.

313.2.2 **Fixed or permanent awnings:** The clearance from the sidewalk to the lowest part of any fixed or permanent awning shall be the same as required in Section 313.2.1 for retractable awnings. Fixed or permanent awnings installed above the first story shall not project more than four (4) feet.

313.3 **Canopies:** Canopies shall be constructed of a metal framework, with an approved covering, attached to the building at the inner end and supported at the outer end by not more than two (2) stanchions with braces anchored in an approved manner and placed not less than two (2) feet in from the curb line. The horizontal portion of the framework shall be not less than eight (8) feet nor more than twelve (12) feet above the sidewalk and the clearance between the covering or valance and the sidewalk shall be not less than seven (7) feet. The width of canopies shall not exceed eight (8) feet.

313.4 **Special applications of awnings:** Rigid awnings supported in whole or part by members resting on the ground and used for patio covers, car ports, summer houses or other similar uses shall comply with the requirements of Section 313.5 for design and structure. Such structures shall be braced as required to provide rigidity.

313.5 **Design and construction:** Fixed awnings, canopies and similar structures shall be designed and constructed to withstand wind or other lateral loads and live loads as required by Article 7 of this code with due allowance for shape, open construction and similar features that relieve the pressures or loads. Structural members shall be protected to prevent deterioration.

SECTION 314.0 SUBDIVISION OF ATTIC SPACES

314.1 **General:** The attic spaces of all buildings, except where the roof and attic are of noncombustible or fireproof construction, shall be subdivided into areas not exceeding three thousand (3,000) square feet by means of approved fire stops. When doors or other openings are provided in such subdividing partitions, they shall be of noncombustible or similarly protected materials and the construction shall be tightly fitted around all ducts or other assemblies piercing such partitions.

SECTION 315.0 TEMPORARY STRUCTURES

315.1 **General:** Pursuant to a variance granted by the board of appeals under the provisions of Section 127.0, the building official may issue a permit for temporary construction as approved by the board of appeals.

APPENDIX B

FLORIDA ATTIC FIRE INCIDENT DATA FOR MULTIFAMILY DWELLINGS

Appendix B - Florida Attic Fire Incident Data for Multifamily Dwellings of 3 to 4 Stories

Incident Data	Heat Source	Fire Cause	Total Loss	Fatalities / Injuries	Detector
1/7/2012	Electrical arcing	All Other Causes	$0	0	Did not alert occupants
8/13/2012	Electrical arcing	All Other Causes	$0	0	Did not alert occupants
8/13/2012	Electrical arcing	Exposure from Another Fire	$0	0	Did not alert occupants
8/13/2012	Electrical arcing	Exposure from Another Fire	$0	0	Did not alert occupants
8/13/2012	Electrical arcing	Exposure from Another Fire	$0	0	Did not alert occupants
8/13/2012	Electrical arcing	Exposure from Another Fire	$0	0	Did not alert occupants
4/10/2013	Lightning discharge	Natural Cause	$10,000	0	Did not alert occupants
7/21/2012	Lightning discharge	Natural Cause	$70,000	0	-
6/21/2013	Lightning discharge	Natural Cause	$115,000	0	-
8/18/2012	Lightning discharge	Natural Cause	$120,000	0	Unknown
6/30/2013	Lightning discharge	Natural Cause	$122,500	0	Alerted occupants
5/12/2012	Operating equipment	All Other Causes	$1,503,000	0	-
10/10/2012	Undetermined	All Other Causes	$0	0	-
8/23/2011	Undetermined	Natural Cause	$21,000	0	Did not alert occupants

APPENDIX C

NFPA ATTIC FIRE REPORT

Structure Fires Starting in the Attic, With and Without Automatic Extinguishing Systems, by Occupancy Type

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September 2013

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Acknowledgements

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We are also grateful to the U.S. Fire Administration for its work in developing, coordinating, and maintaining NFIRS.

Keywords:

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.

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NFPA Index No. 1990-REV

Structure Fires Starting in the Attic, With and Without Automatic Extinguishing Systems, by Occupancy Type

This analysis contains four tables intended to provide reasonably comparable estimates of fires in sprinklered and non-sprinklered attics over two different time periods. National estimates were derived from the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS) and NFPA's annual fire department experience survey. Due to changes in the data definitions and reporting instructions in NFIRS, caution must be used in comparing data from the two periods.

Tables 1 and 2 show estimated annual averages for non-confined structure fires (NFIRS incident type 110-129, excluding incident types 113-118) that began in the attic or vacant crawl space above the top story (NFIRS area of origin 74), by occupancy type, or in NFIRS terms, property use. The NFIRS 5.0 *Complete Reference Guide* notes that this area of origin includes cupolas, concealed roof/ceiling spaces, and steeples. Most NFIRS reports today are entered directly into a computer, and the Data Dictionary definition is simply "Attic: vacant, crawl space above top story." Confined and non-confined structure fires are discussed below.

Version 5.0 of NFIRS (NFIRS 5.0) was first introduced in 1999. Its usage gradually increased over the next few years. By 2003, 79% of the data in NFIRS was originally collected according to the NFIRS 5.0 rules. Estimates from the transition years of 1999-2002 are considered less stable and are not included in this analysis. The data element in NFIRS 5.0 for incident type was expanded to three digits and includes a category of structure fires collectively referred to as "confined fires." These include cooking fires confined to the vessel of origin, confined chimney or flue fires, confined trash fires, confined fuel burner or boiler fires, confined commercial compactor fires, and confined incinerator fires (incident type 113-118). Other structure fire incident types are referred to as "non-confined structure fires." Note that it is possible for the fire to be limited to the object of origin in a non-confined structure fire. Data about fire protection equipment and other casual elements are not required for the so-called "confined fires" but are sometimes provided. Because these scenarios would be unusual for this particular area of origin, these fires were excluded from the analysis.

Table 1 shows estimated averages of non-confined structure fires in properties with no automatic extinguishing systems (AES) (NFIRS AES presence = N). Table 2 shows comparable estimates for properties in which sprinklers were present (NFIRS AES presence = 1 and NFIRS type of AES = 1-3). Note that the directions in the *Complete Reference Guide* define AES presence as "the existence of an AES within the AES's designed range of a fire." The small number of fires coded as having partial systems, or initially coded as having AES present but the equipment failed because it was not in the fire area, were excluded from this analysis.

Tables 3 and 4 provide the closest comparable estimates for the 19-year period of 1980-1998, i.e., structure fires (NFIRS incident type 11) that began in the ceiling and roof assembly or concealed roof/ceiling space (NFIRS area of origin 74). Note that there is no distinction between confined and non-confined fires during this time and that the area of origin definition does NOT specifically mention attic. Table 3 shows estimated averages of structure fires in properties with no automatic

extinguishing systems (NFIRS AES performance = 8). Table 4 shows comparable estimates for properties in which AES was present, regardless of operation. (NFIRS performance = 1-3).

For all four tables, the occupancy type or property use is shown if it is a major category heading, or at least 1% of the fires occurred in or at that type of occupancy. Unclassified subcategories, such as "unclassified residential property," are not shown, even when the percent of fires exceeded 1%.

The estimates in this analysis are national estimates of fires reported to U.S. local fire departments and so exclude fires reported only to federal or state agencies or industrial fire brigades. All estimates include proportional shares of fires in which the area of origin and AES data were undetermined or not reported. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Property damage estimates were NOT adjusted for inflation. The extent of rounding was based on the number of total fires. In Table 1 and 4, fires are rounded to the nearest ten, in Table 2 to the nearest one, and in Tables 3, to the nearest hundred. Civilian deaths and injuries are rounded to the nearest one. Direct property damage is rounded to the nearest million in Tables 1 and 3 and to the nearest hundred thousand in Table 2 and 4. Sums may not equal totals due to rounding errors. See Appendix A for more details about the methodology used to calculate national estimates.

Table 1.
Non-Confined Structure Fires that Began in the Attic, Vacant Crawl Space Above the Top Story, or Concealed Roof/Ceiling Space and in which No Automatic Extinguishing System was Present by Occupancy Type
2003-2011 Annual Averages

Occupancy Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Residential property	**9,580**	**(90%)**	**26**	**(97%)**	**120**	**(93%)**	**$454**	**(83%)**
One-or-two-family home	8,600	(81%)	22	(81%)	97	(76%)	$384	(70%)
Apartment or multi-family dwelling	680	(7%)	1	(4%)	13	(10%)	$61	(11%)
Store or office property	**370**	**(3%)**	**0**	**(0%)**	**4**	**(3%)**	**$36**	**(7%)**
Office, bank or mail facility	90	(1%)	0	(0%)	1	(0%)	$11	(2%)
Grocery or convenience store	60	(1%)	0	(0%)	0	(0%)	$6	(1%)
Public assembly property	**230**	**(2%)**	**0**	**(0%)**	**1**	**(1%)**	**$36**	**(7%)**
Eating or drinking establishment	110	(1%)	0	(0%)	0	(0%)	$13	(2%)
Place of worship or funeral property	80	(1%)	0	(0%)	0	(0%)	$13	(2%)
Storage property	**200**	**(2%)**	**1**	**(3%)**	**1**	**(1%)**	**$4**	**(1%)**
Vehicle storage, garage or fire station	80	(1%)	0	(0%)	0	(0%)	$1	(0%)
Manufacturing property	**40**	**(0%)**	**0**	**(0%)**	**0**	**(0%)**	**$7**	**(1%)**
Educational property	**40**	**(0%)**	**0**	**(0%)**	**1**	**(1%)**	**$2**	**(0%)**
Special property	**30**	**(0%)**	**0**	**(0%)**	**0**	**(0%)**	**$1**	**(0%)**
Basic industry, utility or defense property	**30**	**(0%)**	**0**	**(0%)**	**0**	**(0%)**	**$3**	**(1%)**
Institutional property	**30**	**(0%)**	**0**	**(0%)**	**1**	**(0%)**	**$2**	**(0%)**
Unclassified or unknown property use	**60**	**(1%)**	**0**	**(0%)**	**0**	**(0%)**	**$2**	**(0%)**
Total	**10,620**	**(100%)**	**27**	**(100%)**	**128**	**(100%)**	**$548**	**(100%)**

Note: Sums nay not equal totals due to rounding. All major occupancy categories are shown, as are subcategories that accounted for at least 1% of the fires. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS 5.0 and NFPA survey.

Table 2.
Non-Confined Structure Fires that Began in the Attic, Vacant Crawl Space above the Top Story, or Concealed Roof/Ceiling Space in which Sprinklers were Present, by Occupancy Type
2003-2011 Annual Averages

Occupancy Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Residential property	**117**	**(49%)**	**0**	**(NA)**	**1**	**(60%)**	**$14.3**	**(52%)**
Apartment or multi-family dwelling	52	(21%)	0	(NA)	0	(24%)	$5.8	(21%)
One-or-two-family home	39	(16%)	0	(NA)	0	(23%)	$5.7	(21%)
Store or office property	**40**	**(17%)**	**0**	**(NA)**	**0**	**(27%)**	**$5.1**	**(18%)**
Office, bank or mail facility	11	(4%)	0	(NA)	0	(16%)	$3.6	(13%)
Grocery or convenience store	7	(3%)	0	(NA)	0	(0%)	$0.3	(1%)
Department store or unclassified general retail	6	(3%)	0	(NA)	0	(12%)	$0.1	(1%)
Laundry, drycleaning or professional supplies or services	4	(2%)	0	(NA)	0	(0%)	$0.5	(2%)
Specialty shop	3	(1%)	0	(NA)	0	(0%)	$0.1	(0%)
Personal service or recreational or home repair store	3	(1%)	0	(NA)	0	(0%)	$0.1	(0%)
Household goods sales or repair	3	(1%)	0	(NA)	0	(0%)	$0.1	(0%)
Textile or apparel sales	1	(1%)	0	(NA)	0	(0%)	$0.0	(0%)
Service station or vehicle sales, service or repair	1	(1%)	0	(NA)	0	(0%)	$0.3	(1%)
Public assembly property	**35**	**(15%)**	**0**	**(NA)**	**0**	**(13%)**	**$6.3**	**(23%)**
Eating or drinking establishment	24	(9%)	0	(NA)	0	(0%)	$2.5	(9%)
Place of worship or funeral property	4	(2%)	0	(NA)	0	(0%)	$0.3	(1%)
Club	4	(2%)	0	(NA)	0	(0%)	$3.4	(12%)
Library, museum, courthouse or other public property	2	(1%)	0	(NA)	0	(0%)	$0.0	(0%)
Studio or theatre	2	(1%)	0	(NA)	0	(13%)	$0.0	(0%)
Institutional property	**26**	**(11%)**	**0**	**(NA)**	**0**	**(0%)**	**$0.9**	**(3%)**
Nursing home	17	(7%)	0	(NA)	0	(0%)	$0.7	(2%)
Prison, jail or police station	2	(1%)	0	(NA)	0	(0%)	$0.0	(0%)
Clinic or doctor's office	2	(1%)	0	(NA)	0	(0%)	$0.1	(0%)
Hospital or hospice	2	(1%)	0	(NA)	0	(0%)	$0.1	(0%)
Mental retardation or substance abuse	1	(1%)	0	(NA)	0	(0%)	$0.1	(0%)
Manufacturing property	**11**	**(5%)**	**0**	**(NA)**	**0**	**(0%)**	**$0.9**	**(3%)**

Table 2. (Continued)
Non-Confined Structure Fires that Began in the Attic, Vacant Crawl Space above the Top Story, or Concealed Roof/Ceiling Space in which Sprinklers were Present, by Occupancy Type
2003-2011 Annual Averages

Occupancy Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Educational property	**6**	**(3%)**	**0**	**(NA)**	**0**	**(0%)**	**$0.0**	**(0%)**
Preschool through grade 12	3	(1%)	0	(NA)	0	(0%)	$0.0	(0%)
Adult education or college classroom	1	(1%)	0	(NA)	0	(0%)	$0.0	(0%)
Storage property	**2**	**(1%)**	**0**	**(NA)**	**0**	**(0%)**	**$0.0**	**(0%)**
Warehouse, residential or self-storage	1	(1%)	0	(NA)	0	(0%)	$0.0	(0%)
Special property	**1**	**(0%)**	**0**	**(NA)**	**0**	**(0%)**	**$0.0**	**(0%)**
Basic industry, utility or defense property	**0**	**(0%)**	**0**	**(NA)**	**0**	**(0%)**	**$0.0**	**(0%)**
Unclassified or unknown property use	**1**	**(1%)**	**0**	**(NA)**	**0**	**(0%)**	**$0.0**	**(0%)**
Total	**241**	**(100%)**	**0**	**(NA)**	**2**	**(100%)**	**$27.7**	**(100%)**

NA - Not applicable because the total is zero.

Note: Sums nay not equal totals due to rounding. All major occupancy categories are shown, as are subcategories that accounted for at least 1% of the fires. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS 5.0 and NFPA survey.

Table 3.
Structure Fires that Began in the Ceiling and Roof Assembly or Concealed Roof/Ceiling Space and in which No Automatic Extinguishing System was Present, by Occupancy Type
1980-1998 Annual Averages

Occupancy Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Residential property	**11,900**	**(72%)**	**25**	**(91%)**	**125**	**(83%)**	**$162**	**(61%)**
One- or two-family dwelling	10,600	(64%)	22	(81%)	107	(71%)	$133	(51%)
Apartment, tenement or flat	1,100	(6%)	2	(8%)	14	(9%)	$24	(9%)
Hotel, motel or inn	100	(1%)	0	(1%)	4	(3%)	$3	(1%)
Store or office property	**1,300**	**(8%)**	**0**	**(1%)**	**6**	**(4%)**	**$42**	**(16%)**
Office property	300	(2%)	0	(0%)	1	(1%)	$11	(4%)
Food or beverage sales	200	(1%)	0	(1%)	1	(1%)	$7	(2%)
Motor vehicle or boat sales or services	200	(1%)	0	(0%)	1	(1%)	$3	(1%)
Specialty shop	100	(1%)	0	(0%)	0	(0%)	$2	(1%)
Household goods sales or repairs	100	(1%)	0	(0%)	0	(0%)	$4	(2%)
Recreation, hobby or home repair supply sales or personal services	100	(1%)	0	(0%)	1	(0%)	$3	(1%)
General item store	100	(1%)	0	(0%)	0	(0%)	$3	(1%)
Special property	**900**	**(5%)**	**0**	**(0%)**	**3**	**(2%)**	**$5**	**(2%)**
Construction or unoccupied property	700	(4%)	0	(0%)	2	(1%)	$4	(2%)
Storage property	**800**	**(5%)**	**1**	**(2%)**	**4**	**(3%)**	**$10**	**(4%)**
Vehicle storage	300	(2%)	0	(1%)	2	(1%)	$2	(1%)
Agricultural product storage	300	(2%)	0	(0%)	1	(1%)	$3	(1%)
Unclassified or unknown-type storage property	100	(1%)	0	(1%)	1	(0%)	$1	(0%)
General item storage	100	(1%)	0	(0%)	0	(0%)	$2	(1%)
Public assembly property	800	(5%)	1	(2%)	6	(4%)	$24	(9%)
Eating or drinking establishment	500	(3%)	0	(1%)	3	(2%)	$12	(5%)
Place of worship or funeral parlor	200	(1%)	0	(1%)	1	(1%)	$6	(2%)
Manufacturing	300	(2%)	0	(0%)	2	(2%)	$9	(3%)
Metal or metal product manufacture	100	(1%)	0	(0%)	1	(1%)	$2	(1%)

Table 3. (Continued)
Structure Fires that Began in the Ceiling and Roof Assembly or Concealed Roof/Ceiling Space and in which No Automatic Extinguishing System was Present, by Occupancy Type
1980-1998 Annual Averages

Occupancy Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Basic industry, utility or defense property	**200**	**(1%)**	**0**	**(0%)**	**1**	**(1%)**	**$3**	**(1%)**
Agriculture	100	(1%)	0	(0%)	1	(0%)	$2	(1%)
Educational property	**100**	**(1%)**	**0**	**(0%)**	**1**	**(0%)**	**$6**	**(2%)**
Non-residential school through grade 12	100	(1%)	0	(0%)	1	(0%)	$5	(2%)
Institutional	**100**	**(1%)**	**0**	**(1%)**	**1**	**(1%)**	**$1**	**(0%)**
Unclassified or unknown-type property use	**100**	**(1%)**	**1**	**(2%)**	**0**	**(0%)**	**$2**	**(1%)**
Total	**16,600**	**(100%)**	**27**	**(100%)**	**150**	**(100%)**	**$264**	**(100%)**

Note: Sums nay not equal totals due to rounding. All major occupancy categories are shown, as are subcategories that accounted for at least 1% of the fires. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

Table 4.
Structure Fires that Began in the Ceiling and Roof Assembly or Concealed Roof/Ceiling Space
And in which Some Type of Automatic Extinguishing Equipment was Present, by Occupancy Type
1980-1998 Annual Averages

Occupancy Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Manufacturing	**200**	**(32%)**	**0**	**(NA)**	**3**	**(38%)**	**$5.8**	**(44%)**
Metal or metal product manufacture	70	(11%)	0	(NA)	2	(19%)	$0.4	(3%)
Wood, furniture or paper manufacture or printing	50	(8%)	0	(NA)	0	(2%)	$0.8	(6%)
Food manufacturing	20	(2%)	0	(NA)	0	(1%)	$0.8	(6%)
Chemical, plastic or petroleum manufacturing or processing	10	(2%)	0	(NA)	0	(2%)	$3.3	(25%)
Textile manufacture	10	(2%)	0	(NA)	0	(1%)	$0.1	(1%)
Vehicle assembly or manufacture	10	(2%)	0	(NA)	0	(5%)	$0.0	(0%)
Unclassified or unknown-type manufacturing property	10	(2%)	0	(NA)	0	(0%)	$0.0	(0%)
Other manufacturing	10	(1%)	0	(NA)	0	(4%)	$0.3	(2%)
Footwear, wearing apparel, leather or rubber manufacture	10	(1%)	0	(NA)	0	(4%)	$0.0	(0%)
Store or office property	**160**	**(25%)**	**0**	**(NA)**	**1**	**(13%)**	**$2.2**	**(16%)**
General item store	40	(6%)	0	(NA)	1	(8%)	$0.4	(3%)
Food or beverage sales	30	(5%)	0	(NA)	0	(1%)	$0.3	(2%)
Office property	30	(5%)	0	(NA)	0	(1%)	$0.5	(4%)
Textile or wearing apparel sales	10	(2%)	0	(NA)	0	(0%)	$0.4	(3%)
Specialty shop	10	(2%)	0	(NA)	0	(0%)	$0.1	(1%)
Household goods sales or repairs	10	(2%)	0	(NA)	0	(0%)	$0.2	(1%)
Professional supply sales or services	10	(1%)	0	(NA)	0	(0%)	$0.0	(0%)
Motor vehicle or boat sales or services	10	(1%)	0	(NA)	0	(4%)	$0.1	(1%)
Recreation, hobby or home repair supply sales or personal services	0	(1%)	0	(NA)	0	(0%)	$0.0	(0%)
Public assembly	**60**	**(10%)**	**0**	**(NA)**	**1**	**(9%)**	**$1.2**	**(9%)**
Eating or drinking establishment	40	(7%)	0	(NA)	1	(6%)	$1.0	(7%)
Club	10	(1%)	0	(NA)	0	(1%)	$0.1	(0%)
Institutional property	**60**	**(10%)**	**0**	**(NA)**	**2**	**(23%)**	**$0.4**	**(3%)**
Care of the aged	40	(6%)	0	(NA)	1	(16%)	$0.2	(2%)
Care of the sick or injured	20	(3%)	0	(NA)	1	(7%)	$0.0	(0%)

Table 4. (Continued)

Structure Fires that Began in the Ceiling and Roof Assembly or Concealed Roof/Ceiling Space And in which Some Type of Automatic Extinguishing Equipment was Present, by Occupancy Type 1980-1998 Annual Averages

Occupancy Type	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Residential property	**50**	**(8%)**	**0**	**(NA)**	**0**	**(5%)**	**$1.2**	**(9%)**
One- or two-family dwelling	30	(4%)	0	(NA)	0	(2%)	$0.4	(3%)
Apartment, tenement or flat	10	(2%)	0	(NA)	0	(0%)	$0.4	(3%)
Hotel, motel or inn	10	(1%)	0	(NA)	0	(4%)	$0.3	(3%)
Storage property	**30**	**(6%)**	**0**	**(NA)**	**0**	**(4%)**	**$1.7**	**(13%)**
General item storage	20	(3%)	0	(NA)	0	(1%)	$0.6	(4%)
Wood or paper product storage	10	(1%)	0	(NA)	0	(2%)	$0.3	(3%)
Educational property	**20**	**(3%)**	**0**	**(NA)**	**0**	**(4%)**	**$0.1**	**(1%)**
Non-residential school through grade 12	10	(2%)	0	(NA)	0	(0%)	$0.0	(0%)
Basic industry, utility or defense property	**10**	**(2%)**	**0**	**(NA)**	**0**	**(1%)**	**$0.3**	**(2%)**
Non-metallic mineral or mineral product manufacture	10	(1%)	0	(NA)	0	(1%)	$0.0	(0%)
Special property	**10**	**(2%)**	**0**	**(NA)**	**0**	**(0%)**	**$0.1**	**(1%)**
Construction or unoccupied property	10	(2%)	0	(NA)	0	(0%)	$0.1	(1%)
Unclassified or unknown-type property use	10	(1%)	0	(NA)	0	(1%)	$0.1	(1%)
Total	630	(100%)	0	(NA)	8	(100%)	$13.1	(100%)

Note: Sums nay not equal totals due to rounding. All major occupancy categories are shown, as are subcategories that accounted for at least 1% or 10 of the fires (rounded to the nearest ten). Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire.

Source: NFIRS and NFPA survey.

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.

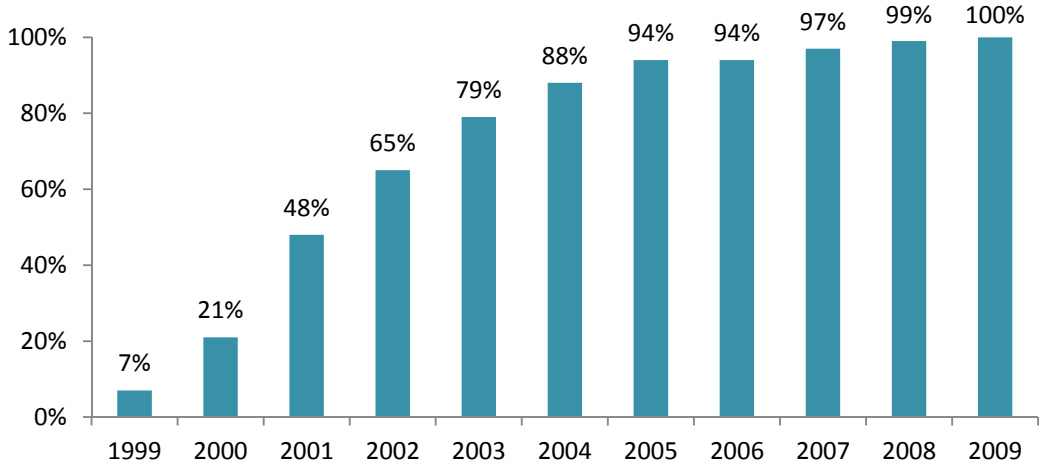
Scaling ratios are obtained by comparing NFPA's projected totals of residential structure fires, non-residential structure fires, vehicle fires, and outside and other fires, and associated civilian deaths, civilian injuries, and direct property damage with comparable totals in NFIRS. Estimates of specific 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:

NFPA survey projections
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 D

SURVEY SUMMARY TABLE

Appendix D - Survey Summary Table															
#	Age	Year	Primary Occupancy	Use	Other Uses	Stories	Sprinkler System	Draftstopping Required	Draftstopping Provided	Draftstopping Material	Arrangement	Orientation to Trusses	Deficiencies	Penetration Protection	Joint Protection	Notes
1	New	-	R-2	Apartment	-	3	NFPA 13R	Yes	Yes	Plywood	One split at each corridor and a split at every unit separation.	Parallel and Perpendicular	None	None	None	-
2	New	-	R-2	Apartment	-	3	NFPA 13R	Yes	Yes	Plywood	Split into 4 sectors, one on each end of the building with the middle portion split in half perpendicularly to the trusses	Parallel and Perpendicular	None	Firestopped	Fire Jointed	-
3	New	-	R-2	Apartment	-	4	NFPA 13R	Yes	Yes	Plywood	Along the corridor	Perpendicular	None	None	None	Each truss was over 60 ft long and placed in two sections. The draftstopping was installed between the two sections. The trusses were also in two sections due to site constraints and the ability of a crane to lift them in place.
4	New	-	R-2	Apartment	-	2	NFPA 13R	Yes	Yes	Plywood	At every unit separation	Parallel	None	None	None	Buildings had no corridors. All units were accessible from the exterior.
5	New	-	R-2	Apartment	Parking - Ground Floor	3	NFPA 13R	Yes	Yes	Plywood	One split at each corridor and every 2 units.	Parallel	None	None	None	-
6	New	-	R-2	Apartment	Retail - Ground Floor	3	NFPA 13R	Yes	Partial	Mostly plywood with some gypsum	Split into 4 equal sectors of 2,800 sq ft	Parallel	1) stops about 2 feet from attic floor 2) Has access openings cut with no self-closing doors	None	None	The permits plans had no draftstopping details.
7	New	-	R-2	Apartment	-	4	NFPA 13R	Yes	Yes	Plywood	One split at each corridor and every 2 units.	Parallel	None	None	None	This property was not surveyed, but the installation was discussed with the contractors.
8	Existing	1998	R-2	Apartment	-	3	NFPA 13R	Yes	Yes	Plywood and Gypsum	At every corridor wall and unit separation wall	Parallel	None	Firestopped	None	-
9	Existing	2001	R-2	Apartment	-	3	NFPA 13R	Yes	Yes	Plywood and Gypsum	At every corridor wall and unit separation wall	Parallel	None	None	None	-
10	Existing	2002	R-2	Apartment	-	3	NFPA 13R	Yes	Yes	Plywood	At every corridor wall and unit separation wall	Parallel	None	None	None	-
11	Existing	1993	R-2	Apartment	-	2	NFPA 13R	Yes	Yes	Gypsum	At every unit separation	Parallel	Damaged in one location only (has fallen out of place)	None	None	Buildings had no corridors
12	Existing	1996	R-2	Apartment	-	3	NFPA 13R	Yes	Yes	Gypsum	At every corridor wall and unit separation wall	Parallel and Perpendicular	1) Was not continuous around part of a roof at one location 2) Was not installed down into a ceiling soffit	Mud and Taped	Mud and Taped	Had minor deficiencies but was over designed and had penetration/joint protection
13	Existing	1998	R-2	Hotel	-	5	NFPA 13	No	Mostly	Plywood	Split into equal sectors of approximately 3,000 sq ft	Parallel	n/a	Yes	None	-
14	Existing	2000	R-2	Hotel	-	3	NFPA 13	No	Mostly	Plywood	Split into equal sectors of approximately 3,000 sq ft	Parallel	n/a	Firestopped	None	Some of the draftstopping was missing or never completed, mainly around the access openings.
15	Existing	1996	B	Business	Clubhouse, offices, gym	1	none	Yes	Yes	Plywood	Split into equal sectors of approximately 3,000 sq ft	Parallel	1) Had access holes cut in them 2) Had large holes for penetrations	None	None	Was a 10,000 sq ft clubhouse, had Terracotta roof
16	Existing	1996	B	Business	Clubhouse	1	none	Yes	No	-	-	-	-	-	-	Was a 5,000 sq ft clubhouse
17	Existing	2000	R-2	Hotel	-	5	NFPA 13	No	Mostly	Plywood	Split into equal sectors of approximately 3,000 sq ft	Parallel	n/a	Firestopped	None	Type II construction with wood roof. The draftstopping had access openings but no self-closing doors.
18	New	-	R-2	Apartment	Parking Garage, Retail	5	NFPA 13	No	Only for interstitial sprinkler protection to 1,000 sq ft	Plywood	Only 18 inches deep	Parallel and Perpendicular	1) was not continuous in many areas 2) stopped short of adjacent draftstopping	None	None	Construction Type was IIIB with fire-retardant-treated (FRT) wood exterior walls, had a concrete fire wall between adjacent parking garage, there was no FRT at the wall that faced the concrete fire wall.

APPENDIX E

PICTURES

Picture 01 – Typical Plywood Draftstopping

Picture 02 – Typical Door in Plywood Draftstopping

Picture 03 – Typical Door in Plywood Draftstopping

Picture 04 – Draftstopping with both Plywood and Gypsum

Picture 05 – Gypsum Draftstopping with All Penetrations and Joints Sealed with Mud and Tape

Picture 06 – Draftstopping Installed Perpendicular to the Trusses

Note how the trusses are in two sections.

Picture 07 – Draftstopping Installed Perpendicular to the Trusses

Picture 08 – Building 6 Deficiency.

Note that the draftstopping stops about 2 ft from the attic floor and the access opening is not provided with a self-closing door.

Picture 09 – Building 11 Deficiency.

Note that the draftstopping has partially fallen out of place.

Picture 10 – Building 12 Deficiency.

Note that the draftstopping is not continuous around part of the roof.

Picture 11 – Building 12 Deficiency.

Note that the draftstopping is not installed down into a ceiling soffit.

Picture 12 – Building 12 Ceiling Soffit from Breezeway

Picture 13 – Building 15 Deficiency.

Note the hole cut for access and penetrations.

Picture 14 – Type III Construction with Exterior Walls of Fire-Retardant-Treated Wood Adjacent to Concrete Parking Garage

Picture 15 – Floor Terminating into Exterior Walls in Type III Construction with Exterior Walls of Fire-Retardant-Treated Wood at Concrete Fire Wall

Picture 16 – Draftstopping for Interstitial Sprinklers.

Note that the two sections stop short.

Picture 17 – Lightning Strike through Roof

Picture 18 – Lightning Strike in Wood Attic.

Note that this is post-fire with minor damage.

Picture 19 – Lightning Strike in Wood Attic.

APPENDIX F

RS MEANS COST DATA

06 16 36.10 Sheathing		Crew	Daily Output	Labor-Hours	Unit	2013 Bare Costs Material	Labor	Equipment	Total	Total Incl O&P
0010 SHEATHING	R061636-20									
0012 Plywood on roofs, CDX										
0030 5/16" thick		2 Carp	1600	.010	S.F.	.55	.45		1	1.29
0035 Pneumatic nailed	R061110-30		1952	.008		.55	.37		.92	1.17
0050 3/8" thick			1525	.010		.51	.47		.98	1.29
0055 Pneumatic nailed			1860	.009		.51	.39		.90	1.15
0100 1/2" thick			1400	.011		.58	.51		1.09	1.43
0105 Pneumatic nailed			1708	.009		.58	.42		1	1.29
0200 5/8" thick			1300	.012		.73	.55		1.28	1.65
0205 Pneumatic nailed			1586	.010		.73	.45		1.18	1.50
0300 3/4" thick			1200	.013		.77	.60		1.37	1.77
0305 Pneumatic nailed			1464	.011		.77	.49		1.26	1.61
0500 Plywood on walls with exterior CDX, 3/8" thick			1200	.013		.51	.60		1.11	1.48
0505 Pneumatic nailed			1488	.011		.51	.48		.99	1.30
0600 1/2" thick			1125	.014		.58	.64		1.22	1.62
0605 Pneumatic nailed			1395	.011		.58	.52		1.10	1.43
0700 5/8" thick			1050	.015		.73	.68		1.41	1.85
0705 Pneumatic nailed			1302	.012		.73	.55		1.28	1.65
0800 3/4" thick			975	.016		.77	.74		1.51	1.98
0805 Pneumatic nailed			1209	.013		.77	.59		1.36	1.76
0840 Oriented strand board, 7/16" thick	G		1400	.011		.37	.51		.88	1.20
0845 Pneumatic nailed	G		1736	.009		.37	.41		.78	1.05
0846 1/2" thick	G		1325	.012		.37	.54		.91	1.25
0847 Pneumatic nailed	G		1643	.010		.37	.44		.81	1.08
0852 5/8" thick	G		1250	.013		.47	.57		1.04	1.41
0857 Pneumatic nailed	G		1550	.010		.47	.46		.93	1.23
1000 For shear wall construction, add							20%			
1200 For structural 1 exterior plywood, add					S.F.	10%				
1400 With boards, on roof 1" x 6" boards, laid horizontal		2 Carp	725	.022		1.80	.99		2.79	3.51
1500 Laid diagonal			650	.025		1.80	1.11		2.91	3.68
1700 1" x 8" boards, laid horizontal			875	.018		1.81	.82		2.63	3.25
1800 Laid diagonal			725	.022		1.81	.99		2.80	3.52
2000 For steep roofs, add							40%			
2200 For dormers, hips and valleys, add						5%	50%			
2400 Boards on walls, 1" x 6" boards, laid regular		2 Carp	650	.025		1.80	1.11		2.91	3.68
2500 Laid diagonal			585	.027		1.80	1.23		3.03	3.87
2700 1" x 8" boards, laid regular			765	.021		1.81	.94		2.75	3.44
2800 Laid diagonal			650	.025		1.81	1.11		2.92	3.69
2850 Gypsum, weatherproof, 1/2" thick			1125	.014		.41	.64		1.05	1.43
2900 With embedded glass mats			1100	.015		.72	.65		1.37	1.80
3000 Wood fiber, regular, no vapor barrier, 1/2" thick			1200	.013		.56	.60		1.16	1.54
3100 5/8" thick			1200	.013		.71	.60		1.31	1.70
3300 No vapor barrier, in colors, 1/2" thick			1200	.013		.68	.60		1.28	1.67
3400 5/8" thick			1200	.013		.72	.60		1.32	1.71
3600 With vapor barrier one side, white, 1/2" thick			1200	.013		.55	.60		1.15	1.53
3700 Vapor barrier 2 sides, 1/2" thick			1200	.013		.77	.60		1.37	1.77
3800 Asphalt impregnated, 25/32" thick			1200	.013		.30	.60		.90	1.25
3850 Intermediate, 1/2" thick			1200	.013		.22	.60		.82	1.16

09 26 Veneer Plastering

09 26 13 – Gypsum Veneer Plastering

	09 26 13.20 Blueboard	Crew	Daily Output	Labor-Hours	Unit	2013 Bare Costs Material	Labor	Equipment	Total	Total Incl O&P
6500	For over 3 stories high, add per story	2 Carp	6100	.003	S.F.		.12		.12	.18
	09 26 13.80 Thin Coat Plaster									
0010	**THIN COAT PLASTER**									
0012	1 coat veneer, not incl. lath	J-1	3600	.011	S.F.	.11	.44	.04	.59	.81
1000	In 50 lb. bags				Bag	14.45			14.45	15.85

09 28 Backing Boards and Underlayments

09 28 13 – Cementitious Backing Boards

	09 28 13.10 Cementitious Backerboard									
0010	**CEMENTITIOUS BACKERBOARD**									
0070	Cementitious backerboard; on floor, 3' x 4' x 1/2" sheets	2 Carp	525	.030	S.F.	.78	1.37		2.15	2.97
0080	3' x 5' x 1/2" sheets		525	.030		.73	1.37		2.10	2.91
0090	3' x 6' x 1/2" sheets		525	.030		.68	1.37		2.05	2.86
0100	3' x 4' x 5/8" sheets		525	.030		.97	1.37		2.34	3.18
0110	3' x 5' x 5/8" sheets		525	.030		.97	1.37		2.34	3.18
0120	3' x 6' x 5/8" sheets		525	.030		.88	1.37		2.25	3.08
0150	On wall, 3' x 4' x 1/2" sheets		350	.046		.78	2.05		2.83	4.02
0160	3' x 5' x 1/2" sheets		350	.046		.73	2.05		2.78	3.96
0170	3' x 6' x 1/2" sheets		350	.046		.68	2.05		2.73	3.91
0180	3' x 4' x 5/8" sheets		350	.046		.97	2.05		3.02	4.23
0190	3' x 5' x 5/8" sheets		350	.046		.97	2.05		3.02	4.23
0200	3' x 6' x 5/8" sheets		350	.046		.88	2.05		2.93	4.13
0250	On counter, 3' x 4' x 1/2" sheets		180	.089		.78	3.99		4.77	7
0260	3' x 5' x 1/2" sheets		180	.089		.73	3.99		4.72	6.95
0270	3' x 6' x 1/2" sheets		180	.089		.68	3.99		4.67	6.90
0300	3' x 4' x 5/8" sheets		180	.089		.97	3.99		4.96	7.25
0310	3' x 5' x 5/8" sheets		180	.089		.97	3.99		4.96	7.25
0320	3' x 6' x 5/8" sheets		180	.089		.88	3.99		4.87	7.15

09 29 Gypsum Board

09 29 10 – Gypsum Board Panels

	09 29 10.30 Gypsum Board									
0010	**GYPSUM BOARD** on walls & ceilings R092910-10									
0100	Nailed or screwed to studs unless otherwise noted									
0150	3/8" thick, on walls, standard, no finish included	2 Carp	2000	.008	S.F.	.23	.36		.59	.84
0200	On ceilings, standard, no finish included		1800	.009		.23	.40		.63	.91
0250	On beams, columns, or soffits, no finish included		675	.024		.23	1.06		1.29	1.89
0300	1/2" thick, on walls, standard, no finish included		2000	.008		.24	.36		.60	.85
0350	Taped and finished (level 4 finish)		965	.017		.29	.74		1.03	1.47
0390	With compound skim coat (level 5 finish)		775	.021		.34	.93		1.27	1.81
0400	Fire resistant, no finish included		2000	.008		.27	.36		.63	.88
0450	Taped and finished (level 4 finish)		965	.017		.32	.74		1.06	1.50
0490	With compound skim coat (level 5 finish)		775	.021		.37	.93		1.30	1.84
0500	Water resistant, no finish included		2000	.008		.36	.36		.72	.97
0550	Taped and finished (level 4 finish)		965	.017		.41	.74		1.15	1.59
0590	With compound skim coat (level 5 finish)		775	.021		.46	.93		1.39	1.93
0600	Prefinished, vinyl, clipped to studs		900	.018		.47	.80		1.27	1.76
0700	Mold resistant, no finish included		2000	.008		.38	.36		.74	.99
0710	Taped and finished (level 4 finish)		965	.017		.43	.74		1.17	1.61