

INTERNATIONAL RESIDENTIAL CODE AND RESIDENTIAL FIRE SPRINKLERS

Minnesota Governor's Council on Fire Prevention and Control
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Introduction

The Governor's Council on Fire Prevention and Control dates back to the 1969 Legislative Session and operates today under Executive Order No. 03-04 signed by Governor Pawlenty on April 4, 2003.

Background

Residential fire sprinklers were introduced in the 1970's for use in single- and two-family homes, but have never been required for installation by the model building codes in the United States on a nationwide basis. Recent action by the International Code Council has moved the requirement for the installation of these sprinklers in new single- and two-family homes into the most widely adopted of the model codes and brought the possibility of adoption to the state of Minnesota. **This document provides an overview of information on residential fire sprinklers.**

International Residential Code and Residential Fire Sprinklers

In September of 2008 the International Code Council, a membership organization that develops the codes used to construct residential and commercial buildings in the United States, approved a proposal to require residential fire sprinklers for one- and two-family homes built under the 2009 edition of the International Residential Code (IRC).

Section R313 Fire Sprinkler Systems. R313.1 General. Effective January 1, 2011, an approved automatic fire sprinkler system shall be installed in new one- and two-family dwellings and townhomes in accordance with NFPA 13D.

The IRC calls for an effective date of no sooner than January 1, 2011. If the state of Minnesota adopts the 2009 IRC by January 1 of 2011, or any date after that, residential fire sprinklers would be required in only those new homes built **after** the IRC adoption. The requirement for residential fire sprinklers is not retroactive and **does not** apply to homes built prior to the date of adoption of the 2009 IRC.

National Fire Protection Association Standard NFPA 13D

The National Fire Protection Association (NFPA) originally published the standard for the design, installation, and maintenance of sprinkler systems for one- and two-family dwellings in 1975. The current NFPA 13D standard is the 2010 edition.

Fire in Minnesota

In 2008¹ there were 5,330 residential fires with 3,147 of those in one- and two-family dwellings. The 3,147 fires in homes were 44.2 percent of all fires; causing 30 fatalities

¹ Minnesota Department of Public Safety, State Fire Marshal Division, *2008 Fire In Minnesota*, June 2009

(57.6 percent of all fatalities) and \$79,257,090.00 in property damage. The leading causes of these fires were:

- cooking (48 percent),
- heating (12 percent),
- and open flames (10 percent).

The leading cause of fires with fatalities was smoking. For comparison, in 2007² there were 5,395 residential fires with 3,297 of those in one- and two-family dwellings. The 3,297 fires in homes were 45 percent of all fires; causing 25 fatalities (62.5 percent of all fatalities) and \$89,178,352.00 in property damage.

Residential Fire Problem

Accidental fires in the home cause injuries and deaths to civilians and to firefighters as well as significant property damage to homes, furnishings, and personal belongings. At a minimum, fire displaces families from their homes for weeks and months causing disruption in their life styles.

In a world that is more and more concerned about environmentally friendly or “green” construction practices, fires are not green. Air pollution, ground water contamination, high volumes of water usage for fire fighting, demolition materials trucked to landfills, additional natural resources necessary for rebuilding homes, fuel and other resources consumed by fire department equipment traveling to and from fires and idling at fire scenes all have an environmental impact because of a residential fire. These can all be greatly reduced through the installation of residential fire sprinkler systems.

Firefighter safety is another factor that must be considered when residential fires are discussed. The use of lightweight materials in home construction beginning in the mid 1980’s revolutionized new home construction by reducing the cost of structural materials, but these same materials also reduced the fire safety in homes. Three studies have been conducted of lightweight construction materials by the Canadian Institute for Research in Construction³, Underwriters Laboratories, Inc.⁴, and Tyco Fire Suppression and Building Products⁵, with all three indicating that I-joists and floor trusses in general have shorter burn times to structural failure than the solid joists.

Residential Fire Sprinklers

Residential fire sprinklers are fast-response⁶ automatic sprinklers that are primarily life safety devices and are intended to provide a minimum of ten minutes for the safe

² Minnesota Department of Public Safety, State Fire Marshal Division, *2007 Fire In Minnesota, 2007*

³ Fire Performance of Houses. Phase 1. Study of Unprotected Floor Assemblies in Basement Fire Scenarios. Summary Report, 12/15/2008, <http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/rr/rr252/rr252.pdf>

⁴ Report on Structural Stability of Engineered Lumber in Fire Conditions, 9/30/2008.

⁵ Tyco Fire Suppression & Building Products. *A Technical Analysis: The Performance of Composite Wood Joists Under Realistic Fire Conditions*, 2008.

⁶ National Fire Protection Association, NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 2007 edition, Section 3.3.8.2.

egress for occupants and are not intended to protect structures. In most cases, however, a single residential fire sprinkler operates and protects both lives and property.

Residential fire sprinkler systems, when designed, installed, and maintained in accordance with NFPA 13D, have only a minor comparison to commercial fire sprinkler systems and are more economical. Although the pipe, fittings, valves, and pipe supports may be the same, residential fire sprinkler systems are different from commercial fire sprinkler systems in the following ways:

- Residential fire sprinklers are designed to use less water than commercial sprinklers because residential fires are smaller than fires in commercial buildings. Additionally, residential fire sprinkler systems are designed to allow the occupants to escape a fire, where commercial sprinkler systems are designed to protect the property. This doesn't mean that residential fire sprinklers will not protect property, in fact they will, but their primary function is life safety, allowing occupants to escape safely. The number of fire sprinklers in the residential system that are anticipated to operate is fewer for residential systems allowing for small water supplies. The maximum number of fire sprinklers in the residential design criteria is two and they can flow as little as 8 gallons per minute (gpm) each for a total of 16 gpm.
- The spray pattern of the residential fire sprinklers covers walls and furnishings in addition to floor area, while commercial sprinklers are designed to cover the floor area only.
- The design basis of residential sprinkler systems is to prevent flashover and allow occupants to safely exit and to control the fire until the fire department arrives for extinguishment.
- Residential sprinkler systems allow for smaller piping, smaller fittings, and smaller valves, and do not require a connection for the fire department to use.

Residential fire sprinkler systems do not use nearly the quantity of water that the fire department requires to fight the same fire. Residential fire sprinklers automatically begin applying small amounts of water (8 to 37 gpm) to the fire early in the fire growth. On the other hand, the fire department will not arrive for a number of minutes after the fire has been observed and notification has been made and then after they've connected hoses to trucks and hydrants and made entry into the building the fire department will apply 125 to 400 gallons per minute or more from two hoses.

Maintenance of residential sprinkler systems is limited to the homeowner ensuring that the water supply is on and that the automatic sprinklers are unobstructed.

Fire Growth

In general a fire continues to grow until a sufficient amount of water can be applied to the fire as well as the unburned fuel load – furnishings and finishes in the room. The fire development depends upon many factors such as the fuel load in the area of origin, the ventilation or amount of available oxygen, and how quickly water is applied. The furnishings and finishes in homes have changed over the years and in two studies the time it takes a fire to grow to an intensity that is not safe for humans (in other words the

time to escape) has diminished from seventeen minutes in 1975 to three minutes in 2007⁷.

Fire detection is critical and can be by smoke detectors, humans, or fire sprinklers. Smoke detector and human detection then require appropriate responses to the fire including recognition of the fire, exiting the fire area, and calls to emergency services. Detection, response, exiting and calls all take time and vary with the age and mobility of the people, fire growth, and human behavior. After the calls have been made and the fire department has been notified and dispatched, their travel time, access to water supplies, fire scene operations, and so on contribute to the time required to apply water to the actual fire and begin suppression.

Comparatively, residential fire sprinklers respond without any human intervention or required response and typically activate within the first few minutes, or even seconds, of a fire to "...prevent flashover (total involvement) in the room of fire origin, where sprinklered, and to improve the chance for occupants to escape or be evacuated."⁸

Economic Issues

The cost of residential sprinkler system installations is a product of several variables that include:

- New or existing home
- The size of the home
- The water supply to the home
- Construction materials and products
- Sprinklers in additional areas such as garages and attics that are not required by NFPA 13D
- Local permit fees

Residential Sprinkler System Costs

Based upon the variables the cost of the residential sprinkler system can be compared to other components of the home such as granite counter tops, lawn sprinklers, or the furnishings for one room. The cost can also be expressed in terms of dollars per square foot or as a percentage of the construction cost. However, these cost estimates vary widely because of the variables above and using either method of estimating without properly identifying the variables would lead to improper conclusions.

The Fire Protection Research Foundation commissioned research in 2008, "...to provide information on this topic, and to understand the factors that may influence the costs and hence impede the widespread use of residential fire sprinklers, the Foundation undertook this study to provide a national perspective on the cost of home

⁷ National Institute of Standards and Technology, US Department of Commerce, NIST 1455-1, December 2007, *Performance of Home Smoke Alarms Analysis of the Response of Several Available Technologies in Residential Fire Settings*, page xxv

⁸ National Fire Protection Association, NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 2007 edition, Section 1.2

fire sprinklers by developing data on installation costs and cost savings for ten communities distributed throughout the United States.”⁹ From this study came the following:

The term “sprinklered square feet” (sprinklered SF) reflects the total area of sprinklered spaces, including basements, garages, and attics when applicable. This term is used to better characterize the cost of sprinklers per unit of space which is covered by the system, especially since many of the homes have sprinklers in spaces beyond the normal living space, such as a garage. In terms of absolute costs, the total sprinkler system costs to the homebuilder ranged from \$2,386 to \$16,061 for the 30 houses.

The cost of sprinkler systems to the homebuilder, in dollars per sprinklered SF, ranged from \$0.38 to \$3.66. This range represents the 30 different house plans, with the average cost being \$1.61 per sprinklered SF. The low end of this range (\$0.38/sprinklered SF) represents a California house in a community with a longstanding ordinance, sprinklers in the attic and the garage (in addition to the living space), and some potential pricing benefits from a volume relationship with the sprinkler contractor. The high end of this cost range (\$3.66/sprinklered SF) represents a Colorado house on well water and a system constructed with copper piping which utilized anti-freeze for freeze protection during the winter. These costs include all costs to the builder associated with the sprinkler system including design, installation, and other costs such as permits, additional equipment, and increased tap and water meter fees – to the extent that they apply. When accounting for any available credits given for the use of residential sprinklers (as was the case in Wilsonville, OR), the total sprinkler system costs to the builder averaged \$1.49 per sprinklered SF.

Variables associated with higher cost systems included extensive use of copper piping (instead of CPVC or PEX), an on-site water supply (instead of municipal water), local requirements to sprinkler additional areas like garages or attics, and higher local sprinkler permit fees. The cost data also support the concept that communities with sprinkler ordinances in effect for more than five years tend to experience market acceptance and increased competition leading to lower system costs.

Credits or “trade-offs,” which could include incentives like greater fire hydrant spacing in a community with sprinklers, were also investigated in each of the ten communities. While trade-offs may be used in communities as part of the zoning approval process for specific developments, just one of the ten communities had a credit or trade-off that applied to the houses which were analyzed. Wilsonville,

⁹ The Fire Protection Research Foundation, *Home Fire Sprinkler Cost Assessment, Final Report*, Newport Partners, September 2008.
<http://www.nfpa.org/assets/files//PDF/Research/FireSprinklerCostAssessment.pdf>

OR, offers a credit of \$1.21 per square foot of living space in an effort to partially offset the costs of sprinklers.

As complementary data to the cost analysis, a survey of available insurance premium discounts for homeowners with sprinkler systems was conducted. For each of the ten communities where sprinkler cost data was analyzed, the average insurance premium discount (as a percentage) was obtained from five insurers with significant market share in the state. Discount savings percentages ranged from 0 to 10% among all companies and agencies surveyed, with an average premium discount of 7%. Related issues such as limits on the overall discount allowed for protective devices, sprinkler system requirements, and any potential insurance penalties for sprinklers were also explored. There were no instances discovered of insurance penalties or extra fees associated with the use of residential sprinkler systems due to concerns such as system leakage.

Construction Materials

The materials used in the construction of one- and two-family dwellings has changed since the 1980's with the use of "Engineered" construction members instead of traditional dimensional lumber such as 2 inch by 10 inch wood joists. These engineered components are sometimes referred to as lightweight members and have been utilized by the construction industry because of several cost and forest conservation reasons, including eliminating multiple joists for multiple spans, drying, and floor squeaks. The I-joist or floor truss enabled the use of longer and lighter pieces of lumber that spanned the entire width of the house, eliminated excess labor, allowed a product that was created out of new young trees (saving the mature trees) and gave the ability to have site cut holes in the center of the span.¹⁰

From, the National Institute for Occupational Safety and Health (NIOSH) Publication No. 2009-114, titled, "Preventing Deaths and Injuries of Fire Fighters Working Above Fire-Damaged Floors" comes the following:

Fire fighters are at risk of falling through fire-damaged floors. Floors may fail within minutes of flame contact. Carpet, ceramic tile, lightweight concrete, and similar floor coverings may increase the danger to firefighters because of the added weight being supported by the floor system and the insulation these materials provide that may cause the floor to not feel warm, despite the fire underneath.

All wood-based construction materials are subject to failure when exposed to fire. Experimental studies and NIOSH investigations suggest that engineered wood floor systems may fail sooner than traditional sawn lumber floors. The difference in times to failure appears to be a matter of minutes, and fire fighters will seldom know how long a fire has been burning when they arrive on scene.

¹⁰ Sprinkler Quarterly Magazine, National Fire Sprinkler Association, "Don't Tread on Me" – Lightweight construction Performance in Residential Fires, Jeff Hugo, September – October 2009

Consequently, fire fighters must use extreme caution when operating on any flooring system potentially exposed to fire.

Engineered wood I-joists represent a rising technology in the building sector; they offer several advantages over traditional construction methods. Engineered wood I-joists are typically prefabricated using sawn or structural composite lumber for the top and bottom flanges (usually 1½ to 3½ inches wide) and plywood or oriented strand board (OSB) sheathing for the vertical web (3/8 to 7/16 inches thick) (see Figure 1). Engineered wood I-joists are lighter, stiffer, and will not warp, twist, or shrink like traditional framing materials.

Engineered wood I-joists also reduce total construction time and labor costs by their ease of installation.

Engineered wood I-joists have grown in use since the early 1990's and by 2005 were estimated to be used in more than half of all wood-frame construction [APA 2005]. Changes in the building construction industry driven by technological advancements and societal needs suggest that the use of engineered wood products will continue to grow.

Underwriters Laboratories, Inc., in testing completed in 2008, documented that traditional dimensional 2 inch by 10 inch lumber subjected to loaded fire tests lasted 18 minutes before it failed while engineered I-joists in the same test set up lasted 14 minutes less or only 4 minutes.¹¹

Community Issues

Municipalities with residential sprinklers benefit from a reduction in insurance costs to both the community and the residents whose homes are sprinklered. From the Insurance Services Office, Inc.¹² is the following:

The ISO Building Code Effectiveness Grading Schedule (BCEGS®) is used to review public building code enforcement agencies and to develop a classification that is provided as advisory information to insurers who may use it for insurance underwriting and rating. If the requirement of the International Residential Code (2009) for automatic fire sprinkler protection of residential dwellings was removed by legislation or local ordinance, BCEGS would not provide full recognition for adoption of code without amendments. A building code enforcement agency which adopted a code with amendments that weaken hazard mitigation issues as defined in the model codes and referenced standards would not receive maximum recognition for code adoption.

¹¹ Underwriters Laboratories, Inc., *Report on Structural Stability of Engineered Lumber in Fire Conditions*, Project Number: 07CA42520, September 30, 2008.

¹² www.isomitigation.com, *Residential Sprinklers ISO Fact Sheet*

Additionally, there is vastly improved water application to one- and two-family dwelling fires, significantly reduced loss of personal property, potentially reduced infrastructure costs (taxes), a reduced cost of fire suppression, and a reduction in water usage.

Summary

Local government provides fire protection services in one form or another and the implementation of residential fire sprinklers in new home construction is an important supplement to this provision. Homeowners, firefighters, and their communities achieve a higher level of life safety and property protection from the installation of residential fire sprinklers. Costs of these residential fire sprinkler systems can be compared to other home improvements. Cost savings are measured in lives saved; injuries prevented; reduced damage to personal property; as well as minimizing the time that a family is displaced from their home compared to a fire in an unsprinklered home; and the reduction of pollutants and use of natural resources such as water and trees.