Analysis of the Economic and Life-Saving Impact of a Residential Fire Sprinkler Requirement in Connecticut

Report Developed by the
Connecticut Fire Sprinkler Coalition

Scope of Report

The Connecticut Fire Sprinkler Coalition was formed in 2014 to underscore and eliminate one of the state's biggest safety threats to its residents: home fire death and injury. The vast majority of Connecticut's fire deaths and injuries each year are happening at home. Through the coalition, the state's key fire service organizations and other safety groups are urging state officials to adopt an updated version of the model building code, which includes the provision for home fire sprinklers in new construction, the solution proven to reduce the risk of dying or being injured from fire. The group also attempts to overcome barriers to requiring fire sprinklers in new one- and two-family homes.

Since fire sprinklers are a proven life-safety technology, the country's codes and standards organizations have made this technology a requirement in new homes. Since 2009, every edition of the model building codes used in the U.S. includes the requirement to install fire sprinklers in new one- and two-family homes. Unfortunately, Connecticut is not up-to-date on its code requirements, forcing the state's citizens to live with substandard construction requirements and a lack of protection from fire in their homes.

The state is currently in the process of updating its residential building code. Looking to adopt the 2015 *International Residential Code* (IRC), one of the country's model building codes, the state's Codes and Standards Committee will vote on whether or not to adopt the provision for the use of fire sprinklers in new one- and two-family homes. A subcommittee has been tasked with researching this provision. Adhering to this safety requirement is crucial to provide Connecticut residents with the minimal level of safety in their homes. As the coalition has learned, failure to adopt requirements for home fire sprinklers has deadly ramifications.

The threat from substandard construction requirements has already affected the people of Connecticut. In 2016, a six-year-old girl from Plainfield died in a fire that occurred in a home built just months prior. Her mother was injured in the blaze. The home was built to meet the construction standards in place in Connecticut, but those standards fell short of the requirements included in national model building codes. The new home had at least one working smoke alarm, but its activation did not save the child. The tragic death of this young child proves smoke alarms are only one component of home fire safety. The furnishing and contents in homes burn more quickly than ever, and automatic sprinklers provide the best protection for Connecticut families. Had this home's construction followed model building code requirements, it would have had home fire sprinklers. Sadly, Connecticut residents will continue to die in home fires if the state continues to allow the construction of new homes that do not comply with model building codes.

The coalition has produced this report, which is an update to a 2011 analysis created by a subcommittee tasked with researching concerns and impacts of a statewide fire sprinkler ordinance. (The 2011 analysis has been kept intact.) It is the hope of the coalition that the new research illuminates why today's home environment is a cause for concern, the cost-effectiveness of home fire sprinklers, and successes of fire sprinkler requirements elsewhere.

Hundreds of U.S. communities and certain states now require fire sprinklers in their one- and two-family homes. Our state's decision makers have the power to give Connecticut residents the same level of protection at home. It is the coalition's position that the state should not intentionally weaken model codes used in Connecticut by removing the fire sprinkler provisions. Instead, the state should protect Connecticut residents and firefighters from home fires for future generations.

—The Connecticut Fire Sprinkler Coalition
Keith Flood
West Haven Fire Marshal and Chair, Connecticut Fire Sprinkler Coalition

Implementation of Residential Fire Sprinkler Systems Within One- and Two-Family Dwellings and Townhouses in Connecticut

On October 13, 2010, the Codes Amendment Subcommittee (CAS) of the Codes and Standards Committee voted to create a separate committee charged with researching the various issues associated with mandating residential sprinklers in one- and two-family homes and townhouses. In the meantime, the 2009 *International Residential Code* (IRC), Section R313, would be deleted from what will be an amendment to the 2005 *State Building Code*, and NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, would be added to the appendix of that amendment. (By adding NFPA 13D to the appendix, the standard would be applicable to voluntary installations.) After completion of its review of the remainder of the 2009 International Code Council (ICC) family of codes, the CAS could then revisit the sprinkler issue and incorporate it into the building code during the next code cycle. Robert Ross, Director of the Department of Public Safety Division of Fire Emergency and Building Services, offered to coordinate membership of and chair a study group (committee), which was accepted by CAS Chair Louis Free.

Note: Although the committee was not asked to address this type of system, Section R313 of the 2009 IRC allows the installation of the required residential sprinkler system to comply with *either* NFPA 13D or Section P2904 of the above code. Section P2904, which is under the plumbing section of the 2009 IRC, was developed to provide a design and installation method for a fire sprinkler system that will provide an equivalent level of protection as provided by a NFPA 13D system, but without the need for sophisticated calculations and other installation complexities. Even though Section P2904 is under the plumbing section of the 2009 IRC, the Department of Consumer Protection would still consider this fire sprinkler work and require a license for sprinkler contractors to perform the work unless the homeowner is doing the work within their own single-family dwelling. Also, leading manufacturers are developing a residential sprinkler system that incorporates a water mist system.

SCOPE OF REVIEW

This committee addressed the following issues:

1. What is the specific historical data on fire statistics for one- and two-family dwellings, as well as townhouses and the age of such homes with an incident? Also, what are the statistics on which homes did and did not contain early warning detection such as smoke detectors?
2. What are the unknown requirements of the state's water purveyors and for individual supply lines, metering, back flow preventers, and related annual fees if applicable?
3. What are the related costs for installation outside of the building footprint for this water service, excavation costs, and other related expenses?
4. What is the estimated financial installation cost (relative to the State of Connecticut construction industry) of the NFPA 13D system inside the residence, based on NFPA 13D installation requirements?
5. Who is the licensed installer who can install this system, and how many of such individuals are licensed in Connecticut and are available to do this work?
6. Who can be the responsible individual to design the system? Can a homeowner do this?
7. What are the required annual maintenance and inspection requirements of an NFPA 13D residential sprinkler system? Can a homeowner do this or a specialized tradesman?
8. What components are needed to install such systems, and will product suppliers sell the materials such as sprinkler heads and related equipment to homeowners or to only licensed contractors?
9. Will the municipalities include this new system as an additional item on which to financially assess the homeowner, and what are the implications of such annual cost assessment to a homeowner?
10. What are the specific insurance implications to a homeowner?
11. What are the financial costs to rebuild a home that experiences a fire with and without a residential sprinkler system, here in Connecticut and/or the Northeast?
12. What are the impacts on firefighters, first responders, and residential occupant safety?
13. What education is needed to understand the requirements of the 2009 IRC, Sections R313 and P2904, for potential user groups such as the construction industry, and code officials relative to NFPA 13D?

ISSUE 1

What is the specific historical data on fire statistics for one- and two-family dwellings as well as townhouses, and the age of such homes with an incident? Also, what are the statistics on which homes did and did not contain early warning detection such as smoke detectors?

2011 Findings
This question was not researched by the committee. The direction of the Codes and Standards Committee was to determine the impact "if" the ICC requirement for sprinklers was adopted here in Connecticut. It was determined that the historical data research could consume a large amount of time to collect and the efforts of this committee would be better served on researching the impact of adoption.

New Findings
Data on the Age of Dwellings Experiencing Fire Fatalities

Specific historical data, either national or specific to Connecticut, has not successfully been ascertained by anyone, including members of the fire service who complete fire incident reports. Fire data captured by the National Fire Information Reporting System (NFIRS) does not record the age of structures involved in fire incidents because the year of construction is often difficult to accurately determine without extensive research.

This point is further illustrated by a document titled "Connecticut Residential Fires/Deaths Life Threatening Injuries for Years 2000 – 2006, by Age of Home/Structure," which is posted on the Home Builders & Remodelers Association of Connecticut (HBRACT) website. The table in that document, which appears to have been generated by manually comparing addresses of fire fatalities in Connecticut with tax records, identifies almost half of the entries as "NO DATA" (supplemented in some cases by an unsubstantiated estimate). Furthermore, a comparison of fire data vs. home age can often mistakenly characterize the occurrence of residential fires as a problem associated with "old" homes, which can deflect the ultimate economic and life-saving impact of a residential fire sprinkler requirement in Connecticut.

The impact of home fires and fire sprinkler ordinances has been extensively researched by entities including the National Fire Protection Association (NFPA), the U.S. Fire Administration (USFA), National Fire Incident Reporting System (NFIRS), the Home Fire Sprinkler Coalition, and many other accredited national and local organizations. While historical data specific to Connecticut regarding fire statistics for one- and two- family dwellings is still an outstanding need, there is substantial national data regarding this topic.

Since residential structures are frequently renovated and remodeled, the year of construction is truly irrelevant with respect to predicting the age of heating systems and electrical systems, the presence of smoke alarms, and the age of other fixed equipment that might be associated with the occurrence of fire or fire safety. Nationally, the Joint Center for Housing Studies of Harvard University estimates the value of the home remodeling business in 2015 to be $340 billion.

A case in point: A home that had been recently renovated by Habitat for Humanity in Rochester, NY experienced a fire on November 28, 2006. At approximately 11:15 p.m., a fire on the first floor rapidly spread up the stairs leading to the deaths of three children, ages 11, 6, and 5. Three other children in the home narrowly escaped by jumping out from the second floor. This home had five working smoke alarms that sounded and reportedly met code requirements that were applicable to the renovations. The fire department arrived on scene within three minutes of the call.

Data Regarding Homes Experiencing a Fire Incident With and Without Smoke Alarms

There is extensive data available on the presence and operating performance of smoke alarms in homes. Reports serving as the basis for this analysis include *Home Smoke Alarms and Other Fire Detection Equipment* (4/06), and *Smoke Alarms in U.S. Home Fires* (9/09, 9/11, and 9/15), published by NFPA.

Note that townhouses are coded in NFIRS data as multifamily occupancies, which also include apartments and similar uses. Unlike data for one- and two-family dwellings, data for townhouses cannot be uniquely isolated from the general category in which townhouses are included.

Figure 1 shows the presence and absence of smoke alarms in residential occupancies where fire fatalities occurred for years ranging from 2003 to 2013. For one- and two-family dwellings, there is a trend of increasing presence of smoke alarms in properties where fire fatalities occurred, and for the past 10+ years, most homes experiencing a fire fatality were so equipped.

Figure 1
Home Fire Fatalities Smoke Alarms Present / Absent

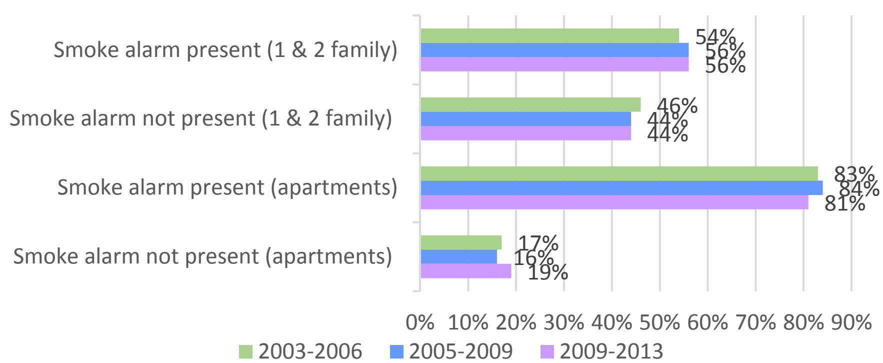


Figure 2 breaks down additional details regarding smoke alarm performance. The data shows an increasing percentage of deaths caused by fires in which smoke alarms were present and operated. A larger percentage of homes now have smoke alarms.

Figure 2 also illustrates the difficulty in maintaining operational smoke alarms in all residential occupancies. Too often, batteries have been disconnected or removed or the alarm may have been disabled. Unfortunately, recommendations regarding testing are often not followed.

Smoke alarms do not last forever. *NFPA 72®*, *National Fire Alarm and Signaling Code,* states that "Smoke alarms installed in one- and two-family dwellings shall not remain in service longer than 10 years from the date of manufacture." While this is a laudable objective, it is no secret that enforcement of the requirement is limited because of privacy laws that restrict right of entry to owner-occupied properties.

Figure 2
Smoke Alarm Status in Home Fire Deaths

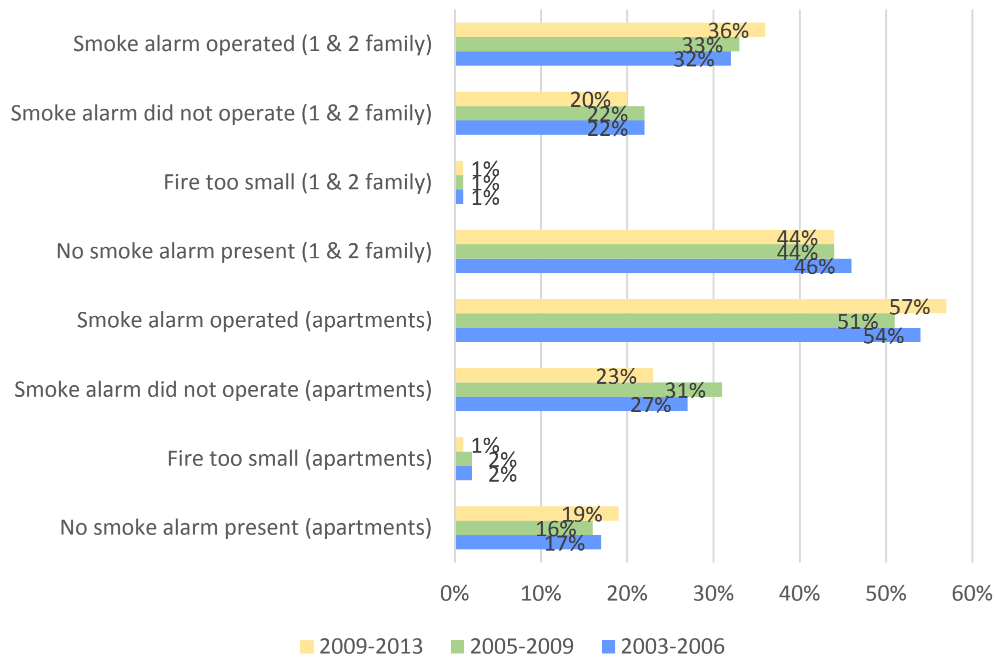
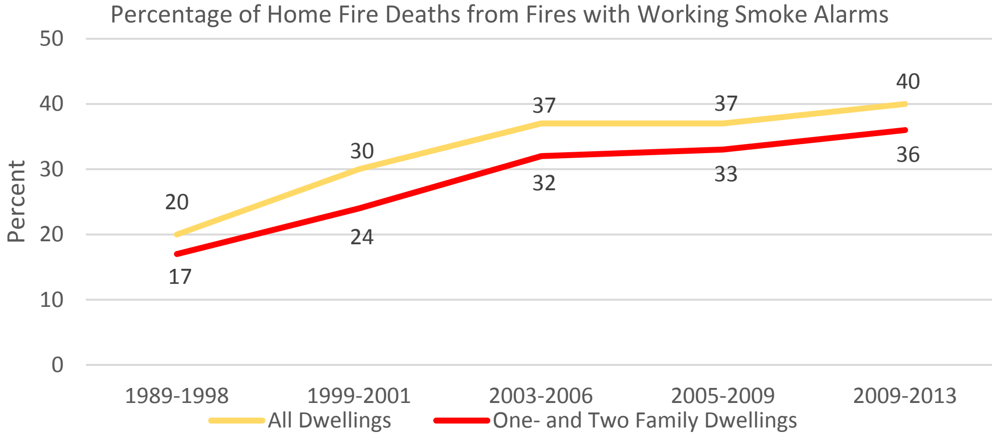


Figure 3 illustrates the disturbing fact that the percentage of fire fatalities in homes with working smoke alarms has been increasing, trending from roughly 1 of every 5 fire fatalities occurring in a home with a working smoke alarm roughly 20 years ago to now be more than 1 of every 3. Some of this is due to the increased number of homes with smoke alarms.

Figure 3
Percentage of Home Fire Deaths from Fires with Working Smoke Alarms



When one considers that a family's fire safety may be entirely reliant on a device that typically costs less than $20 and remains in service 24 hours per day, 365 days per year, for a decade or more with little or no maintenance, it is not surprising that fire fatalities in homes with working smoke alarms are on the rise.

It is also important to note that NIST research has tied the increased use of synthetic furnishings (which increase smoke production and smoke toxicity), open floor plans, and other features common to newer homes, to reduced escape times over the past few decades, dropping from an estimate of 17 minutes to as few as 3 minutes. Because smoke alarms provide only early warning of a fire, reduced escape times also reduce the potential for the warning provided by smoke alarms to be sufficient for escape. This is particularly true for individuals who are young, elderly, mobility impaired, cognitively impaired, or otherwise unable to quickly escape once warning of a fire has been provided.

Although the use of smoke alarms remains an essential aspect of residential fire safety and their presence in homes has become commonplace, the vast majority of fire deaths each year continues to occur in homes at a relatively static rate of about 80 percent over the past four decades. Clearly, smoke alarms alone are not adequate to prevent residential fire deaths and injuries.

ISSUE 2

What are the unknown requirements of the state's water purveyors and for individual supply lines, metering, backflow preventers, and related annual fees if applicable?

2011 Findings
The committee met with representatives from municipal water companies and found that except for backflow preventers, they have different regulations regarding the installation of residential sprinklers. It was concluded that if the sprinklers were going to be required there needs to be a combined effort from the water companies and the authority having jurisdiction from the municipalities to develop a single standard.

New Findings
There are 129 water purveyors in the state of Connecticut. Of those, 124 are regional companies and five are national companies. The committee has made efforts to obtain information specific to requirements per individual water purveyors, and they have found that regulations regarding the installation of residential sprinklers vary among the water purveyors, as do related annual fees.

However, experience has since shown that this variation of regulations and fees does not necessarily have to be the case. The situation with Connecticut water purveyors is no different than that of Maryland and California, both of which have enacted statewide requirements for fire sprinklers in new homes, and both have many individual water purveyors serving areas that range from rural to metropolitan.

Complexities that may be unnecessarily created by uninformed, local water purveyors to accommodate residential fire sprinkler systems can often be eliminated by communicating some simple facts about these systems to the water purveyor. But even cases involving inflexible water purveyors typically can be worked around with minimal expense.

Attached is a residential sprinkler system diagram. There is no requirement for a backflow preventer with a sprinkler system in accordance with NFPA 13D, and the NFPA 13D system does not require a fire department connection. The fees associated with the installation and meter rates can be found on the Regional Water Authority Rate Schedule. Water used through fire service meters will be charged at meter rates, but there will be no charge for water used in case of fire.

Water Demand for Fire Sprinklers

There are approximately 322,578 private residential wells in Connecticut that serve approximately 23 percent of the state's population of 3,574,097 persons (2010 U.S. Census). About 822,575 people are served by their own private residential well. In instances where a homeowner utilizes private residential wells or considers water services through a water purveyor to be cost ineffective, a homeowner also has a secondary option of a tank and pump or stored water source system.

Home fire sprinklers have become so efficient that they can often be designed to use the same or even less water than a new home's plumbing system. Fire sprinklers typically require only 7 pounds per square inch (psi) to operate, which is less than the minimum required pressure for residential plumbing fixtures.

Residential plumbing systems require the following:

- 8 psi minimum pressure for any plumbing fixture[1]
- 20 psi minimum pressure for temperature-controlled shower valves (these are mandatory in new homes)[2]
- 40 psi minimum pressure for the main supply connection (applies to all homes with indoor plumbing, even those supplied by wells)[3]

A single fire sprinkler can use as little as 8 gallons per minute (gpm). With home fire sprinkler systems typically designed to accommodate two simultaneously flowing sprinklers, 16 gpm may be all that's needed to supply fire sprinklers. This is less than the 18 gpm minimum that would be required by the plumbing code to supply plumbing fixtures in a typical entry-level home with three bedrooms, two bathrooms, and two outdoor hose connections.[4]

Fire sprinklers typically will require more water in larger, more expensive homes, but such homes tend to have more plumbing fixtures, which require an increased water supply for plumbing as well. One or two sprinklers must flow for a minimum of seven to 10 minutes, which can be provided by a well and/or a small tank when sprinklers are not supplied by the same size meter that serves the household plumbing.

---

[1] *International Residential Code* (IRC) Table P2903.1
[2] IRC Section P2708
[3] IRC Section P2903.3
[4] IRC Table P2903.6 [17.5 fixture units: 2 bathroom groups, 1 kitchen group, 1 laundry group and 2 hose bibs], and IRC Table P2903.6(1)

Supply Lines and Metering

When a fire sprinkler system is supplied by a water distribution system, water meter size is based on the required pressure and flow, which as stated above may actually be greater for plumbing than for fire sprinklers. Fire sprinklers won't lead to increased meter or tap fees when the sprinkler system is able to be supplied by the same size meter that serves household plumbing.

A typical 5/8 in. meter may flow up to 20 gpm, which is adequate to operate a fire sprinkler system in many homes.[5] A 3/4 in. meter may flow over 30 gpm, which is capable of handling just about any home fire sprinkler system. Most often, the size of underground pipe leading to a house is much more limiting than the meter itself. Upsizing the underground piping between the meter and the house is an easy and inexpensive way to improve pressure and flow for all plumbing, including fire sprinklers, without a larger meter, and there is no technical reason for the size of the underground piping to match the size of the meter.

It is important to note some meter manufacturers' literature may specify lesser flow limits, focusing on the range over which a meter will accurately measure continuous flow. With respect to supplying home fire sprinklers, meter flow limits should be evaluated based on the maximum flow rate rather than continuous flow accuracy limits. Water authorities should recognize that sprinklers will always use less water than fire hoses connected to unmetered fire hydrants that would otherwise be needed to put out a fire, so there is no legitimate value in requiring accurate measurement of sprinkler flow in the event of a fire.

It is also worth noting that landscape irrigation systems, which are often provided for new homes, can have a higher flow demand than fire sprinklers. In such cases, the larger meter provided to satisfy the irrigation system demand can also supply fire sprinklers.

Backflow Prevention

The major U.S. model plumbing codes never require backflow protection for home fire sprinkler systems fabricated with materials approved for household plumbing, such as CPVC, PEX, or copper.[6] However, a local plumbing authority may occasionally ignore the plumbing code and still request a backflow preventer, not recognizing that fire sprinkler systems can be safely connected directly to a potable water supply. Where backflow prevention is an issue because of a local requirement, there are several options whereby additional backflow controls for fire sprinklers can be avoided, as follows:

- Fire sprinklers can be incorporated as part of a multipurpose plumbing system that feeds both sprinklers and plumbing fixtures from a home's cold water plumbing pipes. In this case, all of the equipment associated with the fire sprinkler system becomes part of the potable cold water plumbing system, and potable water plumbing doesn't require backflow prevention.
- The fire sprinkler system can be supplied separately from residential plumbing with a toilet connected to the end of sprinkler piping, which ensures that the piping is occasionally

[5] IRC Table P2904.6.2(2) [This is the prescriptive allowance for any meter. When a meter of known flow characteristics flows more, the higher flow may be used.]

[6] IRC Section P2904.1

purged by flushing the toilet to prevent stagnant water. This arrangement is referred to as "passive purge." Although there is no evidence that "aged" stagnant water in piping complying with NSF 61 for potable water conveyance ever becomes unsafe, water purveyors who harbor concern about aged water are typically satisfied that backflow prevention is not necessary when a passive purge connection is provided on an otherwise standalone fire sprinkler system.

- Where a yard irrigation system is installed, backflow prevention will be required because such systems are subject to backflow of nonpotable water. Fire sprinklers can share the irrigation backflow preventer, thereby eliminating the need for an additional device.

Tank-and-Pump Option

As indicated above, if the water distribution system or well provides enough water to supply household plumbing needs, the supply may be adequate for fire sprinklers. In some cases, a larger pump or tank may be needed for sprinklers, but standard, off-the-shelf pumps and tanks suitable for plumbing systems are permitted for fire sprinkler service. A tank-and-pump option installation actually benefits the owner on a daily basis beyond fire protection, because the home's plumbing system will be more robust, and the additional water storage can also be invaluable for emergency use in the event of a natural disaster that interrupts utilities. Use of a tank and pump also eliminates any concern for backflow prevention because the tank fill connection provides an air break that separates stored water serving fire sprinklers from the water purveyor's supply.

Section 6.2, Water Supply Source, in NFPA 13D allows that a well with a pump of sufficient capacity and pressure will meet sprinkler system demand. The cost of the tank-and-pump system for a ten-minute water supply varies in price but can range from $1800 to $2500.

If you don't have enough water for fire sprinklers, you don't have enough for fire hydrants.

Where a rural water distribution system is considered to be inadequate to supply the minimum 16 gpm needed for fire sprinklers, the supply will also almost certainly fall short of the minimum code-required plumbing demand. Furthermore, it will absolutely fall far short of the 1,000+ gpm needed from fire hydrants to support a fire department extinguishing a fire in an unsprinklered home.

ISSUE 3

What are the related costs for installation outside of the building footprint for this water service, excavation costs, and other related expenses?

2011 Findings

The cost would vary depending on the nature of the soil (rock, ledge, etc.). An approximate cost of $2,500 was obtained for a 100-foot-long trench with a 1 in. copper water service pipe installed from the curbside to the foundation. *This cost would offset for newly constructed residential buildings because of utilization of the same trench and water service pipe to the home.*

New Findings
In the original report of the Connecticut Residential Fire Sprinkler Research Working Group, it was reported that the cost of an underground water service would vary, depending on the nature of the soil (rock, ledge, etc.). The report included an estimated cost of approximately $2,500 for a 100 ft.-long trench with a 1 in. copper water service pipe installed from the curbside to the foundation, and it was stated that this cost would be offset for newly constructed residential buildings by utilizing the same trench and water service pipe to the home.

The last statement offered by the original report remains true today. A trench and a water service line will be provided for any home built with an indoor plumbing system. Changing the size of the service line to accommodate fire sprinklers, if necessary, is of negligible cost, particularly where plastic service lines are permitted. Since the expense of excavating for and installing a service line is necessary for plumbing, that expense cannot be fairly attributed as an additional cost associated with providing fire sprinklers.

ISSUE 4

What is the estimated financial installation cost (relative to the State of Connecticut construction industry) of the NFPA 13D system inside the residence, based on NFPA 13D installation requirements?

2011 Findings
The committee decided to use a typical, two-story, 2,500 ft^2 house with a full basement, placing the total square footage at 3,750 ft^2. An American Institute of Architects (AIA) committee member drew up a set of plans that included elevations, floor plans, and basement plans. These plans were sent out to a number of sprinkler contractors throughout the state with a letter asking for cost estimates for the design and installation of a standard system installed to the NFPA 13D standard using black iron piping in the basement and CPVC fire sprinkler piping for the house.

The installers and designers were requested to submit two costs, one for the installation of a system for municipal water and one for the installation on a well system. The committee received four estimates for the installation. One of the estimates was disqualified for not complying with the requirements. These estimates also included the design cost.

Based on the information submitted, the average cost of design work for the typical 2,500 ft^2 colonial is $500. The average cost for the typical 2,500 ft^2 colonial on a municipal water system is $6,904, with an average cost of $1.84/ft^2. The average cost for the typical 2,500 ft^2 colonial on a well system is $6,843, with an average cost of $1.82/ft^2. (Note: These prices do not reflect any profit margin of the general contractor.)

New Findings
In the original report, an estimate was prepared for sprinklering a typical two-story 2,500 ft^2 house with a full basement (total square footage was 3,750 ft^2). It was also assumed that the full cost of the sprinkler system would be passed on to the homebuyer, which may or may not be the case. In addition, no credit was assumed for cost offsets, such as not having to provide a fire-resistive membrane or other method required by the IRC to fire protect the basement ceiling assembly, which is not needed when fire sprinklers are installed.

An AIA committee member drew up a set of plans that included elevations, floor plans, and basement plans. These plans were sent out to a number of sprinkler contractors throughout the state with a letter asking for cost estimates for the design and installation of a standard system installed to the NFPA 13D standard using black iron piping in the basement and CPVC fire sprinkler piping for the house. Since the time that this initial estimate was prepared, CPVC has been listed for exposed use in unfinished basements, which significantly reduces the cost of protecting the basement and typically eliminates the need for backflow prevention.

The estimates noted above do not reflect any profit margin of the general contractor.
It's important to also note that once fire sprinklers are required in all Connecticut homes, market demand can help drive down installation costs. NFPA's "Home Fire Sprinkler Cost Assessment – 2013" report concluded that in states requiring fire sprinklers in all new homes, a decline in installation costs can be expected based on increased demand and more competitive pricing by installing contractors.

Supplemental Finding

Contrary to often repeated claims that adding a fire sprinkler requirement will negatively impact the housing market, no evidence has ever been provided to substantiate that assertion. An NFPA study examining more than 100 jurisdictions with fire sprinkler requirements, "Comparative Analysis of Housing Cost and Supply Impacts of Sprinkler Ordinances at the Community Level," found that enactment of a fire sprinkler ordinance caused no detrimental effects on housing supply and costs. This finding is further supported by an analysis of single-family unit construction data in the U.S. Census Bureau's American Housing Survey that was performed for this report. In the case of California, which implemented a statewide requirement for new homes effective January 1, 2011, approximately 170,000 single-family dwelling units have been constructed with fire sprinklers, and the number of units constructed annually more than doubled between 2011 and 2015.

This result should not come as a surprise because fire sprinkler systems represent a small fraction of the cost of building a new home. Builders are skilled at dealing with price swings associated with changes in material costs, labor costs, and interest rates by adjusting home features and prices in a way that matches sales prices with local markets.

Consequently, where sprinklers are required in new homes, builders simply adjust their products, with sprinklers included, to meet the market. Incorporating fire sprinklers as a standard feature is no different than providing granite countertops, wood floors, upgraded cabinets, or plumbing fixtures as a standard feature. In either case, the builder adapts the base sales price to include these features.

Even if builders were to add the full cost of a residential fire sprinkler system to the sales price of a home, the impact of that variation would be negligible in the monthly payment on a 30-year mortgage. Using the 2,500 ft^2 example home and applying the $1.84/$ft^2$ cost (which would be expected to drop based on the new allowance to use plastic piping to protect unfinished basements):

- The gross installation cost of $4,600 would yield a net monthly cost of $4.47 on a three percent, 30-year mortgage, after estimated savings of a five-percent credit on an

estimated $2,000 annual insurance bill and a mortgage interest deduction using a combined 34 percent federal/state income tax rate.
- Substituting the national cost estimate of $1.35/ft^2 published in NFPA's "Home Fire Sprinkler Cost Assessment" report, the net monthly cost drops to $1.06 using the same estimated savings applied above.

The net monthly expense roughly equates to the cost of a premium beverage at a local coffee shop, or less. Based on the increased level of safety provided to people, pets, and property, this investment seems very cost-effective.

ISSUE 5

Who is the licensed installer who can install this system, and how many of such individuals are licensed in Connecticut and are available to do this work?

2011 Findings
At this time, Connecticut requires that persons installing a fire suppression system be licensed for such work. The licensed installers are unlimited fire protection sprinkler contractors (F-1) and unlimited fire protection sprinkler journeypersons (F-2) provided he/she is an employee of an F-1 contractor. There are 666 licensed F-1 contractors and 854 F-2 journeypersons licensed in the State of Connecticut.

Note: A homeowner can install an NFPA 13D fire suppression system without a license if it is installed only within a standalone, single-family dwelling; a license is required for townhouses and two-family dwellings.

New Findings
There are currently 480 licensed F-1 contractors, 854 F-2 journeypersons, and 396 contractors with F-1/P-1 combination licenses in the state. Contractors with F-1 and P-1 licenses are permitted to install multipurpose systems.

Supplemental Finding
To provide for increased contractor availability and market competition, multipurpose fire sprinkler systems that serve fire sprinklers from the cold water domestic plumbing service are recognized as an option to standalone fire sprinkler systems in one- and two-family dwellings and townhouses. Contractors with F-1 and P-1 licenses are permitted to install multipurpose systems.

Connecticut is in the active process of developing a limited license for a F7 and F8 two-year apprenticeship to install fire sprinklers in new one- and two-family dwellings. The end result will yield a limited license to install residential fire sprinklers in newly constructed one- and two-family homes with a multipurpose system.

On October 20, 2016, the Fire Protection Sprinkler Systems Work Examining Board voted unanimously to investigate a limited license category for multipurpose residential fire sprinklers in one- and two-family dwellings per NFPA 13D, with the training and exam to be determined by the Board, DCP, and DOL.

On November 17, 2016, the Fire Protection Sprinkler Systems Work Examining Board reviewed the Proposed Regulations for Licensure for Limited Residential Fire Sprinkler Work Draft Revision dated November 4, 2016. After discussion, the Board voted unanimously to move forward with the Limited Residential License categories of F-7/F-8.

ISSUE 6

Who can be the responsible individual to design the system? Can a homeowner do this?

2011 Findings

Section 29-263 of the Connecticut General Statutes states "In the event that working drawings are used for the installation, alteration, or modification of a fire sprinkler system, no state, city, town, or borough building official responsible for the enforcement of laws, ordinances, or regulations relating to the construction or alteration of buildings or structures, pursuant to section 29-263, shall accept or approve any such drawings or specifications which are not accompanied by evidence of licensure by the state as an automatic fire sprinkler system layout technician licensed pursuant to section 20-304a or are not accompanied by evidence of licensure by the state as a professional engineer in accordance with chapter 391."

New Findings

According to Sec. 29-263a of the Connecticut General Statutes, working drawings are to be accompanied by evidence of licensure by the state. "*In the event that working drawings are used for the installation, alteration, or modification of a fire sprinkler system, no state, city, town, or borough building official responsible for the enforcement of laws, ordinances, or regulations relating to the construction or alteration of buildings or structures, pursuant to section 29-263, shall accept or approve any such drawings or specifications which are not accompanied by evidence of licensure by the state as an automatic fire sprinkler system layout technician licensed pursuant to section 20-304a or are not accompanied by evidence of licensure by the state as a professional engineer in accordance with chapter 391.*"

Further, it is certainly feasible for a homeowner to design sprinkler systems in accordance with NFPA 13D or Section P2904 of the IRC for a new home. The task is no more complex than designing an irrigation sprinkler system, and brochures instructing homeowners how to do that are readily available online and in stores that sell irrigation equipment.

One of the primary reasons that Section P2904 was added to the IRC was to provide a simple, cookbook design basis for residential sprinkler systems that could be used by builders, plumbing contractors, and homeowners for a fire sprinkler system. The method was later adopted by NFPA 13D. Both standards provide a path for a simple design that literally can be accomplished with a hand sketch and a calculator. NFPA 13D, 2016 edition, states in Section 4.6, Qualifications, *The layout, calculation, and installation of sprinkler systems installed in accordance with this standard shall only be performed by people knowledgeable and trained in such systems.*

Residential sprinkler design tools are available at www.IRCFireSprinkler.org on the resources page.

ISSUE 7

What are the required annual maintenance and inspection requirements of an NFPA 13D residential sprinkler system? Can a homeowner do this or a specialized tradesman?

2011 Findings

Annual maintenance and inspections consist of do-it-yourself procedures by homeowners. Keeping the control valve open, not hanging items from sprinklers, and making sure that the sprinklers do not get painted or obstructed are the most important items. It is also important to know where the control valve is located so that the water can be shut down after sprinkler activation to minimize water damage. The building owner or manager should understand the sprinkler operation and should conduct periodic inspections and tests to make sure that the system is in good working condition. Recommended inspection and testing includes the following simple procedures:

- Monthly inspection of all valves to ensure that they are open
- Monthly inspection of tanks, if present, to confirm that they are full
- Monthly testing of pumps, if present, to make sure that they operate properly and do not trip circuit breakers when starting
- Testing of all water flow devices, when provided, every six months, including monitoring service (Note that notification of the monitoring service is essential to make sure that the fire department is not called due to testing.)
- Ongoing visual inspection of all sprinklers to make sure that they are not obstructed and decorations are not attached or hung from them
- Whenever painting or home improvements are made in the dwelling unit, ensure sprinklers are not painted or obstructed either at the time of installation or during subsequent redecoration. When painting near sprinklers, cover them with a bag and remove it immediately after painting.

New Findings

Although the aforementioned inspection and maintenance procedures are recommended, the reality is that sprinkler systems can be expected to perform for decades with little to no maintenance if left unchanged, and any basic inspection or maintenance task can be performed by a homeowner. This is clearly demonstrated by decades of history in jurisdictions that have enacted residential sprinkler ordinances for new home construction. Reports from jurisdictions that allow homeowners to inspect, test, and maintain their sprinkler systems, including Scottsdale, Arizona; Prince George's County, Maryland; and California have not shown any pattern of unsatisfactory performance associated with inadequate system maintenance or inspection by homeowners or tenants.

- If valves supplying water to a standalone sprinkler system are secured in the open position using a lock or nylon tie, they can be expected to remain in the open position. In the case of a multipurpose sprinkler system, the availability of water to sprinklers is verified every time someone operates a plumbing fixture, such as a faucet or toilet.
- NFPA 13D now requires that tanks have an automatic fill connection. Without someone taking specific action to drain a tank, it can be expected that the tank will always remain full without additional inspection.
- Although it is good practice to exercise plumbing pumps, NFPA 13D now requires all pumps to be connected to a 240-volt supply circuit. The purpose of this voltage vs.

allowing pumps to be connected to a 120-volt supply is to ensure adequate torque to start a motor that has remained stationary for an extended period of time.

- Waterflow alarms are not required equipment on NFPA 13D sprinkler systems. However, if a waterflow alarm is provided, an owner may wish to conduct an occasional operation test to verify functionality. However, it is important to note that failure of the waterflow alarm will NOT adversely impact the operation of a fire sprinkler system with respect to suppressing a fire.
- Without a deliberate action to impair a sprinkler in a home, there is no reason to expect that sprinklers would become obstructed, painted, or have decorations hung from them.

ISSUE 8

What components are needed to install such systems, and will product suppliers sell the materials such as sprinkler heads and related equipment to homeowners or to only licensed contractors?

2011 Findings

An automatic sprinkler system consists of valves, pipes, and sprinklers with heat-sensitive elements. The system is connected to a water supply system such as a city main or water tank. When heat from a fire raises the temperature, it melts a fusible element located in the sprinkler near the fire, thus releasing water. Each sprinkler head operates independently, distributing water only *over* the area of the fire. The melting temperature of the fusible element (usually 155 degrees Fahrenheit) is referred to as the rating of the sprinkler.

New Findings

Unlike many refrigerants or commercial pesticides, which require special licensing to purchase, there are no federal, state, or local regulations that restrict the purchase of components needed to install a residential fire sprinkler system. All such components are available for purchase at distributors' facilities. Examples of large national companies with local distribution that sell residential fire sprinkler equipment to the public in and near Connecticut include F. W. Webb, HD Supply, and Ferguson Enterprises, Inc. Components of the NFPA 13D sprinkler system can be found in Chapter 5, System Components.

ISSUE 9

Will the municipalities include this new system as an additional item to financially assess the homeowner on, and what are the implications of such annual cost assessment to a homeowner?

2011 Findings

Approximately 20 towns were contacted in order to determine whether or not they would financially assess the homeowner on an NFPA 13D sprinkler system. Most towns have a computer-based appraisal system. Some of these systems include "sprinklers within a home" and others do not. The cost between the 12 towns that assess sprinklers within single-family dwellings are from $60 to $300 based on the mill rate as well as a wet, dry, or concealed system and the square footage of the home.

New Findings

In looking at Hartford County, for instance, which has a tax rate of 2.038 percent and assuming a $5,000 increase in value based on sprinkler installation, it yields only a $100 bump in the annual tax rate. It appears that the original data included faulty information as it came up with $300/year for sprinklers. Therefore, it is inconclusive.

ISSUE 10

What are the specific insurance implications to a homeowner?

2011 Findings

Homeowner policies have coverage for both property (building and contents) and liability (injury to others and negligence). The rate charged and resultant premium paid are a composite of the property exposure and the liability exposure. Three companies provide credits that apply to the composite premium. The first company provides a credit on only the property portion of the premium. The first and second companies are using the Insurance Services Office (ISO) rates. The third company has individually filed rates. Additional research can be obtained by reviewing all insurance company filings at the State Insurance Department.

Connecticut Rate Survey

Company 1:	13 percent credit for full protection (NFPA 13) 8 percent credit for NFPA 13D system No variation of type of water supply Applies to base policy premium No change in credit between “high value” and standard homes
Company 2:	10 percent credit for full protection (NFPA13) 6 percent credit for NFPA 13D system Applies to the fire portion of the policy premium No change in credit between “high value” and standard homes
Company 3:	13 percent credit for full protection (NFPA 13) 8 percent credit for NFPA13D system Applies to the total premium No change in credit between “high value” and standard homes

The Insurance Services Office (ISO has published advisory rates to 13 percent for NFPA 13 systems and 8 percent for NFPA 13D systems. ISO also develops and provides a community grading (1 through 9) that is an evaluation of local fire department, water supply, communications, and code enforcement functions. Many insurance companies use this grading in their rating and premium calculation processes. ISO would “downgrade” a community that has adopted a code with amendments that weaken the code.

New Findings
The following insurance companies were contacted regarding insurance incentives to homeowners installing a NFPA 13D sprinkler system in a newly built home in Connecticut.

Allstate Insurance:	On average 10 percent policy discount
State Farm Insurance:	On average 6 percent policy discount
Progressive Insurance:	Varied on average 5 to 20 percent

Additional insurance considerations that were not fully described in the initial findings relate to ISO's rating of local building code effectiveness and enforcement. ISO administers a Building Code Effectiveness Grading Schedule (BCEGS) that evaluates the strength of local codes and code enforcement and assigns a score that directly impacts property insurance ratings for new buildings, both residential and commercial.

It is important to note that a better community insurance rating is analogous to a rising tide that lifts all boats. But, the opposite is also true. Code amendments that weaken requirements of national model codes, such as deleting the requirement for new homes to be equipped with residential fire sprinkler systems, yield penalties in the BCEGS score that increase insurance premiums for all new buildings, not just homes.

By supporting an amendment to the Connecticut residential code that removes residential sprinkler requirements, the homebuilding industry is able to increase its own profit by passing a financial burden on owners of all newly constructed commercial and residential properties in the form of higher insurance premiums that may last throughout such properties' lifespans. In addition, all new and existing property owners, both commercial and residential, insured under the National Flood Insurance Program (NFIP), may pay higher premiums for flood insurance because the NFIP references ISO's BCEGS score as part of the NFIP rating calculation.

Long after home builders are gone, communities will continue to pick up the tab for the cost of not requiring home fire sprinklers in the form of:

- Increased property insurance premiums for unsprinklered properties
- Increased property insurance premiums for properties in a community having a lowered BCEGS score
- Increased flood insurance premiums for properties insured under the NFIP
- Increased risk to current and future owners of properties that could have been sprinklered cost-effectively when new, but cannot be reasonably retrofitted with sprinklers due to the high cost of replacing the water service and concealing sprinkler piping behind existing walls and ceilings
- Increased cost of providing fire service resources, both manpower and equipment, to protect unsprinklered properties
- Increased risk to firefighters who will be called upon to enter burning homes in an attempt to rescue trapped occupants

Another point to be made is debunking the myth that insurance companies may raise premiums because of concerns related to the risk of water damage from a fire sprinkler system. The IRC Fire Sprinkler Coalition reviewed this concern with ISO, State Farm, and major insurers several years ago and could not find a single insurer that assigned a rate increase associated with this possible concern. Although there are occasional anecdotes of uninformed local insurance agents making such claims, none have ever been validated as accurate.

ISSUE 11

What are the financial costs to rebuild a home that experiences a fire with and without a residential sprinkler system, here in Connecticut and/or the Northeast?

2011 Findings

These were simultaneously answered in Issue 12.

New Findings

The state of Connecticut reported more than $22 million in fire property loss to dwellings during 2016. Research confirms that home fire sprinklers have the capability of significantly minimizing fire damage. In reported home fires with wet pipe sprinklers between 2010-2014, the average direct property loss per fire was less than half that of fires in homes with no automatic extinguishing system (see NFPA's "Home Structure Fires" report, 2016). The Federal Emergency Management Agency (FEMA) has also considered residential fire sprinkler systems to be a valuable tool in helping reduce the risk of deaths, injuries, homeowner insurance premiums, and uninsured property loss.

However, no local or other regional source of information could be identified to respond to this question. The most relevant long-term analysis providing insight to answer this question is reported in a document titled *Benefits of Residential Fire Sprinklers: Prince George's County 15-year History with its Single-family Residential Dwelling Fire Sprinkler Ordinance*, which was published in 2009. This report documents the county's experience with fire losses in one- and two-family dwellings and townhouses, with and without fire sprinklers, 15 years after an ordinance was enacted requiring all newly constructed homes in the county to have fire sprinklers. During the 15-year period, there were 13,494 fires in these occupancies, which caused $134 million in damage.

Assuming that few homes were sprinklered prior to enactment of the ordinance, the impact of sprinklering all new homes after the ordinance triggered was readily evident in future loss data. In the 15-year period, the county issued more than 45,000 permits for construction of one- and two-family dwellings and townhouses. Even though these properties were "new" at the time of completion, the county recorded 245 activation incidents, with a potential loss risk estimated at $42 million in fire-related property damage. However, based on sprinkler activations, the total loss was reduced to approximately $1.3 million, or just over $5,000 per incident.

Even though sprinklers discharge water to extinguish a fire, the volume of water discharged is far less than what will be used by the fire department when hoses are needed for manual suppression. The City of Scottsdale, Arizona studied this in an attempt to quantify the difference, and concluded that, on average, a nonsprinklered residential fire will require 2,935 gal of water to suppress a fire vs. 341 gal for a fire in a sprinklered home. That's a reduction in water discharged of nearly 90 percent.

The reduced water discharged by sprinklers translates to less damage and reduced cost of rebuilding. Reduced fire damage associated with sprinkler-controlled fires versus waiting for the fire department to arrive and suppress a fire also translates to a cost reduction for rebuilding. However, the focus on dollar loss and rebuilding cost completely ignores the human toll of losing a home, possessions, pets, and the challenge of rebuilding your life after a devastating fire.

Even when insurance covers some or all of the loss, the challenge of documenting loss of goods and collecting on a home insurance claim is daunting. A sprinkler-suppressed fire typically involves little fire damage, leaving possessions intact for documenting insured damage and typically allowing a family to move back into a home the same day or shortly thereafter. An often-used quote related to fire sprinklers is pertinent: “Wet things will dry out; burned things won’t unburn.”

ISSUE 12

What are the impacts on firefighters, first responders, as well as residential occupant safety?

2011 Findings

The committee decided to answer these two questions together based on the fact that information that was obtained dealt with both issues in a consolidated manner.

Newer Homes and Fire

Opponents of residential fire sprinkler systems like to boast that newer homes are safer homes and that the fire and death problem is limited to older homes. Age of housing is a poor predictor of fire death rates. When older housing is associated with higher rates, it usually is because older housing tends to have a disproportionate share of poorer, less-educated households. Statistically, the only fire safety issue that is relevant to the age of the home is outdated electrical wiring. Beyond that, age of the home has little to nothing to do with fire safety. In fact, new methods of construction negatively impact occupant and firefighter life safety under fire conditions. The National Research Council of Canada (NRC) tested the performance of unprotected floor assemblies exposed to fire. The findings of the study, “The Performance of Unprotected Floor Assemblies in Basement Fire Scenarios” assert that these structures are prone to catastrophic collapse as early as six minutes from the onset of fire.

In 2008, Underwriters Laboratories (UL) conducted a study to identify the danger to firefighters created using lightweight wood trusses and engineered lumber in residential roof and floor designs. The findings of the report, “Structural Stability of Engineered Lumber in Fire Conditions,” point to the failure of lightweight engineered wood systems when exposed to fire. Firefighters expecting 30 minutes of structural integrity with dimensional wood structures face higher peril in lightweight structures. The same UL study found that the synthetic construction of today's home furnishings adds to the increased risk by providing a greater fuel load. Larger homes, open spaces, increased fuel loads, void spaces, and changing building materials contribute to the following:

- Faster fire propagation
- Shorter time to flashover
- Rapid changes in fire dynamics

- Shorter escape time
- Shorter time to collapse

Lightweight construction has been variously estimated to be used in one-half to two-thirds of all new one- and two-family homes. Fire sprinklers can offset the increased dangers posed by unprotected lightweight construction and create a safer fire environment for firefighters to operate in.

Home Fire Sprinkler Requirements — Impact on Fire Service

Requiring fire sprinklers in new homes helps fire service efforts. Adopting home fire sprinkler requirements has allowed the fire service to keep up with growth and to continue to provide an appropriate level of service, which many times translates into savings for a community. Where fires occur in sprinklered buildings, fewer man hours are spent fighting the fire. As such, fire-fighters are freed up to handle other tasks necessary of the fire department without having to employ additional personnel. Also included in this category are the savings in materials used to fight a fire, such as fuel for fire trucks, which are left running during a fire event, and water, which costs the utility money to clean and make available at the hydrant. Fires in buildings with sprinkler systems use thousands of gallons of water less than fires that occur in unsprinklered property.

Residential Sprinklers

Residential fire sprinkler systems are specifically intended to provide a minimum of 10 minutes of egress time to dwelling occupants, and therefore are primarily life safety devices. Residential sprinklers are not intended to protect the structure. However, in most real world cases a single sprinkler operates and controls or extinguishes the fire, saving both lives and property. Given the focus on the life-safety aspect of residential sprinkler systems, there has been limited research or testing designed to quantify the property protection benefits of these systems. Additionally, the research that has been conducted to quantify the value of residential sprinklers has typically addressed only the building occupants and has not considered additional benefits arising from firefighter safety. It is generally observed that once a fire progresses from its area and material of origin and begins to involve the building structure, it is difficult for offensive manual firefighting operations to successfully intervene. A very common outcome in these cases is total loss of the involved structure.

Real scale tests using sprinklered and unsprinklered structures including typical lightweight, composite wood joist ceiling/floor assemblies were conducted at UL. The tests demonstrated that residential sprinklers operating at flow rates as low as 13 gpm can arrest fire growth rates sufficiently to prevent excessive fire damage and structural collapse. Tests without sprinklers indicate total failure of the structure can occur in under 10 minutes from ignition.

The results from this test series demonstrate that exposed, lightweight composite wood joists are likely to fail three to five minutes after compartment flashover for structures with typical residential loadings. Further, the time to collapse as measured from the start of flaming combustion for the fire scenarios employed in this test series was between eight and 12 minutes. This relatively small timeframe prior to the failure of exposed, composite wood joists may require the fire service to adopt alternative tactics and procedures for structures built using lightweight construction methods. This test program further highlights the dramatic differences between the sprinklered and unsprinklered scenarios, as demonstrated through photographs, observations, and data collected.

All of the information presented shows that the addition of a sprinkler system can greatly enhance life safety of both residents and firefighters and aid in property protection. Today's homes contain more products with higher heat release rates than in previous years and the construction of these homes has become less fire resistant due to the use of unprotected, lightweight construction materials. This combination has proven to be deadly for firefighters.

New Findings

The National Research Council Canada (NRC) also examined how fire impacts such unprotected floor assemblies and concluded that lightweight assemblies diminish to the point of structural failure 35 to 60 percent faster than dimensional lumber assemblies. A 2012 report from the Fire Protection Research Foundation also underscored the danger of engineered lumber during a fire, labeling its rapid structural failure under fire conditions a "high" level of concern.

Underwriters Laboratories (UL) conducted another study on the topic and published the results in a report, "Structural Stability of Engineered Lumber in Fire Conditions." UL's full-scale tests concluded that lightweight construction assemblies can collapse in as little as six minutes versus more than 18 minutes for legacy dimensional lumber. This is a concern for occupants who may not be able to readily escape from a fire and the firefighters who are called upon to rescue them. Firefighters typically arrive and make entry within six to 10 minutes of receiving a call, and there is a direct correlation between the time of collapse of lightweight floor assemblies and the time that firefighters begin search and rescue operations.

This correlation has played out in numerous residential fires where firefighters entering a dwelling for search and rescue or leaving with a victim have fallen through a failing floor assembly into the fire below. The failures typically occur with no warning, as the level above the floor may only be lightly or moderately charged with smoke while an inferno in the basement below is cooking the floor assembly.

The same UL study found that the synthetic materials used in modern home furnishings increase fire risks by providing an increased fuel load and a higher rate of heat release than furniture made with natural fibers. Larger homes, open spaces, increased fuel loads, void spaces, and changing building materials all contribute to the following:

- Faster fire propagation
- Shorter time to flashover
- Rapid changes in fire dynamics
- Shorter escape time
- Shorter time to collapse

Some estimates suggest that lightweight, engineered construction materials are used in one-half to two-thirds of all new one- and two-family homes. Fire sprinklers offset the increased danger associated with such materials and synthetic furnishings, reducing the risk of the fire environment for firefighters and occupants by reducing the rate of fire growth or entirely extinguishing a fire, which:

- Allows more time for occupants and their pets to escape

- Reduces the likelihood that firefighters will need to perform dangerous search and rescue operations in a burning structure
- Reduces the risk associated with firefighters fighting a large, uncontrolled fire
- Reduces the risk of surrounding structures being exposed to a large fire next door

It is important to point out that, according to the United States Fire Administration's National Fire Department Registry, 85 percent of Connecticut fire departments are comprised of all volunteers or mostly volunteers. There is a national trend of increasing difficulty recruiting and retaining volunteer firefighters, and the diminishing number of firefighters reduces resources available to fight uncontrolled residential fires and diminishes firefighter safety by placing more demand on fewer firefighters at the fire scene.

With ever-increasing job and family demands and a general reluctance on the part of businesses to allow employees to leave work for fire calls, it is incumbent on builders and homebuyers to recognize the need for providing built-in fire protection as opposed to expecting the fire service to always arrive in time to save lives and property. Residential fire sprinklers are the solution to this increasingly important concern.

Supplemental Finding

NFPA's report, "Sprinkler Impact on Fire Injury," explores the impact of residential sprinklers on fire-related injuries in sprinklered and nonsprinklered homes. The report states that sprinklers provide the following:

- An 80 percent reduction in the rate of civilian fire deaths per 100 fires
- A 65 percent reduction in the rate of firefighter fireground injuries per 100 fires
- A 29 percent reduction in civilian injuries per 100 reported fires
- A 53 percent reduction in medical cost of civilian injuries per 100 reported home fires

A relevant long-term, jurisdiction-specific analysis providing statistical evidence that quantifies a relative answer to this question is the report *Benefits of Residential Fire Sprinklers: Prince George's County 15-year History with its Single-family Residential Dwelling Fire Sprinkler Ordinance*. The report documents Prince George's County, Maryland, experience with fire losses in one- and two-family dwellings and townhouses, with and without fire sprinklers. In the 15-year period since the sprinkler ordinance was enacted, there were 101 fire deaths and 328 civilian injuries in single-family and townhouse fires in non-sprinklered properties versus no fire deaths and six civilian injuries in the 245 activation incidents that were recorded in sprinklered properties.

ISSUE 13

What is the education needed to understand the requirements of the 2009 International Residential Code, Sections R313 and P2904, for potential user groups such as the construction industry, and code officials relative to NFPA 13D?

2011 Findings

The committee found that training on residential fire sprinkler systems is necessary to educate the affected stakeholders. These stakeholders are members of the fire service, building departments, building developers, architects, fire sprinkler contractors, public/private water suppliers, public health officials, and other interested parties throughout Connecticut. Additionally, the committee found that through the Office of Education and Data Management, NFPA, International Code Council and the sprinkler industry, this training is readily available.

New Findings

The Connecticut Fire Sprinkler Coalition (CFSC), which maintains a webpage at www.FireSprinklerInitiative.org/Connecticut, was formed with a goal of serving as an education resource for residential fire sprinkler systems. CFSC has already hosted meetings for stakeholder groups, such as water purveyors, and has created and distributed a public education pamphlet related to residential sprinklers. CFSC has also conducted live burn demonstrations showing the functionality and effectiveness of residential sprinklers. Videos documenting this and more are also on the CFSC site.

When Connecticut adopts the IRC requirement for fire sprinklers in new homes, CFSC and its partner organizations will readily provide free training throughout the state to facilitate understanding by builders, code officials, homeowners, and others with an interest in the topic. These programs will also benefit builders by emphasizing incentives that are available to offset the cost of sprinkler installations. For example, the 2012 residential code allows waiving the requirement to fire protect the floor assemblies, as required by Section R501.3 (moved to R302.13 in the 2015 IRC), which can provide a significant cost reduction and eliminate the complexity sometimes associated with framing and installing a basement ceiling.

The IRC Fire Sprinkler Coalition www.ircfiresprinkler.org and the Home Fire Sprinkler Coalition www.homefiresprinkler.org also provide many online resources that support builders, homeowners, code enforcer/inspectors, and other stakeholder groups seeking information on residential fire sprinklers. NFPA also offers free public education in the form of downloadable and printable information via its Fire Sprinkler Initiative, FireSprinklerInitiative.org.

The U.S. Fire Administration (USFA) and our National Fire Academy offer free training and education programs to support fire departments and emergency services organizations. Both the U.S. Fire Administration (USFA) and The Federal Emergency Management Agency (FEMA) offer grant funding available to educate and understand the requirements for fire safety, code, regulation, and training.

The National Fire Sprinkler Association (NFSA) offers training seminars on training, standards, and new requirements in NFPA 13D. Since 2012, NFSA has offered and will provide the following classes:

5/17/2012	NFPA 13, 13R, and 13D Update, 2010
6/14/2012	Hydraulics for Fire Sprinkler Systems
8/15/2012	Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
6/12/2014	Understanding, Applying, and Enforcing NFPA 25
7/30/2014	Pumps for Fire Protection
1/6/2015	Sprinkler System Plan Review
2/5/2015	ITM: Navigating through the Liability Minefield
9/30/2015	Rough and Final Inspections of Fire Sprinkler Systems
3/3/2016	Seismic Protection for Sprinkler Systems

8/25/2016	Sprinkler System Plan Review
9/14/2016	Sprinkler Protection of Storage
11/9/2016	Understanding, Applying, and Enforcing (UAE) NFPA 25
11/29/2016	UAE NFPA 25
3/1/2017	Pumps for Fire Protection
5/11/2017	NFPA 13D Automatic Sprinkler Systems
5/23/2017	NFPA 13D Automatic Sprinkler Systems
5/23/2017	NFPA 13D Automatic Sprinkler Systems
5/30/2017	NFPA 13D Automatic Sprinkler Systems
6/1/2017	NFPA 13D Automatic Sprinkler Systems

The Connecticut Fire Marshals Association in collaboration with The National Fire Sprinkler Association have developed the Connecticut Fire Sprinkler Awareness Program. The program offers free education and raises public awareness about the life-saving value of fire sprinkler technology. Educational events on fire sprinklers are taking place throughout 2017 in Connecticut, including the Construction Pro Rodeo, Fire Team USA, and town-specific events. Other supporters of the program include State Farm, CFSC, and the Connecticut Chapter of the National Fire Sprinkler Association.

Recommendation from the Connecticut Fire Sprinkler Coalition

Members of the coalition have seen firsthand the realities of today's home fires and recommend the Codes and Standards Committee to embrace the solution to this problem. Basing its opinions on the extensive research found in this report, it is the positon of the coalition that the Codes and Standards Committee vote to adopt the 2015 IRC with the requirement to fire sprinkler the state's new one- and two-family homes intact. This requirement can be implemented cost-effectively and without any adverse effects to the state's housing market. Moreover, it will help safeguard residents from future tragedies associated with home fires.

ATTACHMENTS

1. State of CT Correspondence
2. Residential Sprinkler Committee Members
3. House Diagram
4. Riser Diagram
5. UTC Fire & Security
6. Annex A of NFPA 13D, 2016 Edition

STATE OF CONNECTICUT

DEPARTMENT OF CONSTRUCTION SERVICES

Office of the State Building Inspector

November 1, 2011

Louis Free, AIA
Chairman, Codes and Standards Committee
1111 Country Club Road
Middletown, CT 06457

Dear Chairman Free:

Attached please find the Connecticut Residential Fire Sprinkler Working Group Final Report that addresses the issues that the Codes Amendment Subcommittee have raised.

The members of the Working Group will be happy to attend the next Codes Amendment Subcommittee meeting to address any questions you might have regarding our findings.

Please let me know when you would like us to attend.

Sincerely,

Daniel Tierney,
Co-Chairman

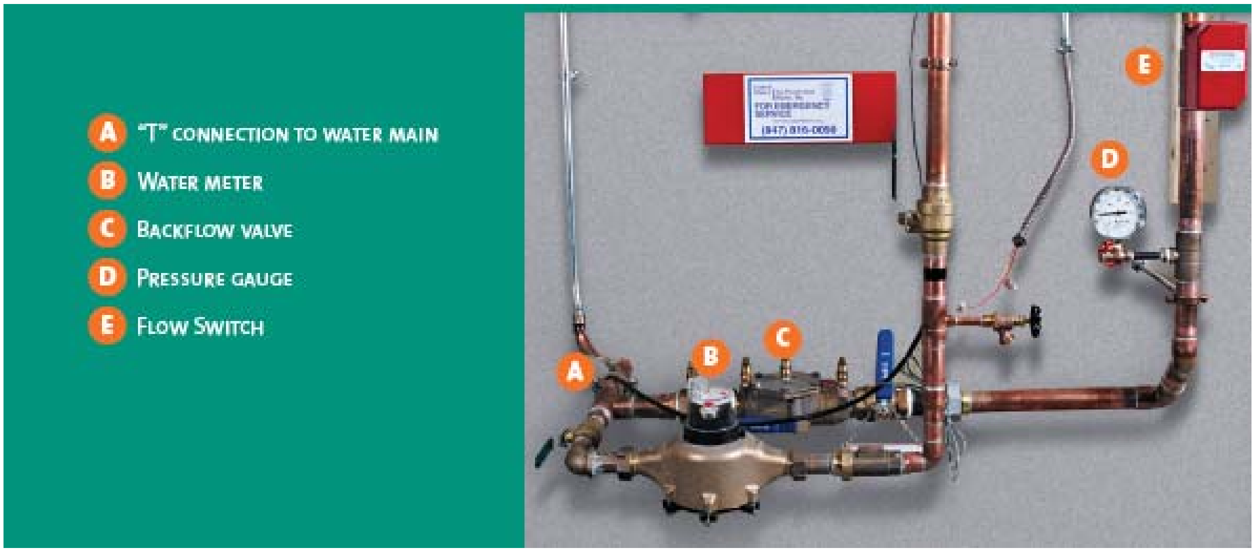
DT:pm
Attachment

1111 Country Club Road, Middletown, CT 06457
Phone: (860) 685-8310 / Fax: (860) 685-8365 www.ct.gov/dps
An Equal Opportunity Employer

RESIDENTIAL SPRINKLER COMMITTEE MEMBERS

NAME	REPRESENTING
Appleby, Chuck	CT Plumbers Association
Campion, Brooks	Robinson and Cole
Carozza, Peter	President, Uniformed Professional Fire Fighter of CT
Crombie, Phillip Jr.	Insurance Industry
DiPace, Jamie	CT Fire Chiefs
Doyle, John	American Institute of Architects, CT Chapter
Duval, Robert	National Fire Protection Association
Ellrod, Earl III	American Society of Plumbing Engineers, CT Chapter
Finn, Brian	Local 669 Sprinkler Fitters Union
Fusari, Robert Sr.	CT Home Builders Association
Huber, J. Whitney	AIA-American Institute of Architects
Hurlburt, Richard M.	CT Dept. of Consumer Protection-Occupational & Professional Licensing Division
Keefe, Jack	
Keith, Gary	National Fire Protection Association
Kingston, Joe Co-Chairman	**DCS-Office of State Fire Marshal**
Kasmauskas, Dominick	National Fire Sprinkler Association
Jansen, Jack	American Fire Sprinkler Association, CT Chapter
Lagocki, Alan	AIA-American Institute of Architects, CT Chapter
Livingstone, John	Local 669 Sprinkler Fitters Union
McCarthy, Dennis	CT Career Fire Chief's Association
Michelson, John	
Paige, Todd	CT Career Fire Chief's Association
Pellecchia, Joe	CT Plumbing, Heating and Cooling Construction
Association	
Rapanault, Paul	Uniformed Professional Fire Fighter of CT
Richards, Ken	CT Fire Chiefs Association
Ross, Rob, Chairman	**DESPP-DFEBS**
Thompson, Dave	American Builders & Contractors, CT Chapter
Tierney, Dan, Co-Chairman	**DCS-Office of State Building Inspector**
Tourville, Patrick	President & Representative, CT Fire Marshals Association
Travers, Tim	National Fire Protection Association
Viola, Jack	American Fire Sprinkler Association, CT Chapter
Walker, Raymond Jr.	CT Conference of Municipalities
York, Timothy	President, CT Building Officials Association
Waskowicz, Dave	Industry

House Diagram (Courtesy of Home Fire Sprinkler Coalition.)

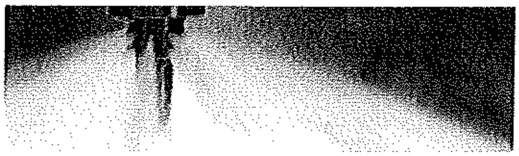


Riser Diagram (Courtesy of Home Fire Sprinkler Coalition.)

Contact Information:
TC Fire & Security
Global Fire Products
Jack Viola
John.viola@fs.utc.com
(413)-575-3596

0 **UTC Fire & Security**
A United Technologies Company

HI-FOG® Water Mist -A Fire Protection System for the Home



UTC Fire & Security is developing a fire protection system for the home based on the world's leading commercial water mist technology; Marioff HI-FOG•, which Is Installed in prestigious buildings such as the National Gallery of Art, Hearst Castle, The Nobel Peace Center and Marriott Hotels around the world.

The HI-FOG Water Mist Fire Protection System Is the most modern and effective fire protection technology for your home.

- Superior fire protection
- Uses 80% less water
- Minimizes water and fire damage
- Quick and easy installation

PRODUCT RELEASE
Early 2012

Seeking UL approvals

What Is Water Mist?

HI-FOG• water mist system is composed of tiny micro-droplets that represent water in its most efficient fire-fighting form. When a HI-FOG• system activates, it instantly attacks the fire by discharging high -velocity water mist that penetrates the fire plume and controls the fire. The space cools as it quickly fills with mist. The micro-droplets block and scatter the fire's radiant heat. Using 80% less water the fire is suppressed before it **can spread and do serious harm.**

Why Water Mist?

Water mist provides superior fire protection by suppressing the fire, cooling the surrounding area and providing a safe pathway out of the home. Water mist uses dramatically less water, which allows the water and fire damage to be kept to a minimum. It resolves many concerns homeowners may have related to water issues such as water meter connections and fees, well water and water sustainability.

Easy Installation

The water mist system uses small flexible hose that is quick to Install and easy to maneuver around unique angles, corners and architectural obstructions. The system is small enough to be hidden from view by using a variety of design elements such as crown molding to preserve the home aesthetics. The system requires minimal Joints and as a result greatly reduces the risk of leaks.

About UTC Fire & Security

UTC Fire & Security provides fire safety and security solutions to more than 1 million customers worldwide. Headquartered In Conn, U.S., UTC Fire & Security Is a business unit of United Technologies Corp., which provides high technology products and services to the building and aerospace industries **worldwide. UTC offers well-known residential consumer brands such as Carrier air conditioning and** heating systems and Kidde fire safety and protection solutions. More information about UTC Fire & Security can be found at http://www.utcfireandsecurity.com

HI·FOG®
water mht flro protet!lon

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1 NFPA 13D is appropriate for protection against fire hazards only in one- and two-family dwellings and manufactured homes. Residential portions of any other type of building or occupancy should be protected with residential sprinklers in accordance with NFPA 13 or in accordance with NFPA 13R. Other portions of such buildings should be protected in accordance with NFPA 13 or NFPA 13R as appropriate for areas outside the dwelling unit.

The criteria in this standard are based on full-scale fire tests of rooms containing typical furnishings found in residential living rooms, kitchens, and bedrooms. The furnishings were arranged as typically found in dwelling units in a manner similar to that shown in Figure A.1.1(a), Figure A.1.1(b), and Figure A.1.1(c). Sixty full-scale fire tests were conducted in a two-story dwelling in Los Angeles, California, and 16 tests were conducted in a 14 ft (4.2 m) wide mobile home in Charlotte, North Carolina.

Sprinkler systems designed and installed according to this standard are expected to prevent flashover within the compartment of origin where sprinklers are installed in the compartment. A sprinkler system designed and installed according to this standard cannot, however, be expected to completely control a fire involving fuel loads that are significantly higher than average for dwelling units [10 lb/ft^2 (49 kg/m^2)] and where the interior finish has an unusually high flame spread index (greater than 225) when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials.*

(For protection of multifamily dwellings, see NFPA 13 or NFPA 13R.)

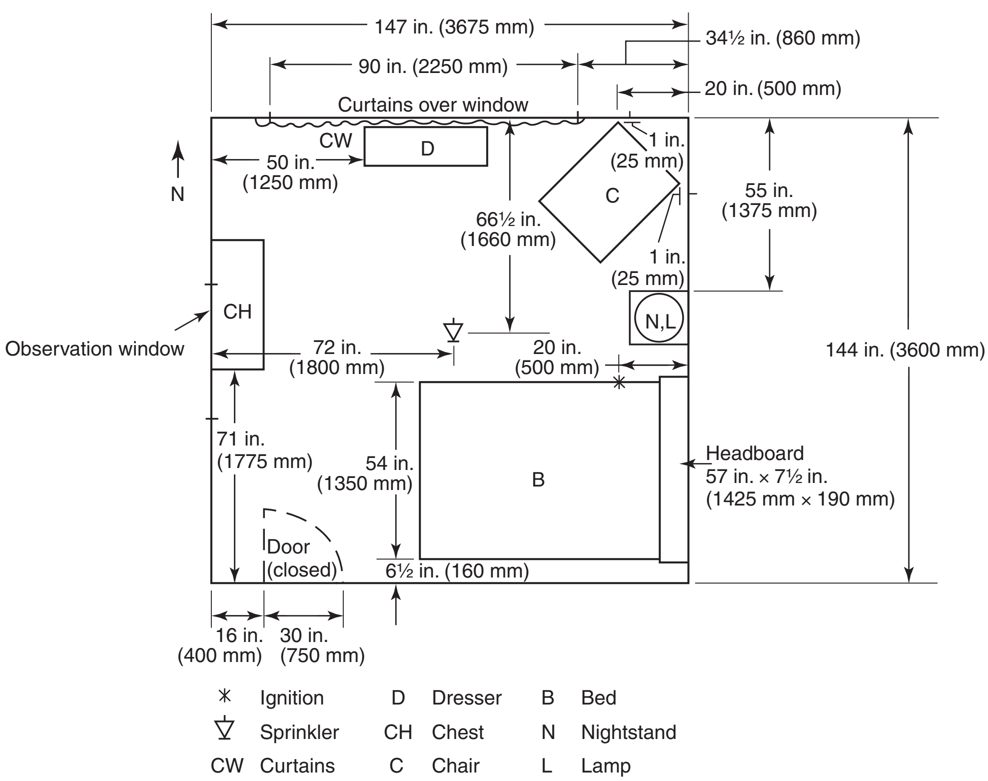


FIGURE A.1.1(a) Bedroom.

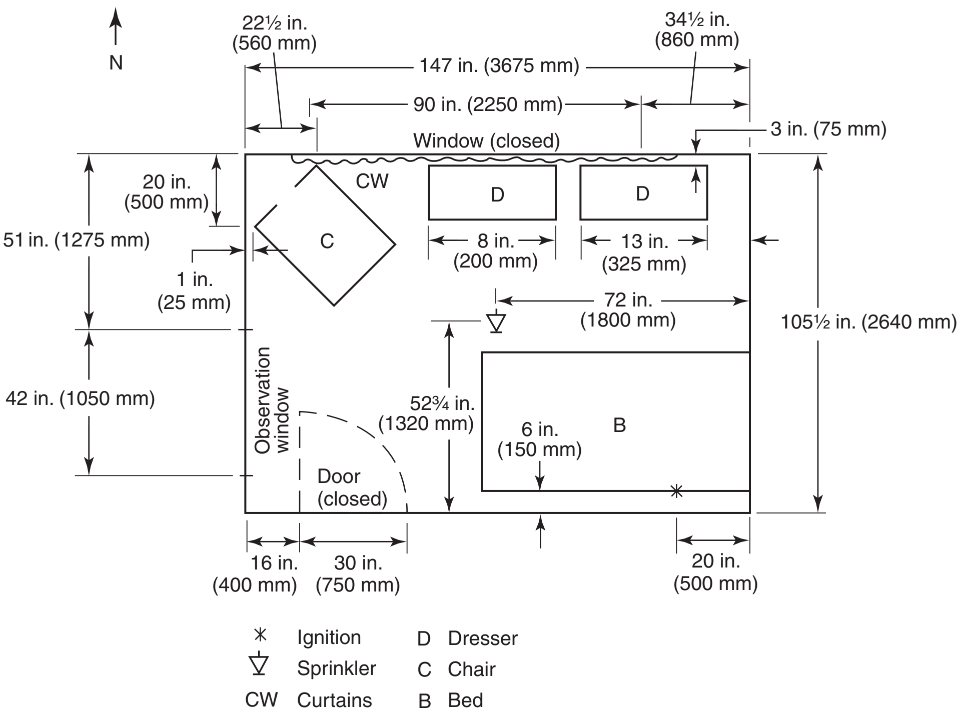


FIGURE A.1.1(b) Manufactured Home Bedroom.

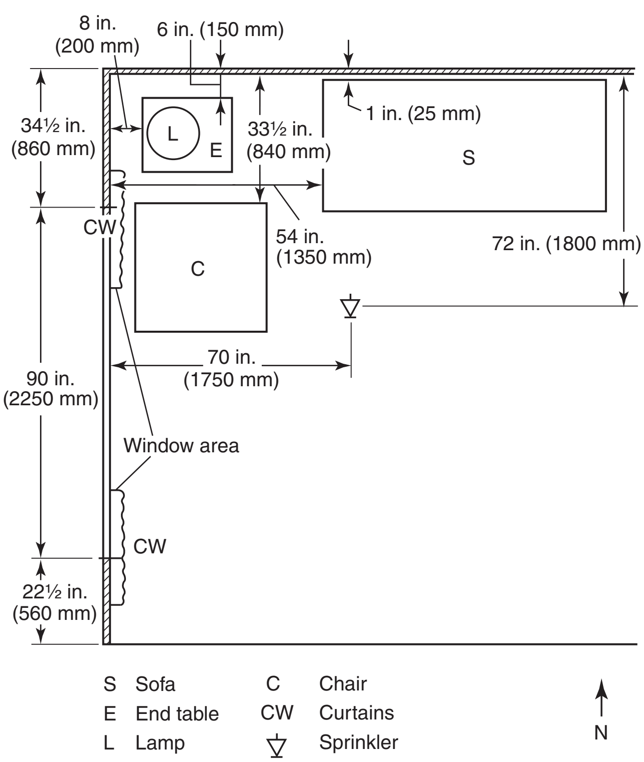


FIGURE A.1.1(c) Living Room.

A.1.2 While the purpose of this standard is to provide improved protection against injury and loss of life, the use of these systems has demonstrated an ability to provide improved protection against property damage. Various levels of fire safety are available to dwelling occupants to provide life safety and property protection.

This standard recommends, but does not require, sprinklering of all areas in a dwelling; it permits sprinklers to be omitted in certain areas. These areas have been proved by NFPA statistics *[see Table A.1.2(a), Table A.1.2(b), and Table A.1.2(c)]* to be those where the incidence of life loss from fires in dwellings is low. Such an approach provides a reasonable degree of fire safety. Greater protection to both life and property is achieved by sprinklering all areas.

Guidance for the installation of smoke detectors and fire detection systems is found in *NFPA 72*.

A.1.5.1 For additional conversions and information, see IEEE/ASTM SI 10, *Standard for Use of the International System of Units (SI): The Modern Metric System*.

A.1.5.4 A given equivalent value is considered to be approximate.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

Table A.1.2(a) Fires and Associated Deaths and Injuries in Dwellings, Duplexes, and Manufactured Homes by Area of Origin: Annual Average of 2005–2009 Structure Fires Reported to U.S. Fire Departments

Area of Origin	Civilian Deaths	Civilian Percent	Fires	Percent	Injuries	Percent
Living room, family room, or den	540	24	11,300	4	990	11
Bedroom	540	24	22,300	8	1,810	20
Kitchen	310	14	85,600	32	2,870	32
Unclassified function area	240	11	7,900	3	480	5
Unclassified structural area	80	4	5,200	2	150	2
Crawl space or substructure space	50	2	5,000	2	190	2
Unclassified area of origin	40	2	6,500	2	70	1
Laundry room or area	40	2	8,900	3	280	3
Garage or vehicle storage area*	30	1	8,600	3	420	5
Bathroom	30	1	5,500	2	200	2
Exterior balcony or unenclosed porch	30	1	4,600	2	140	2
Wall assembly or concealed space	30	1	6,400	2	110	1
Attic or ceiling/roof assembly or concealed space	30	1	9,000	3	90	1
Heating equipment room	20	1	6,000	2	140	2
Unclassified outside area	10	0	6,600	2	50	1
Exterior wall surface	10	0	8,500	3	90	1
Confined chimney or flue fire†	0	0	22,500	8	30	0
Other known area of origin	200	9	34,100	13	740	8
Total	2,210	100	264,500	100	8,860	100

Source: NFIRS 5.0 and NFPA survey.

Note: Sums may not equal totals due to rounding errors.

*Does not include fires with property use coded as residential garage.

†NFIRS 5.0 does not have a separate area of origin code for fires starting in chimneys. Any home fire with NFIRS incident type 114 (Chimney of fire originating in and confined to a chimney or flue) is captured here.

Table A.1.2(b) Fires and Associated Deaths and Injuries in Dwellings, Duplexes, and Manufactured Homes by Heat Source: Annual Average of 2005–2009 Structure Fires Reported to U.S. Fire Departments

Heat Source	Civilian Deaths	Civilian Percent	Fires	Percent	Injuries	Percent
Smoking materials	510	23	11,600	4	760	9
Radiated or conducted heat from operating equipment	290	13	46,000	17	1,920	22
Arcing	290	13	29,900	11	850	10
Unclassified heat source	160	7	22,900	9	500	6
Unclassified heat from powered equipment	160	7	39,900	15	1,290	15
Spark, ember, or flame from operating equipment	140	6	16,900	6	620	7
Lighter	130	6	7,300	3	590	7
Candle	110	5	10,000	4	740	8
Unclassified hot or smoldering object	100	4	18,600	7	450	5
Hot ember or ash	100	4	21,200	8	340	4
Match	80	4	9,000	3	240	3
Heat from direct flame or convection current	10	1	5,900	2	90	1
Lightning	10	0	4,100	2	30	0
Other known heat source	130	6	21,200	8	440	5
Total fires	2,210	100	264,500	100	8,860	100

Source: NFIRS 5.0 and NFPA survey.

Note: Sums may not equal totals due to rounding errors.

Table A.1.2(c) Fires and Associated Deaths and Injuries in Dwellings, Duplexes, and Manufactured Homes by Item First Ignited: Annual Average of 2005–2009 Structure Fires Reported to U.S. Fire Departments

Item First Ignited	Civilian Deaths	Civilian Percent	Fires	Percent	Injuries	Percent
Upholstered furniture	420	19	5,400	2	560	6
Mattress or bedding	280	13	8,000	3	910	10
Flammable or combustible liquid or gas or associated part	200	9	13,200	5	880	10
Structural member or framing	120	6	18,500	7	330	4
Floor covering rug, carpet, or mat	110	5	4,500	2	200	2
Unclassified furniture or utensil	110	5	5,000	2	300	3
Clothing	110	5	6,200	2	390	4
Electrical wire or cable insulation	90	4	15,200	6	360	4
Cooking materials, including food	90	4	53,300	20	2,000	23
Multiple items first ignited	80	4	4,900	2	210	2
Unclassified item first ignited	80	4	23,600	9	340	4
Interior wall covering	70	3	7,100	3	220	3
Unclassified structural component or finish	60	3	6,600	2	140	2
Magazine, newspaper, or writing paper	50	2	4,100	2	140	2
Rubbish, trash, or waste	40	2	9,100	3	180	2
Cabinetry	40	2	4,600	2	210	2
Appliance housing or casing	30	2	8,700	3	200	2
Exterior wall covering or finish	30	1	12,000	5	140	2
Household utensil	10	1	5,700	2	130	1
Insulation within structural area	10	0	5,500	2	80	1
Unclassified organic material	0	0	6,300	2	40	0
Film or residue, including paint, resin, and creosote	0	0	4,400	2	10	0
Other known item first ignited	160	7	32,500	12	890	10
Total	2,210	100	264,500	100	8,860	100

Source: NFIRS 5.0 and NFPA survey.

Note: Sums may not equal totals due to rounding errors.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.5 Manufactured Home. Manufactured homes were formerly referred to as "mobile homes" or "trailer coaches."

A.3.3.6 Premixed Antifreeze Solution. Where a tank is used as the water supply for the sprinkler system, the tank is not permitted to be filled with antifreeze.

A.3.3.9 Shadow Area. Water is not required to fall on every square inch of floor space of the occupancy. This definition establishes a term that will be used to address the rules for acceptable dry spaces that occur when walls interfere with the sprinkler's spray pattern. Angled walls, wing walls, and slightly indented walls can disrupt water discharging from a sprinkler, which does not travel only in an absolute straight line, as if it were beams of light. Where small (typically triangular) shadowed areas are formed on the floor adjacent to the wall, these shadowed areas are purely on paper and do not take into account the dynamic variables of sprinkler discharge. In order to be acceptable, the shadow area needs to be within the coverage area of a sprinkler, meaning that water would discharge to the space directly if the structural or architectural feature was not there. The purpose of the shadow area is not to replace any existing obstruction requirements. Instead the shadow area concept has been added to the standard to provide clarity to specific situations in which walls form non-rectangular-shaped rooms as shown in Figure A.3.3.9.

A.3.3.11.3 Multipurpose Piping Sprinkler System. Examples of multipurpose piping systems are shown in Figure A.3.3.11.3(a), Figure A.3.3.11.3(b), and Figure A.3.3.11.3(c).

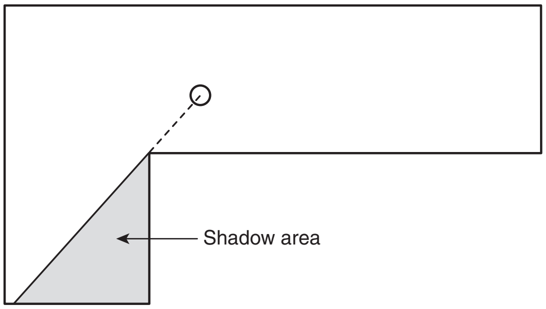


FIGURE A.3.3.9 Shadow Area Created by a Wall.

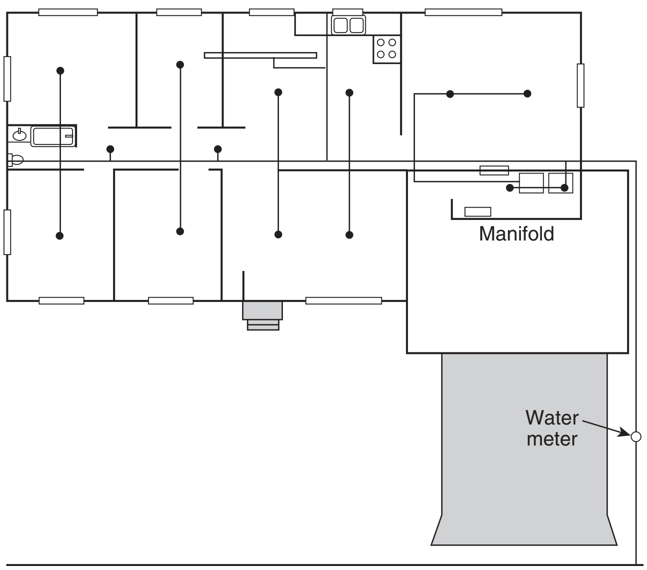


FIGURE A.3.3.11.3(a) Multipurpose Piping System (Tree System) — Example 1.

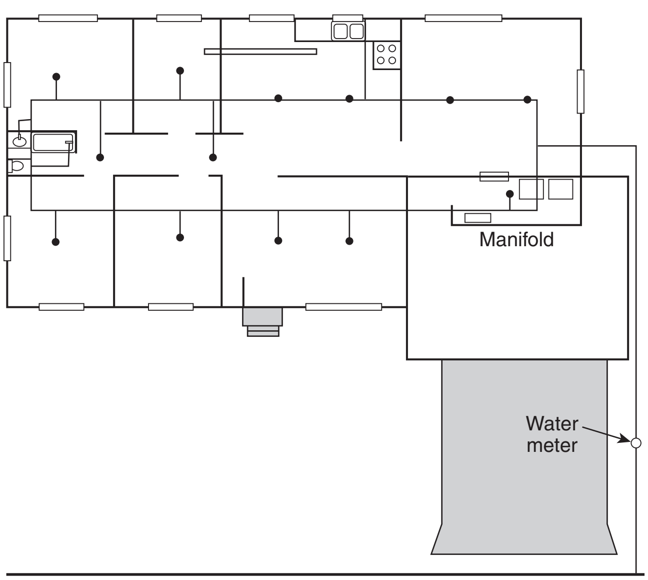


FIGURE A.3.3.11.3(b) Multipurpose Piping System (Looped System) — Example 2.

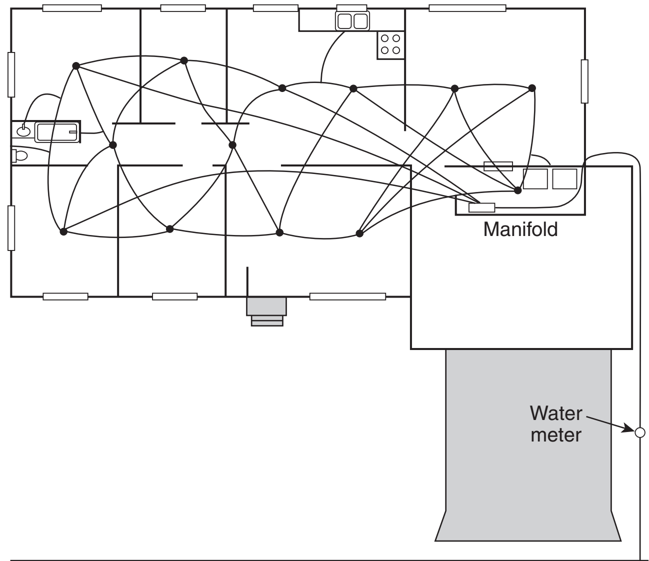


FIGURE A.3.3.11.3(c) Multipurpose Piping System — Example 3 (Network System).

A.3.3.11.4 Network Sprinkler System. A network system is a type of multipurpose system that often uses ½ in. (15 mm) piping to serve both domestic and fire protection needs, providing an equivalent level of suppression capability as larger piping systems. To accomplish this protection, each sprinkler is supplied by water flowing to it from at least three separate paths. An example of a network system is shown in Figure A. 3.3.11.3(c).

A.3.3.11.5 Passive Purge Sprinkler System. The domestic plumbing fixture should be on a remote portion of the system or the system should be designed as a loop so that water moves through a majority of the system when the fixture is used. This type of system is also called a "flow through system" in much of North America.

A.3.3.11.9 Stand-Alone Sprinkler System. Underground piping is permitted to serve domestic use as well as sprinkler system use, but once the split is made between systems, the piping serving fire sprinklers only serves the fire sprinklers.

A.3.3.13.2 Control Valve. System control valves should be of the indicating type, such as plug valves, ball valves, butterfly valves, or OS&Y gate valves.

A.4.5 A scaled drawing where required should show the following:

(1) Address (if known)
(2) Size and type of domestic line, including length to city connection
(3) Water meter size
(4) Current static water pressure
(5) Interior walls
(6) Model, manufacturer, temperature, orifice size, and spacing requirements of sprinklers
(7) Type of pipe
(8) Hanger spacing requirement per the pipe manufacturer
(9) Riser detail
(10) Installing contractor information
(11) Preliminary hydraulic calculations

A.5.1.1 Where fused sprinklers are replaced by the owner, fire department, or others, care should be taken to ensure that the replacement sprinkler has the same operating characteristics.

A.5.1.1.1 Where the sprinkler being removed from the system remains attached to the original fitting or welded outlet, the sprinkler should be permitted to be reinstalled provided care has been taken to ensure the sprinkler has not been damaged. Flexible hose connections are considered a fitting.

A.5.2.2 For reference, the information in Table A.5.2.2(a) through Table A.5.2.2(d) is provided to assist in the determination of acceptable water availability.

A.5.2.2.2 In most installations, pressure increases due to temperature fluctuations or pressure surges do not cause the system pressure to exceed the pressure rating of the pipe. In situations where the system pressure has the potential to exceed the pipe pressure rating, installation of a relief valve should be considered. Where a relief valve is installed, consideration should be given to making sure that an adequate drain is available to handle the anticipated discharge.

A.5.2.3.2 Not all pipe or tube made to ASTM F442, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)*, as described in 5.2.3.2 is listed for fire sprinkler service. Listed pipe is identified by the logo of the listing agency.

Table A.5.2.2(a) SDR 13.5 IPS Pipe (CPVC)

Nominal Pipe Size		Average Outside Diameter		Average Inside Diameter	
(in.)	(mm)	(in.)	(mm)	(in.)	(mm)
¾	(20)	1.05	(26.7)	0.87	(22.1)
1	(25)	1.32	(33.5)	1.10	(27.9)
1¼	(32)	1.66	(42.2)	1.39	(35.3)
1½	(40)	1.90	(48.3)	1.60	(40.6)
2	(50)	2.38	(60.5)	2.00	(50.8)
2½	(65)	2.88	(73.2)	2.42	(61.5)
3	(80)	3.50	(88.9)	2.95	(74.9)

All nonmetallic pipe and fitting materials can be damaged by contact with chemicals found in some construction products, such as thread sealants, leak detectors, firestops, insulation, spray foams, cutting oils, termiticides, insecticides, antifreeze, coupling lubes, communication cables, wires, flux, solder, mastic, PVC-coated floor clamps, pipe tapes, grease and cooking oils, rubber and plasticizers, antimicrobial coatings, and so forth. The chemical compatibility of such products with the particular pipe or fitting material must be verified prior to

Table A.5.2.2(b) SDR 9 CTS Pipe (PEX)

Nominal Diameter		Outside Diameter		Wall		Inside Diameter	
(in.)	(mm)	in.*	mm	in.†	mm	in.	mm
⅜	(9)	0.50	12.7	0.07	1.8	0.36	9.1
½	(15)	0.63	15.9	0.07	1.8	0.49	12.3
¾	(20)	0.88	22.2	0.10	2.5	0.68	17.2
1	(25)	1.30	32.5	0.13	3.2	0.88	22.2
1¼	(32)	1.38	34.5	0.15	3.9	1.07	27.2
1½	(40)	1.63	41.2	0.18	4.6	1.26	32.1
2	(50)	2.13	54.0	0.24	6.0	1.65	42.0

*Average dimensions from ASTM F876, *Standard Specification for Crosslinked Polyethylene (PEX) Tubing*.
†Minimum wall thickness from ASTM F876.

Table A.5.2.2(c) Steel Pipe Dimensions

Nominal Pipe Size		Outside Diameter		Schedule 5				Schedule 10*				Schedule 30				Schedule 40			
				Inside Diameter		Wall Thickness		Inside Diameter		Wall Thickness		Inside Diameter		Wall Thickness		Inside Diameter		Wall Thickness	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
½†	15	0.84	21.3	—	—	—	—	0.67	17.0	0.08	2.1	—	—	—	—	0.62	15.8	0.11	2.77
¾†	20	1.05	26.7	—	—	—	—	0.88	22.4	0.08	2.1	—	—	—	—	0.82	21.0	0.11	2.87
1	25	1.32	33.4	1.19	30.1	0.07	1.7	1.10	27.9	0.11	2.8	—	—	—	—	1.05	26.6	0.13	3.37
1¼	32	1.66	42.2	1.53	38.9	0.07	1.7	1.44	36.6	0.11	2.8	—	—	—	—	1.38	35.1	0.14	3.56
1½	40	1.90	48.3	1.77	45.0	0.07	1.7	1.68	42.7	0.11	2.8	—	—	—	—	1.61	40.9	0.15	3.68
2	50	2.38	60.3	2.25	57.0	0.07	1.7	2.16	54.8	0.11	2.8	—	—	—	—	2.07	52.5	0.15	3.91
2½	65	2.88	73.0	2.71	68.8	0.08	2.1	2.64	66.9	0.12	3.0	—	—	—	—	2.47	62.7	0.20	5.16
3	80	3.50	88.9	3.33	84.7	0.08	2.1	3.26	82.8	0.12	3.0	—	—	—	—	3.07	77.9	0.22	5.49

* Schedule 10 defined to 5 in. (127 mm) nominal pipe size by ASTM A135, *Standard Specification for Electric-Resistance-Welded Steel Pipe*.
† These values applicable when used in conjunction with 8.15.19.3 and 8.15.19.4 of NFPA 13.
[**13:**Table A.6.3.2]

Table A.5.2.2(d) Copper Tube Dimensions

Nominal Tube Size		Outside Diameter		Type K				Type L				Type M			
				Inside Diameter		Wall Thickness		Inside Diameter		Wall Thickness		Inside Diameter		Wall Thickness	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
¾	20	0.88	22.2	0.75	18.9	0.07	1.7	0.79	19.9	0.05	1.1	0.81	20.6	0.03	0.8
1	25	1.13	28.6	1.00	25.3	0.07	1.7	1.03	26.0	0.05	1.3	1.06	26.8	0.04	0.9
1¼	32	1.38	34.9	1.25	31.6	0.07	1.7	1.27	32.1	0.06	1.4	1.29	32.8	0.04	1.1
1½	40	1.63	41.3	1.48	37.6	0.07	1.8	1.51	38.2	0.06	1.5	1.53	38.8	0.05	1.2
2	50	2.13	54.0	1.96	49.8	0.08	2.1	1.99	50.4	0.07	1.8	2.01	51.0	0.06	1.5
2½	65	2.63	66.7	2.44	61.8	0.10	2.4	2.47	62.6	0.08	2.0	2.50	63.4	0.07	1.7
3	80	3.13	79.4	2.91	73.8	0.11	2.8	2.95	74.8	0.09	2.3	2.98	75.7	0.07	1.8

[**13:**Table A.6.3.5]

use. Otherwise, contact between the construction product and the pipe or fitting must be avoided.

A.5.2.9.2 Compatible thread sealant or Teflon tape can be used in a CPVC sprinkler head adapter. The combination of the two cannot be used together. The manufacturer of the sprinkler head adapter installation instructions must be followed for each sprinkler head adapter used. Not all fittings made to ASTM F437, *Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*; ASTM F438, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40*; and ASTM F439, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*, as described in 5.2.9.2 are listed for fire sprinkler service. Listed fittings are identified by the logo of the listing agency.

A.5.3 It is not the intent of NFPA 13D to require the use of NFPA 24 for any supply piping.

A.6.2 The connection to city mains for fire protection is often subject to local regulation of metering and backflow prevention requirements. Preferred and acceptable water supply arrangements are shown in Figure A.6.2(a)through Figure A.6.2(d). Where it is necessary to use a meter between the city water main and the sprinkler system supply, an acceptable arrangement as shown in Figure A.6.2(c)and Figure A.6.2(d)can be used. Under these circumstances, the flow characteristics of the meter are to be included in the hydraulic calculation of the system *[see Table 10.4.4(a)]*. Where a tank is used for both domestic and fire protection purposes, a low water alarm that actuates when the water level falls below 110 percent of the minimum quantity specified in 6.1.2 should be provided.

The effect of pressure-reducing valves on the system should be considered in the hydraulic calculation procedures.

Figure A.6.2(a), Figure A.6.2(c), or Figure A.6.2(d)are acceptable methods for getting the water supply into the unit for a stand-alone sprinkler system (one that does not also provide direct connections to the cold water fixtures) because the common supply pipe for the domestic system and the sprinkler system between the water supply and the dwelling unit has a single control valve that shuts the sprinkler system, which helps to ensure that people who have running water to their domestic fixtures also have fire protection. This serves as a form of supervision for the control valve and can be used to make sure that the valve stays open in place of other, more expensive options such as tamper switches with a monitoring service.

Some water utilities insist on separate taps and supply pipes from the water supply to the dwelling unit for fire sprinkler systems as shown in Figure A.6.2(d), due to concerns about shutting off the water supply for nonpayment of bills and the desire not to shut off fire protection if this ever occurs. While these types of arrangements are acceptable, they might not be cost efficient and should be discouraged due to the extra cost burden this places on the building owner. The concern over shutting off the water for nonpayment of bills is a nonissue for a number of reasons. First, the water utilities rarely actually shut off water for nonpayment. Second, if they do shut off water for nonpayment, they are creating violations of all sorts of health and safety codes, allowing people to live in a home without running water. Concern over the fire protection for those individuals when they are violating all kinds of other health codes is disingenuous. More likely, the water utility will not shut off the water and will follow other legal avenues to collect on unpaid bills, such as liens on property. Millions of people should not have to pay hundreds of millions of dollars to install separate water taps and lines for the few services that might get shut off.

A.6.2.3 The best method for getting the water supply into the unit for a stand-alone sprinkler system (one that does not also provide direct connections to the cold water fixtures) is to have a common pipe for the domestic system and the sprinkler system between the water supply and the dwelling unit. Once inside the dwelling unit, the pipes can be split to provide the individual domestic and sprinkler systems. In this arrangement, a single control valve on the combined pipe (prior to the split) as shown in Figure A.6.2(a) being the only control valve that shuts the sprinkler system is preferred because it ensures that people who have running water to their domestic fixtures also have fire protection. This serves as a form of supervision for the control valve and can be used to make sure that the valve stays open in place of other, more expensive options such as tamper switches with monitoring service.

Some water utilities insist on separate taps and supply pipes from the water supply to the dwelling unit for fire sprinkler systems due to concerns about shutting off the water supply for nonpayment of bills and the desire not to shut off fire protection if this ever occurs. While this type of arrangement is acceptable *[see Figure A.6.2(b)]*, it is not cost efficient and should be discouraged due to the extra burden this places on the building owner. The concern over shutting off the water for nonpayment of bills is a nonissue for a number of reasons. First, the water utilities rarely actually shut off water for nonpayment. Second, if they do shut off water for nonpayment, they

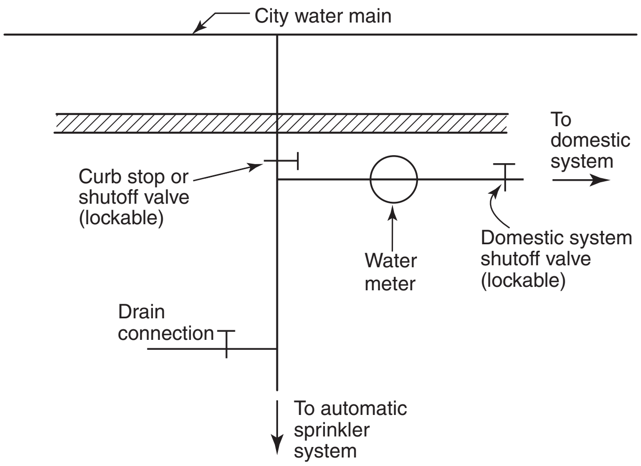


FIGURE A.6.2(a) Minimum Requirements for a Stand-Alone System.

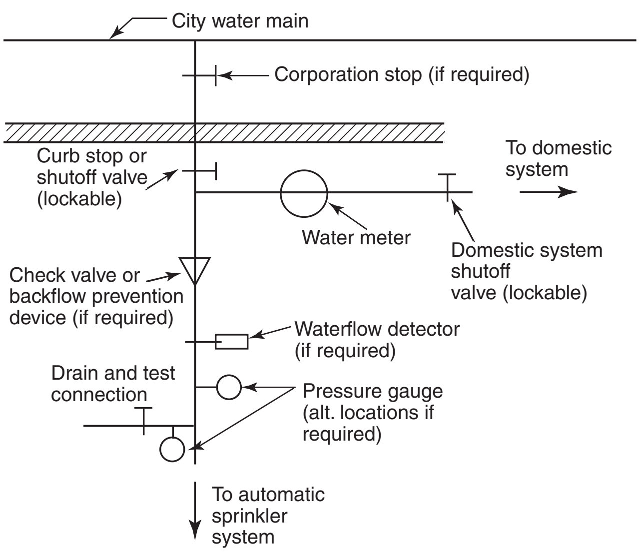


FIGURE A.6.2(b) Acceptable Arrangement for Stand-Alone Piping Systems — Option 1.

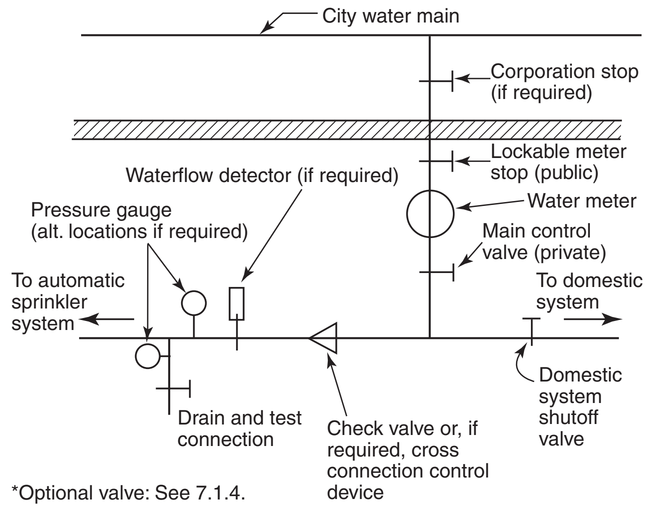
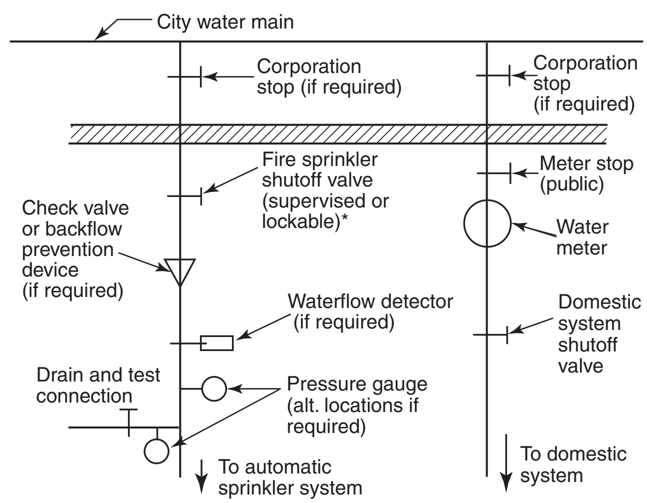


FIGURE A.6.2(c) Acceptable Arrangement for Stand-Alone Piping System — Option 2.



*Optional valve: See 7.1.4.

FIGURE A.6.2(d) Acceptable Arrangement for Stand-alone Piping Systems — Option 3.

are creating violations of all sorts of health and safety codes, allowing people to live in a home without running water. Concern over the fire protection for those individuals when they are violating all kinds of other health codes is disingenuous. More likely, the water utility will not shut off the water and will follow other legal avenues to collect on unpaid bills such as liens on property. Millions of people should not have to pay hundreds of millions of dollars to install separate water taps and lines for the few services that might get shut off.

A.6.3 Multipurpose piping systems consist of a single piping system within a residential occupancy that is intended to serve both domestic and fire protection needs. Basic forms of this system are shown in Figure A.6.3(a), Figure A.6.3(b), Figure A. 6.3(c), and Figure A.6.3(d). A network system, as defined in 3.3.11.4, is a type of multipurpose system that utilizes a common piping system supplying domestic fixtures and fire sprinklers where each sprinkler is supplied by a minimum of three separate paths. In dwellings where long-term use of lawn sprinklers is common, provision should be made for such usage.

A.7.2.4 These connections should be installed so that the valve can be opened fully and for a sufficient time period to ensure a proper test without causing water damage. The test connection should be designed and sized to verify the sufficiency of the water supply and alarm mechanisms.

A.7.2.6 Where the pressure-reducing or pressure-regulating valve also serves the domestic water supply, the domestic fixtures in the home serve as the connection for which the device can be tested, but a gauge is still needed downstream to verify valve performance and function.

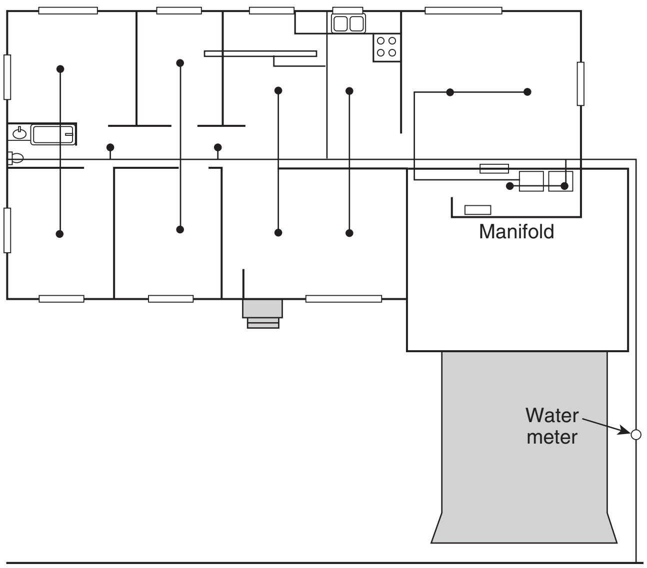


FIGURE A.6.3(a) Multipurpose Piping System (Tree System) — Example 1.

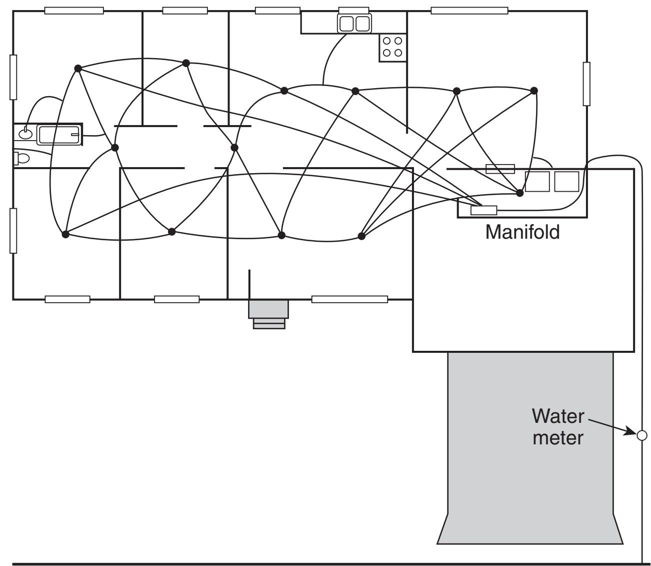


FIGURE A.6.3(c) Multipurpose Piping System — Example 3 (Network System).

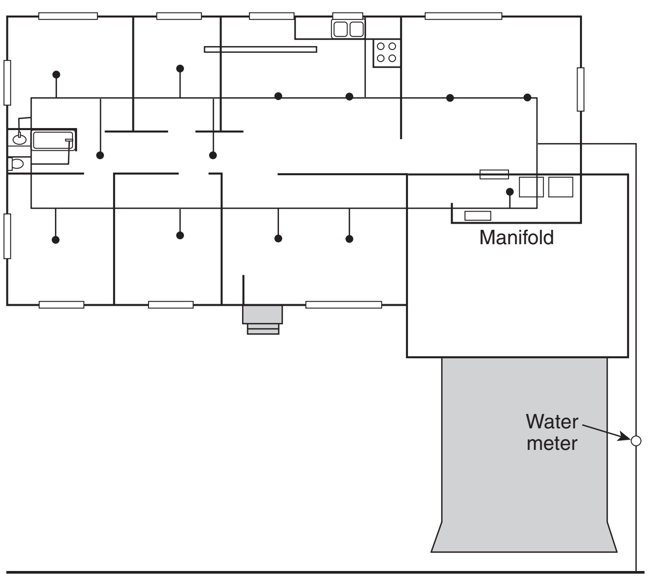


FIGURE A.6.3(b) Multipurpose Piping System (Looped System) — Example 2.

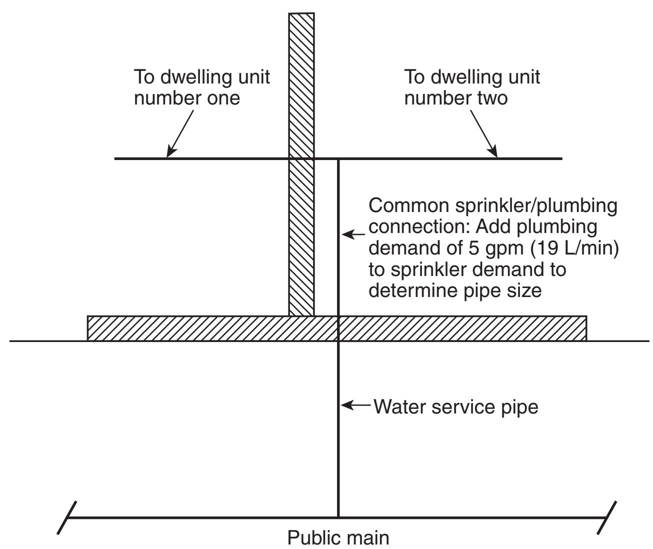


FIGURE A.6.3(d) Common Water Supply Connection Serving More Than One Dwelling Unit.

A.7.4.4 The reaction forces caused by the flow of water through the sprinkler could result in displacement of the sprinkler, thereby adversely affecting sprinkler discharge.

A.7.5.1 See A.10.2.

A.7.5.5 Corrosion-resistant sprinklers should be considered for use in steam rooms.

A.7.5.6.3 Care should be taken in positioning sprinklers in bathrooms near exhaust fan units. Some exhaust fan units have heaters built in to warm up the bathroom, and these units have the potential to activate sprinklers. Combination exhaust fan and heater units should be treated as wall-mounted diffusers for the purposes of using Table 7.5.6.3.

A.7.5.7 Decorative painting of a residential sprinkler is not to be confused with the temperature identification colors as specified in 6.2.5 of NFPA 13.

A.7.6 The waterflow detection device and the audible alarm device do not have to be listed. The local waterflow alarm is intended to be a single alarm audible from the outside of the building. It can be mounted on the outside of the home or within the building close to the outside. This should not limit its use to prevent interior or remote notification. Interconnection with a smoke alarm or remote monitoring might improve notification, but is considered too costly to mandate for every system installed in accordance with this standard. It is not the intent of this standard to require central station monitoring or a fire alarm system.

An exterior alarm can be of benefit in areas where a neighbor could alert the fire department or to enhance the ability for an assisted rescue by a passerby.

A waterflow test is normally conducted using the system drain. Figure A.6.2(a), Figure A.6.2(b), and Figure A.6.2(c) show examples of this arrangement.

A.8.1.3.1.2 See A.10.2.4.

A.8.2.5 The objective is to position sprinklers so that the response time and discharge are not unduly affected by obstructions such as ceiling slope, beams, light fixtures, or ceiling fans. The rules in this section, while different from the obstruction rules of NFPA 13, provide a reasonable level of life safety while maintaining the philosophy of keeping NFPA 13D relatively simple to apply and enforce.

Fire testing has indicated the need to wet walls in the area protected by residential sprinklers at a level closer to the ceiling than that accomplished by standard sprinkler distribution. Where beams, light fixtures, sloped ceilings, and other obstructions occur, additional residential sprinklers are necessary to achieve proper response and distribution. In addition, for sloped ceilings, higher flow rates could be needed. Guidance should be obtained from the manufacturer.

A series of 33 full-scale tests were conducted in a test room with a floor area of 12 ft × 24 ft (3.7 m × 7.2 m) to determine the effect of cathedral (sloped) and beamed ceiling construction, and combinations of both, on fast-response residential sprinkler performance. The testing was performed using one pendent-type residential sprinkler model, two ceiling slopes (0 degrees and 14 degrees), and two beam configurations on a single enclosure size. In order to judge the effectiveness of sprinklers in controlling fires, two baseline tests, in which the ceiling was smooth and horizontal, were conducted with the pendent sprinklers installed and with a total water supply of 26 gpm (100 L/min) as required by this standard. The results of the baseline tests were compared with tests in which the ceiling was beamed or sloped, or both, and two pendent sprinklers were installed with the same water supply. Under the limited conditions used for testing, the comparison indicates that sloped or beamed ceilings, or a combination of both, represent a serious challenge to the fire protection afforded by fast-response residential sprinklers. However, further tests with beamed ceilings indicated that fire control equivalent to that obtained in the baseline tests can be obtained where one sprinkler is centered in each bay formed by the beams and a total water supply of 36 gpm (135 L/min) is available. Fire control equivalent to that obtained in the baseline tests was obtained for the smooth, sloped ceiling tests where three sprinklers were installed with a total water supply of 54 gpm (205 L/min). In a single smoldering-started fire test, the fire was suppressed.

Where obstruction criteria established by this standard are followed, sprinkler spray patterns will not necessarily get water to every square foot of space within a room. As such, a sprinkler in a room with acceptable obstructions as outlined in this standard might not be capable of passing the fire test (specified by ANSI/UL 1626, *Residential Sprinklers for Fire-Protection Service*, and other similar laboratory standards) if the fire is started in one of these dry areas. This occurrence is not to be interpreted as a failure of the sprinkler. The laboratory fire tests are sufficiently challenging to the sprinkler without additional obstructions as a safety factor to account for the variables that actually occur in dwellings, including acceptable obstructions to spray patterns.

The rules on 8.2.5.1 and 8.2.5.2 were developed from a testing series conducted by the National Fire Sprinkler Association and The Viking Corporation that included fire modeling, sprinkler response tests, sprinkler distribution tests, and full-scale fire tests (Valentine and Isman, *Interaction of Residential Sprinklers, Ceiling Fans and Similar Obstructions*). This test series, along with additional industry experience, shows that a difference exists between obstructions that are tight to the ceiling and obstructions that hang down from the ceiling, allowing spray over the top. Residential sprinklers require high wall wetting, which means that they tend to spray over obstructions that hang down from the ceiling. The test series showed that the fan blades were not significant obstructions and that as long as the sprinkler was far enough from the fan motor housing (measured from the center of the housing), the sprinkler could control a fire on the other side of the fan in a small room. In larger rooms, the sprinkler will need to be augmented by additional sprinklers on the other side of the fan. The test series showed that the fan on low or medium speed did not make a significant difference in sprinkler performance. On high speed (pushing air down), the fan did impact sprinkler performance, but fire control was still achieved in small rooms. In larger rooms, it is expected that additional sprinklers would be installed. The test series also showed that the fan blowing down was more significant than the fan pulling air up.

The rules in 8.2.5.6 were developed from years of experience with obstruction rules and an additional test series conducted by the National Fire Sprinkler Association with the help of Tyco International (Valentine and Isman, *Kitchen Cabinets and Residential Sprinklers*), which included fire modeling, distribution tests, and full-scale fire tests. The test series showed that pendent sprinklers definitely provide protection for kitchens, even for fires that start under the cabinets. The information in the series was less than definitive for sidewall sprinklers, but distribution data show that sprinklers in the positions in this standard provide adequate water distribution in front of the cabinets and that sidewall sprinklers should be able to control a fire that starts under the cabinets. When protecting kitchens or similar rooms with cabinets, the pendent sprinkler should be the first option. If pendent sprinklers cannot be installed, the next best option is a sidewall sprinkler on the opposite wall from the cabinets, spraying in the direction of the cabinets. The third best option is the sidewall sprinkler on the same wall as the cabinets on a soffit flush with the face of the cabinet. The last option should be putting sprinklers on the wall back behind the face of the cabinet because this location is subject to being blocked by items placed on top of the cabinets. It is not the intent of the committee to require sprinklers to be installed under kitchen cabinets.

A.8.2.5.6 Corridors being protected with sidewall sprinklers frequently have small areas behind the sprinklers called shadow areas that are inset for a doorway. Even though these shadow areas are slightly behind the sprinklers, it is not the intent of NFPA 13D to require additional sprinkler protection in these doorways.

Examples of shadow areas are provided in Figure A. 8.2.5.6(a) and Figure A.8.2.5.6(b).The obstruction shown in Figure A.8.2.5.6(a) is a vertical obstruction in a room similar to a column. Sprinkler response and water distribution tests have been conducted on such obstructions and the data shows that the size of the obstruction as well as the size of the compartment are critical variables to sprinkler response. A larger shadow area can be acceptable in a smaller compartment. The obstruction shown in Figure A.8.2.5.6(b) is a bump out of a wall. Sprinkler response and water distribution tests have shown that this type of obstruction is not a problem.

A.8.2.6 Dry sprinklers must be of sufficient length to avoid freezing of the water-filled pipes due to conduction along the barrel. The values of exposed barrel length in Table 8.2.6.1(a) and Table 8.2.6.1(b) have been developed using an assumption of a properly sealed penetration and an assumed maximum wind velocity on the exposed sprinkler of 30 mph (48 km/h). Where higher wind velocity is expected, longer exposed barrel lengths will help avoid freezing of the wet piping. The total length of the barrel of the dry sprinkler must be longer than the values shown in Table 8.2.6.1(a) and Table 8.2.6.1(b) because the length shown in the tables is the minimum length of the barrel that needs to be exposed to the warmer ambient temperature in the heated space. See Figure A.8.2.6(a) for an example of where to measure the exposed barrel length for a sidewall sprinkler penetrating an exterior wall and Figure A. 8.2.6(b) for an example of where to measure the exposed barrel length for a pendent sprinkler penetrating a ceiling or top of a freezer. *[See Figure A.8.2.6(c).]*

A.8.3.4 Although NFPA 13D does not require garages to be sprinklered, some authorities having jurisdiction take it upon themselves to add this requirement locally. In such circumstances, residential or quick-response sprinklers with a two-sprinkler design in the garage with the same piping used in the rest of the dwelling can be used. It is recognized that residential sprinklers have not been tested specifically for fires in garages, but field experience has shown that the sprinklers help to alert occupants to the fact that there is a fire, to reduce the possibility of flashover, and to improve the chances for occupants to escape.

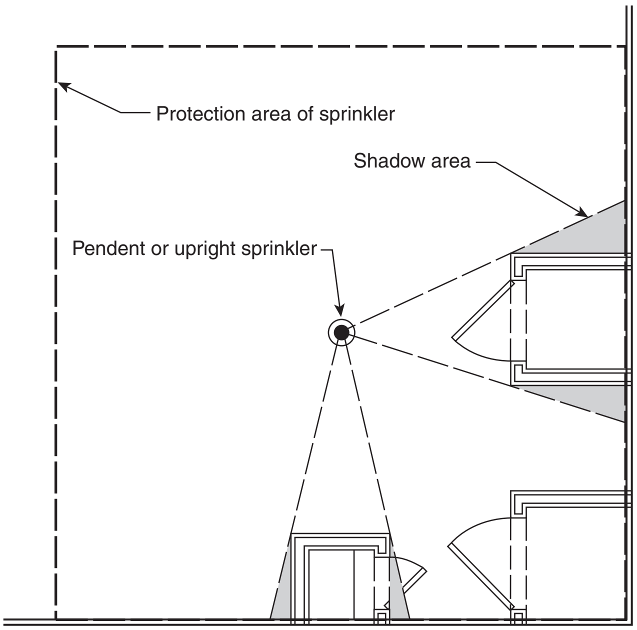


FIGURE A.8.2.5.6(a) Example of Shadow Areas (SSU/SSP).

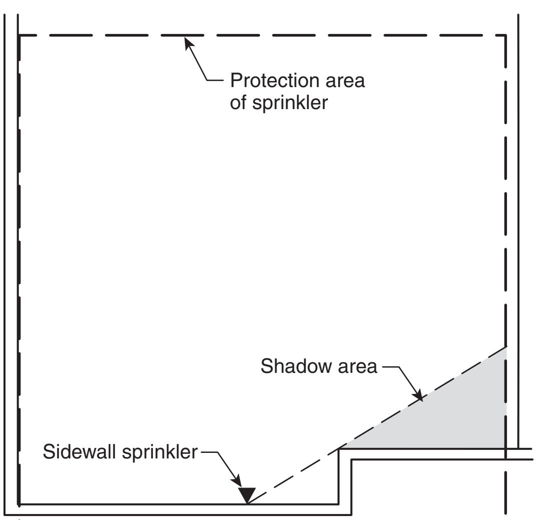


FIGURE A.8.2.5.6(b) Example of Shadow Areas (HSW).

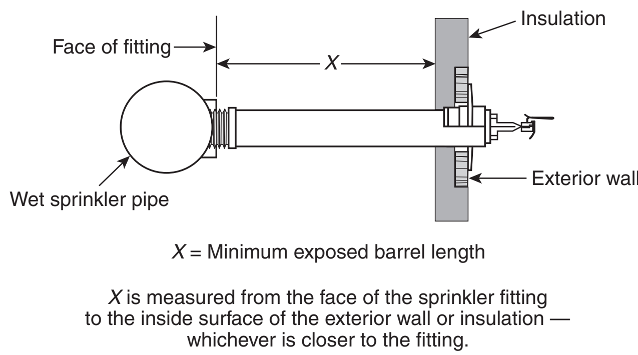


FIGURE A.8.2.6(a) Dry Sidewall Sprinkler Through Wall.

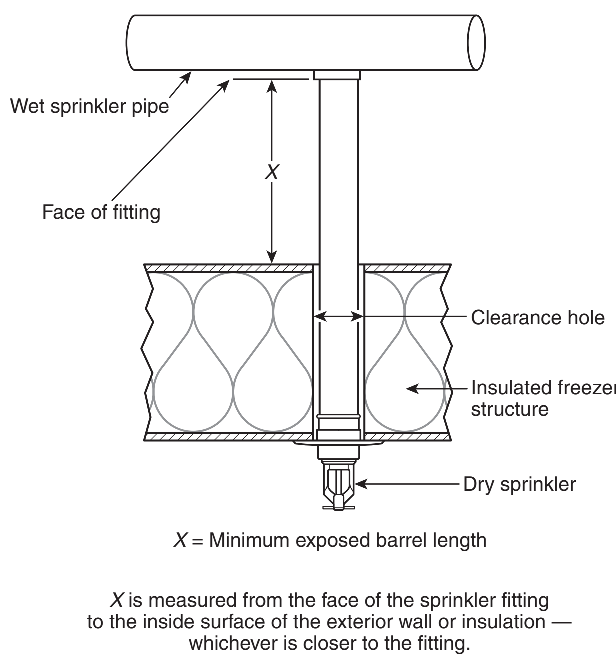
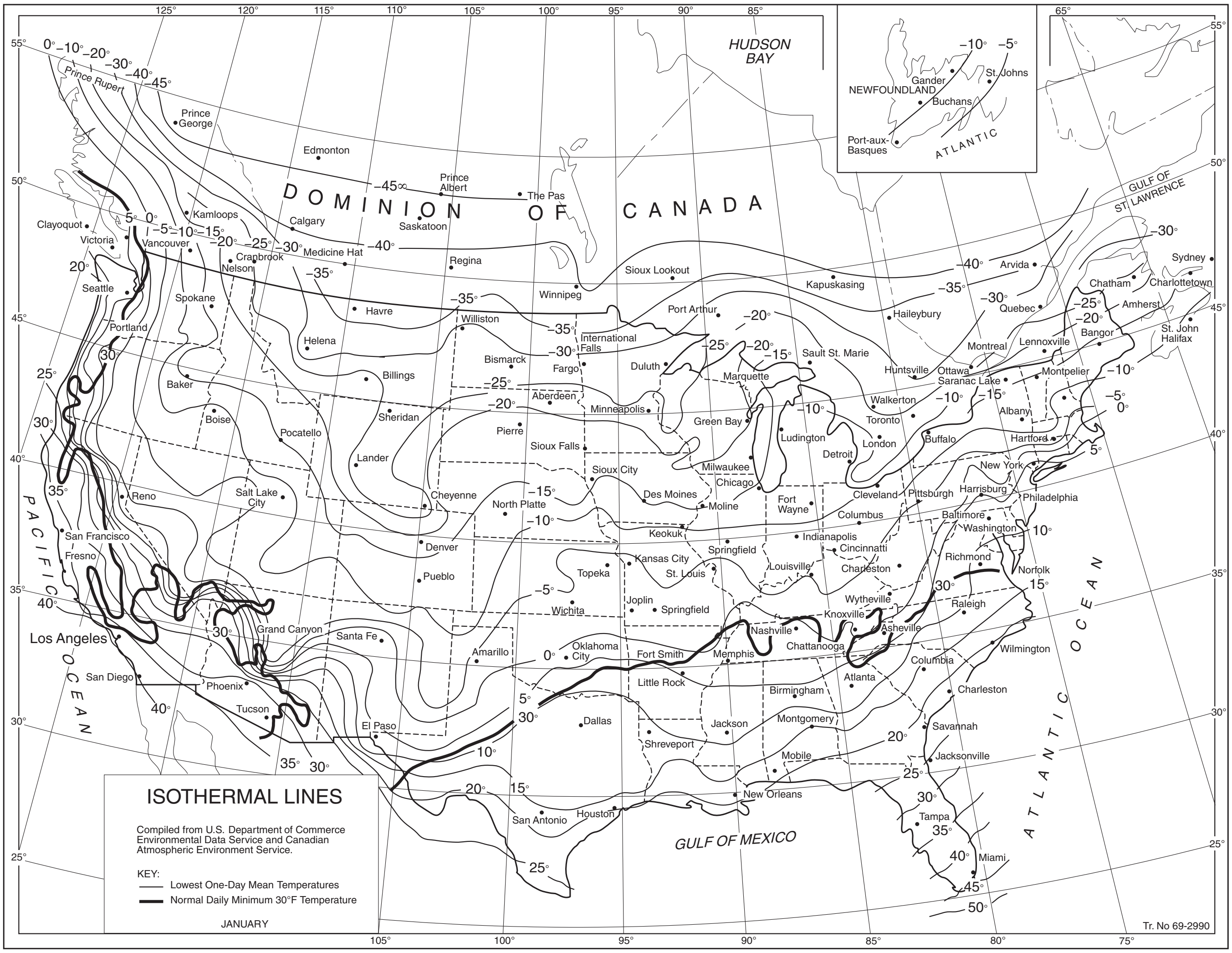


FIGURE A.8.2.6(b) Dry Pendent Sprinkler Through Ceiling or Top of Freezer.



Source: Compiled from United States Weather Bureau records.
For SI units, °C = 5/9 (°F −32); 1 mi = 1.6 km.

FIGURE A.8.2.6(c) Isothermal Lines — Lowest One-Day Mean Temperature (°F). [24:Figure A.10.4.2(b)]

A.8.3.7(3) It is common to have combustible crown molding as decoration.

A.9.1.1 In areas subject to freezing, care should be taken in unheated attic spaces to cover sprinkler piping completely with insulation. Installation should follow the guidelines of the insulation manufacturer. Figure A.9.1.1(a) through A.9.1.1(f) show several methods that can be considered. These are for illustrative purposes only. Consultation with the general contractor and/or owner is recommended to ensure proper methods and materials are used to make sure 40°F (4°C) will be maintained.

The Fire Protection Research Foundation completed a research project ("Sprinkler Insulation: A Literature Review," July 2011) on the use of insulation to protect sprinkler pipe from freezing that can be downloaded for free from their website.

A.9.1.2(4) Where listed heat tracing is used on CPVC piping, it should be compatible with the CPVC piping.

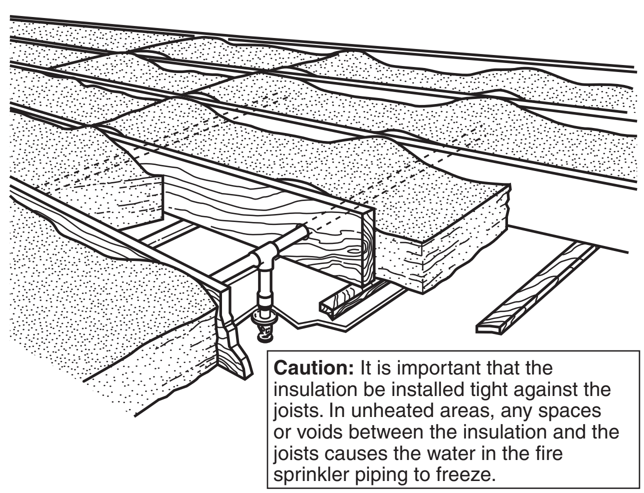


FIGURE A.9.1.1(a) Insulation Recommendations — Arrangement 1.

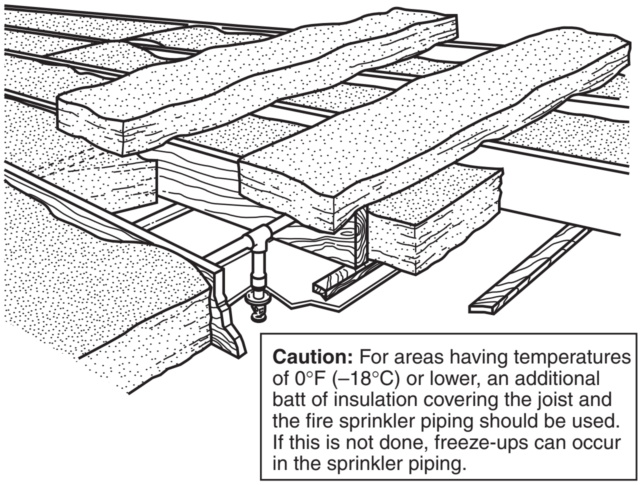


FIGURE A.9.1.1(b) Insulation Recommendations — Arrangement 2.

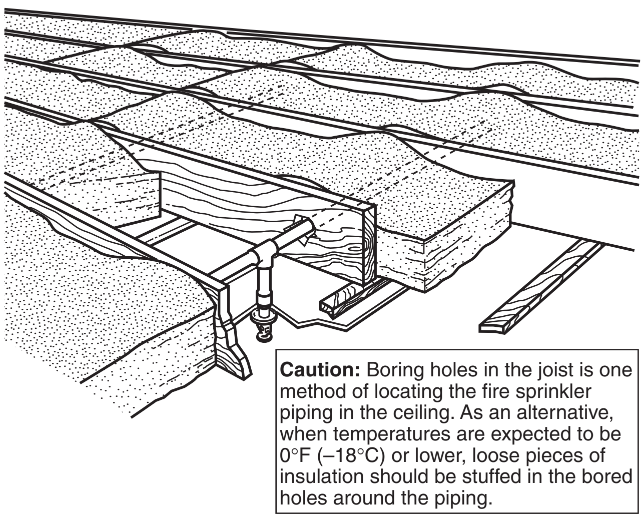


FIGURE A.9.1.1(c) Insulation Recommendations — Arrangement 3.

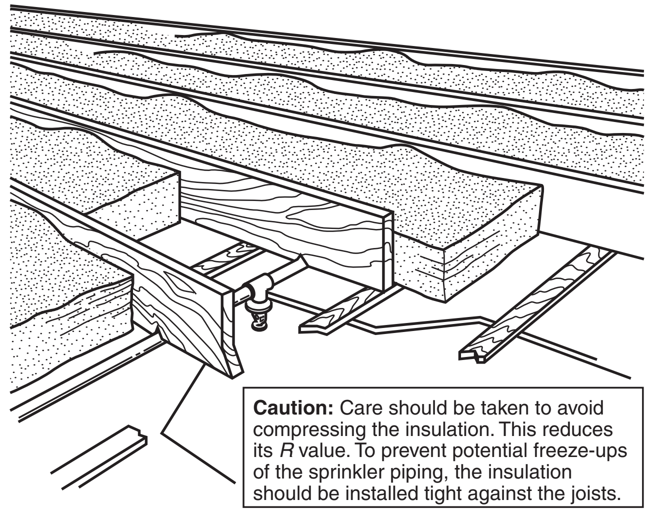


FIGURE A.9.1.1(d) Insulation Recommendations — Arrangement 4.

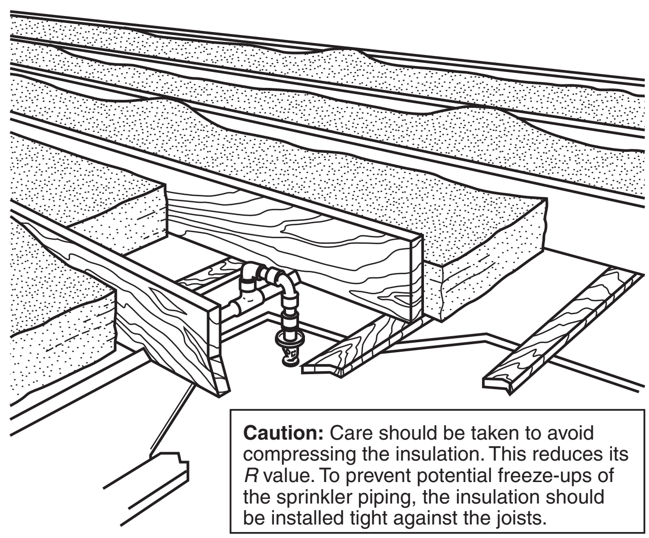


FIGURE A.9.1.1(e) Insulation Recommendations — Arrangement 5.

A.9.2 Where protection of pipes from freezing is a concern, options other than antifreeze are available. Such alternatives include running the piping in warm spaces, tenting insulation over pipe, dry pipe systems, and preaction systems.

A.9.2.1 Antifreeze solutions can be used for maintaining automatic sprinkler protection in small, unheated areas. Antifreeze solutions are recommended only for systems not exceeding 40 gal (150 L).

Because of the cost of refilling the system or replenishing small leaks, small, dry valves should be used where more than 40 gal (150 L) are to be supplied.

Propylene glycol or other suitable material can be used as a substitute for priming water to prevent evaporation of the priming fluid and thus reduce ice formation within the system.

A.9.2.2 Listed nonmetallic sprinkler pipe and fittings should be protected from freezing with an antifreeze solution that is compatible with the nonmetallic material. Laboratory testing shows that glycol-based antifreeze solutions present a chemical environment detrimental to nonmetallic pipe.

A.9.2.2.2 Examples of specific areas might include piping installed in an exterior wall or an unheated concealed space above a cathedral ceiling that cannot be protected with insulation or heat tracing. Premixed solutions of glycerine and propylene glycol should be used only where other freeze protection options are not practical. The specific areas protected by premixed glycerine and propylene glycol shall be limited to the greatest extent possible.

Propylene glycol and glycerine antifreeze solutions discharged from sprinklers have the potential to ignite under certain conditions. Research testing has indicated that several variables can influence the potential for large-scale ignition of the antifreeze solution discharged from a sprinkler. These vari-

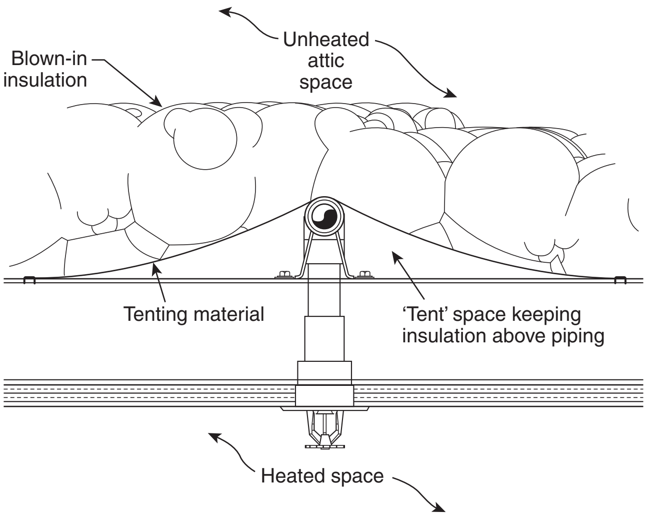


FIGURE A.9.1.1(f) Insulation Recommendations — Arrangement 6.

ables include, but are not limited to, the concentration of antifreeze solution, sprinkler discharge characteristics, the inlet pressure at the sprinkler, the location of the fire relative to the sprinkler, and the size of the fire at the time of sprinkler discharge. Research testing also indicates that propylene glycol or glycerine solutions can be used successfully with certain other combinations of these same variables. Given the need for additional testing to further define acceptable versus unacceptable scenarios, the use of propylene glycol and glycerine antifreeze solutions should be considered only when other sprinkler system design alternatives are not practical. If these solutions are used, all relevant data and information should be carefully reviewed and considered in the sprinkler system. The following is a list of research reports that have been issued by the Fire Protection Research Foundation related to the use of antifreeze in sprinkler systems:

(1) *Antifreeze Systems in Home Fire Sprinkler Systems — Literature Review and Research Plan*
(2) *Antifreeze Systems in Home Fire Sprinkler Systems — Phase II Final Report*
(3) *Antifreeze Solutions Supplied through Spray Sprinklers — Interim Report*

Table A.9.2.2.2 provides an overview of the testing.

A.9.2.2.2.1 The documentation should substantiate that the proposed use of premixed glycerine and propylene glycol antifreeze solutions is consistent with the FPRF testing for the specific installation parameters.

A.9.2.2.4 The specific gravity for any liquid can be found by taking the density of the liquid at a specific temperature and dividing it by the density of water at that same temperature. The densities of propylene glycol and glycerine can be found for a wide range of temperatures in Figure A.9.2.3.2(a) and Figure A.9.2.3.2(b).

A.9.2.3 Many antifreeze solutions are heavier than water. At the point of contact (interface), provisions are required by 9.2.3 to prevent the diffusion of water into unheated areas.

To avoid leakage, the quality of materials and workmanship should be superior, the threads should be clean and sharp, and the joints should be tight. Only metal-faced valves should be used.

A.9.2.3.2 One formula for sizing the chamber is as follows, although other methods also exist:

[A.9.2.3.2a]

$$\Delta L = S_V\left(\frac{D_L}{D_H} - 1\right)$$

where:
ΔL = change in antifreeze solution volume (gal) due to thermal expansion
S_V = volume (gal) of antifreeze system, not including the expansion chamber
D_L = density (g/mL) of antifreeze solution at lowest expected temperature [see Figure A.9.2.3.2(a) for the density of propylene glycol at a variety of temperatures and Figure A.9.2.3.2(b) for the density of glycerine at a variety of temperatures]
D_H = density (g/mL) of antifreeze solution at highest expected temperature [see Figure A.9.2.3.2(a) for the density of propylene glycol at a variety of temperatures and Figure A.9.2.3.2(b) for the density of glycerine at a variety of temperatures]

This method is based on the following information:

[A.9.2.3.2b]

$$\frac{P_0 \cdot V_0}{T_0} = \frac{P_1 \cdot V_1}{T_1} = \frac{P_2 \cdot V_2}{T_2}$$

where:
V_{EC} = minimum required volume (gal) of expansion chamber
V_0 = air volume (gal) in expansion chamber at precharge (before installation)
V_1 = air volume (gal) in expansion chamber at normal static pressure
V_2 = air volume (gal) in expansion chamber at post-expansion pressure (antifreeze at high temperature)
P_0 = absolute precharge pressure (psia) on expansion chamber before installation
P_1 = absolute static pressure (psi) on water (supply) side of backflow preventer
P_2 = absolute maximum allowable working pressure (psi) for antifreeze system
T_0 = temperature (°R) of air in expansion chamber at precharge
T_1 = temperature (°R) of air in expansion chamber when antifreeze system piping is at lowest expected temperature
T_2 = temperature (°R) of air in expansion chamber when antifreeze system piping is at highest expected temperature

This equation is one formulation of the ideal gas law from basic chemistry. The amount of air in the expansion chamber will not change over time. The pressure, temperature, and volume of the air at different times will be related in accordance with this formula:

[A.9.2.3.2c]

$$V_2 = V_1 - \Delta L$$

Table A.9.2.2.2 FPRF Antifreeze Testing Summary

Topic	Information
Scope of sprinklers tested	The following sprinklers were used during the residential sprinkler research program described in *Antifreeze Systems in Home Fire Sprinkler Systems — Phase II Final Report*: (1) Residential pendent style having nominal K-factors of 3.1, 4.9, and 7.4 gpm/psi (44, 70, and 100 lpm/bar-$^{1/2}$) (2) Residential concealed pendent style having a nominal K-factor of 4.9 gpm/psi$^{1/2}$(70 lpm/bar-$^{1/2}$) (3) Residential sidewall style having nominal K-factors of 4.2 and 5.5 gpm/psi$^{1/2}$(60 and 80 lpm/bar-$^{1/2}$) The following sprinklers were used during the spray sprinkler research program described in *Antifreeze Solutions Supplied through Spray Sprinklers — Interim Report*: (1) Residential pendent style having a nominal K-factor of 3.1 gpm/psi$^{1/2}$(44 lpm/bar-$^{1/2}$) (2) Standard spray pendent style having nominal K-factors of 2.8, 4.2, 5.6, and 8.0 gpm/psi$^{1/2}$(40, 60, and 80 lpm/bar-$^{1/2}$) (3) Standard spray concealed pendent style having a nominal K-factor of 5.6 gpm/psi$^{1/2}$(80 lpm/bar-$^{1/2}$) (4) Standard spray upright style having a nominal K-factor of 5.6 gpm/psi$^{1/2}$(80 lpm/bar-$^{2/2}$) (5) Standard spray extended coverage pendent style having a nominal K-factor of 5.6 gpm/psi$^{1/2}$(80 lpm/bar-$^{1/2}$)
Antifreeze solution concentration	**<50% glycerine and <40% propylene glycol antifreeze solutions:** Solutions were not tested. **50% glycerine and 40% propylene glycol antifreeze solutions:** Large-scale ignition of the sprinkler spray did not occur in tests with sprinkler discharge onto a fire having a nominal heat release rate (HRR) of 1.4 MW. Large-scale ignition of the sprinkler spray occurred in multiple tests with sprinkler discharge onto a fire having a nominal HRR of 3.0 MW. **55% glycerine and 45% propylene glycol antifreeze solutions:** Large-scale ignition of the sprinkler spray occurred in tests with sprinkler discharge onto a fire having a nominal HRR of 1.4 MW. **>55% glycerine and >45% propylene glycol antifreeze solutions:** Large-scale ignition of the sprinkler spray occurred in tests with sprinkler discharge onto a fire having an HRR <500 kW. **70% glycerine and 60% propylene glycol antifreeze solutions:** Maximum antifreeze solution concentrations were tested.
Sprinkler inlet pressure	Large-scale ignition of the sprinkler discharge spray was not observed when the sprinkler inlet pressure was ≤50 psi (3.4 bar) for tests using 50% glycerine or 40% propylene glycol.
Ceiling height	When 50% glycerine and 40% propylene glycol antifreeze solutions were discharged onto fires having an HRR of 1.4 MW, no large-scale ignition of the sprinkler spray was observed with ceiling heights up to 20 ft (6.1 m). When 50% glycerine and 40% propylene glycol antifreeze solutions were discharged onto fires having an HRR of 3.0 MW, large-scale ignition of the sprinkler spray was observed at a ceiling height of 20 ft (6.1 m).
Fire control	The test results described in *Antifreeze Systems in Home Fire Sprinkler Systems — Phase II Final Report* and *Antifreeze Solutions Supplied through Spray Sprinklers — Interim Report* indicated that discharging glycerine and propylene glycol antifreeze solutions onto a fire can temporarily increase the fire size until water is discharged. As a part of the residential sprinkler research described in *Antifreeze Systems in Home Fire Sprinkler Systems — Phase II Final Report*, tests were conducted to evaluate the effectiveness of residential sprinklers to control fires involving furniture and simulated furniture. The results of those tests indicated that 50% glycerine and 40% propylene glycol antifreeze solutions demonstrated the ability to control the furniture-type fires in a manner similar to water. For standard spray-type sprinklers, no tests were conducted to investigate the ability of those sprinklers to control the types and sizes of fires they are intended to protect.

The antifreeze in the system is essentially incompressible, so the air volume in the expansion chamber will decrease by an amount equal to the expansion of the antifreeze.

It is assumed that air is not trapped in the system piping, so the only air in the system is in the expansion chamber. This assumption is conservative, since more air is better. In reality, there will be at least some trapped air. However, only the air in the expansion chamber can be relied upon to be available when needed:

[A.9.2.3.2d]

$$V_{EC} = V_0$$

At precharge, the chamber will be completely full of air:

[A.9.2.3.2e]

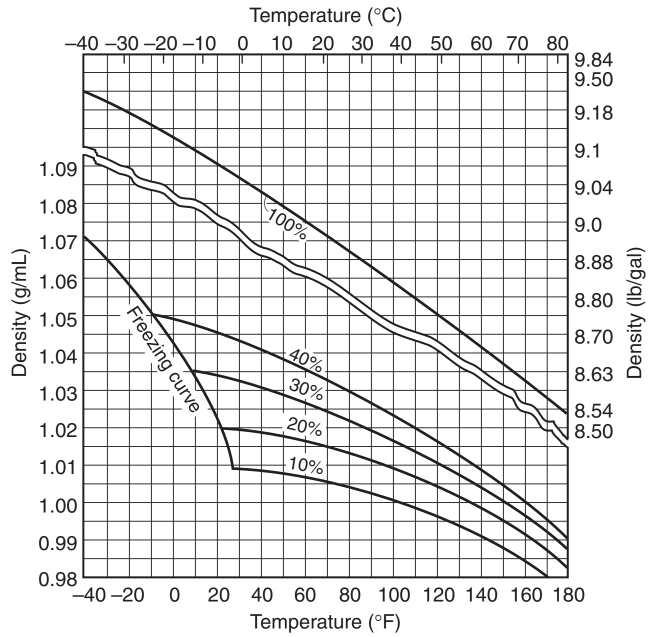
$$V_{EC} = \frac{P_1 \cdot T_0 \cdot P_2 \cdot \Delta L \cdot T_1}{P_0 \cdot T_1 \left(P_2 \cdot T_1 - P_1 \cdot T_2\right)}$$

In cases where the normal static pressure on the sprinkler system is close to the maximum working pressure, antifreeze systems are not advisable if the connection to the wet pipe system will incorporate a backflow device. In these cases, expansion of the antifreeze solution during warm weather will cause the antifreeze system to exceed the maximum working pressure, regardless of the size of the expansion chamber. The normal static pressure is too close to the maximum working pressure if the preceding formula for V_{EC} yields a negative result. If this occurs, use a dry pipe system instead or install a pressure-reducing valve before the backflow preventer.

A.9.3.5 With regard to preaction systems, it is assumed that the release system will activate before the sprinklers. It is generally accepted that smoke detectors and rate-of-rise detectors are more sensitive than sprinklers and that fixed-temperature-release devices with RTIs lower than that of sprinklers will react faster than sprinklers at similar spacings and locations.

A.10.1.1 The minimum pressure and flow requirements need to be satisfied while also meeting the requirements of the formula $q = K(p)^{0.5}$. If a sprinkler with a K-factor of 4.3 is listed to cover an area of 18 ft × 18 ft (5.5 m × 5.5 m) at 16.2 gpm (61 L/min), the minimum pressure is required to be 14.2 psi (0.1 bar) so that the flow is achieved. Likewise, if a sprinkler with a K-factor of 5.6 is covering an area 12 ft × 12 ft (3.7 m × 3.7 m), the minimum flow is required to be 14.8 gpm (56 L/min) [the flow at 7 psi (0.5 bar)] even though a flow of 7.2 gpm (27 L/min) will satisfy the density criteria.

A.10.2 All residential sprinklers have been investigated under a flat, smooth, 8 ft (2.4 m) high horizontal ceiling. Some residential sprinklers have been investigated and listed for use under specific ceiling configurations such as a horizontal beamed ceiling. The performance of residential sprinklers under flat, smooth, horizontal ceilings has been well documented throughout the life of NFPA 13D. Prior to 2010, several manufacturers of residential sprinklers had performed testing and received listings for residential sprinklers under certain slopes and in certain beam conditions. In 2010, the Fire Protection Research Foundation (FPRF) conducted a research project consisting of 76 FDS simulations and 12 full-scale fire tests. The results have been used to develop system design criteria in a generic manner to simplify the use of residential sprinklers.



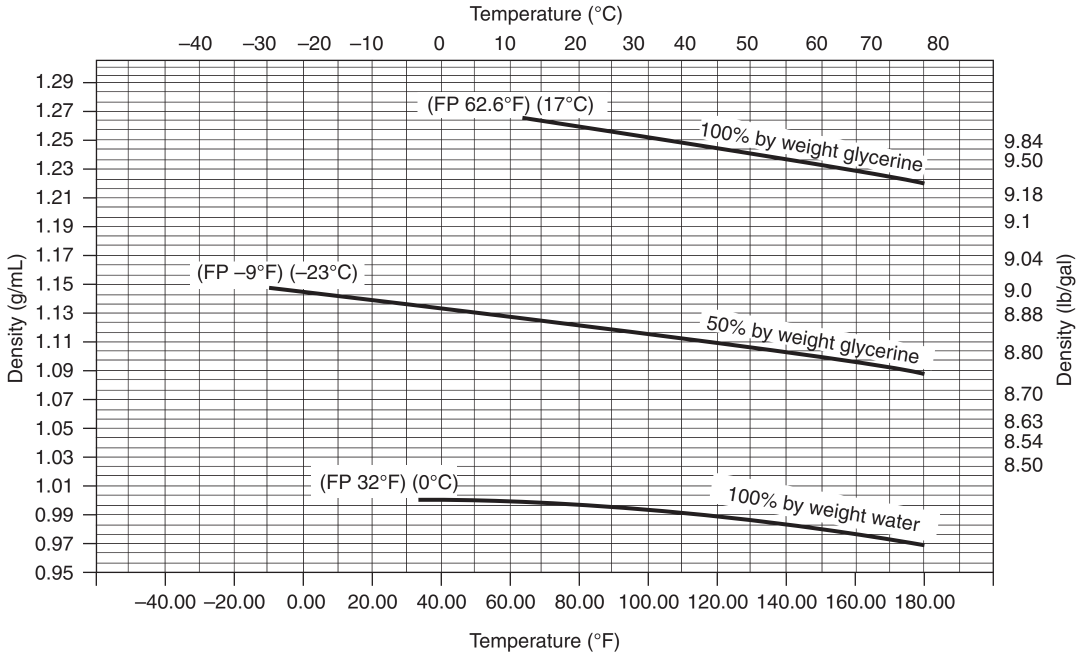
Note: The 100 percent concentration curves are provided for information only so that densities are known for calculating solutions.

FIGURE A.9.2.3.2(a) Densities of Aqueous Propylene Glycol Solutions (Percent by Weight). [13: Figure 7.6.2.5(b)]

Some residential sprinkler listings still exist for situations beyond the scope of the generic design. See the FPRF report, "Analysis of the Performance of Residential Sprinkler Systems with Sloped or Sloped and Beamed Ceilings" dated July 2010 for more information.

Questions are frequently asked regarding the minimum two sprinkler design when certain sprinkler performance statistics have indicated that in a majority of the cases (with residential sprinklers) the fire is controlled or suppressed with a single sprinkler. While these statistics might or might not be accurate, the water supplies for the fire sprinkler systems under which these statistics were generated were designed for two or more sprinklers in the first place. When the fires occurred, the first sprinkler operated in excess of its individual design flow and pressure because the sprinkler system's water supply was strong enough to handle multiple sprinklers and only a single sprinkler opened. At these higher flows and pressures, the discharge from a single sprinkler was sufficient to limit or suppress the heat generated from the fire. This concept is called "hydraulic increase." Hydraulic increase can also occur when a water supply's capabilities during the fire event exceeded that required by the minimum design requirements of the standard. Since none of the data used to generate the previously mentioned statistics captured the capabilities of the water supply in relation to the design requirements, the impact of the hydraulic increase on the number of single sprinkler activations cannot be determined.

But if the minimum water supply requirement of the standard is reduced to only be capable of handling a single sprinkler, then there could be no hydraulic increase safety factor. When the first sprinkler opens, it will only get the flow and pressure



Note: The 100 percent concentration curves are provided for information only so that densities are known for calculating solutions.

FP: Freezing point.

FIGURE A.9.2.3.2(b) Densities of Aqueous Glycerine Solutions (Percent by Weight). [13: Figure 7.6.2.5(c)]

that were originally designed for it, and the potential is significant for that to be insufficient to control the fire, given any obstructions and the layout of the space where the fire starts.

The National Institute for Standards and Technology (NIST), under a grant from the United States Fire Administration, studied this concept several years ago in the hopes of being able to propose a single-sprinkler flow for the 2007 edition of NFPA 13D (see NIST Report NIST GCR 05-875 prepared by Underwriters Laboratories with a publication date of February 2004). Unfortunately, the research did not support the design of a sprinkler system with only the flow for a single sprinkler, even under conditions of small rooms with flat, smooth ceilings. Without the hydraulic increase associated with the two-sprinkler design, the fire scenarios were too many where the first sprinkler to open would have insufficient flow to control the fire and then multiple sprinklers would open, causing the room to reach untenable conditions and the water supply to be overrun. These same fire scenarios were easily controlled by a sprinkler system designed for a two-sprinkler water supply from the start.

In addition to the NIST tests, the National Fire Sprinkler Association conducted a series of full-scale fire tests in simulated bedrooms that were 14 ft × 14 ft (4.2 m × 4.2 m) with an adjoining hallway, each with flat, smooth, 8 ft (2.4 m) high ceilings. The tests were performed to determine better rules for keeping sprinklers clear of obstructions like ceiling fans, but baseline tests were also performed without any obstructions at the ceiling. In nine out of the twelve tests, including the two baseline tests without obstructions at the ceiling, a sprinkler in the hall outside the room of fire origin opened first, followed by the sprinkler in the room of origin. Even though the room of origin met all of the rules of NFPA 13D as a compartment, a sprinkler outside of this room was opening first. All of these fires were controlled by the sprinklers, but if the water supply had only been sufficient for a single sprinkler, the sprinklers might not have been able to provide fire control.

For examples of selecting a compartment for consideration, see Figure A.10.2(a) and Figure A.10.2(b), which show examples of design configurations for compartments based on the presence of lintels to stop the flow of heat.

A.10.2.4 A number of variables exist that would influence the number of sprinklers that might open during a fire. In many of the fire tests that led to the development of the residential sprinkler, and in many of the subsequent tests, including the testing conducted as a part of the previously referenced FPRF

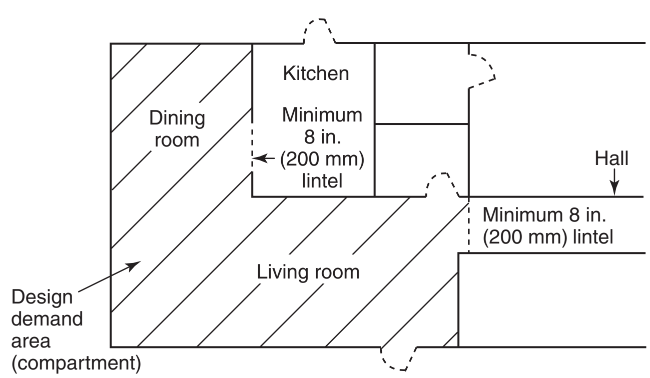


FIGURE A.10.2(a) Sprinkler Design Areas for Typical Residential Occupancy — Without Lintel.

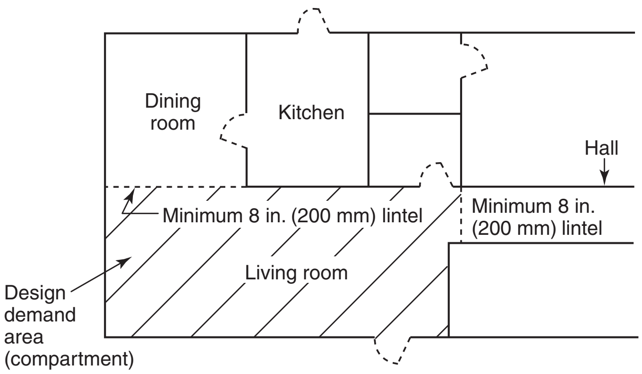


FIGURE A.10.2(b) Sprinkler Design Areas for Typical Residential Occupancy — With Lintel.

sloped ceiling research project, more than two sprinklers have opened during certain fire tests, but the water supply, sized for only two sprinklers, was still capable of controlling the fire for 10 minutes and meeting the goals of NFPA 13D. While there is no guarantee that more than two sprinklers would always open, it is believed that the two-sprinkler design criterion is appropriate for ceiling constructions and room configurations that are within the limitations referenced 10.2.1 and 10.2.3.

For the ceiling constructions and room configurations that are beyond the scope of the two-sprinkler discharge criterion referenced in 10.2.1 and 10.2.3, a greater number of design sprinklers and/or higher discharge flows should be considered in the system design. As of this date, there is limited fire test data available to include specific design criteria in this standard. In these situations, sprinklers can be installed in a manner acceptable to the authority having jurisdiction to achieve the results specified in this standard. In making these determinations, consideration should be given to factors influencing sprinkler system performance, such as sprinkler response characteristics, impact of obstructions on sprinkler discharge, and number of sprinklers anticipated to operate in the event of a fire.

For the situation of flat, smooth, horizontal ceilings with beams at the ceiling, there are a number of variables that could cause many sprinklers to open during a fire. Residential sprinklers used in accordance with all of the restrictions of their listing can be used to protect this circumstance.

A.10.4.2.3 Any special listing of products covered in 10.4.2.3 should include certification by the manufacturer of personnel involved in the layout, calculation, and installation of their product.

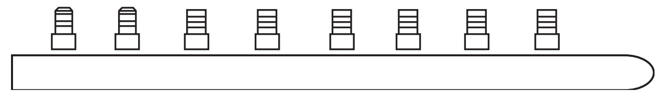


FIGURE A.10.4.2.3(1) Water Supply Manifold.

A.10.4.2.3(1) Where a four-port fitting is used, and one of the ports is not being used to satisfy this requirement or to feed a domestic fixture, the extra port should be connected to another open port at a sprinkler or should be connected to the water supply pipe (manifold). *[See Figure A.10.4.2.3(1).]*

A.10.4.4 The determination of public water supply pressure should take into account the probable minimum pressure conditions prevailing during such periods as during the night or during the summer months when heavy usage can occur. The possibility of interruption by floods or ice conditions in winter also should be considered. *[See Figure A.10.4.4(a), Figure A.10.4.4(b), Table A.10.4.4(a), Table A.10.4.4(b), Table A.10.4.4(c), and Table A.10.4.4(d).]*

A.10.4.4(4) The total length includes equivalent length of fittings as determined by applying Table 10.4.4(b), Table 10.4.4(c), Table 10.4.4(d), or Table 10.4.4(e).

A.10.4.4(6) The flow through water meters is not limited by Table 10.4.4(a). The friction losses in this table are not given for high flows because they are not standardized by all manufacturers. Every size meter has a rated flow (up to which friction losses are generally published by manufacturers). But for flows greater than rated flow, many manufacturers do not publish friction loss data. This does not prohibit the use of such meters. It just means that the friction loss must be obtained before deciding to use any specific meter.

The purpose of the rated flow of a meter has to do with the daily and continuous use of the meter. Higher flows are permitted for meters over short durations. An NFPA 13D sprinkler system is only expected to deliver water for 10 minutes. Flows significantly higher than rated flows can go through water meters for 10 minutes, with no adverse effects on the meter.

To prove that higher flows for short durations are not a problem, the Fire Protection Research Foundation (FPRF) sponsored testing of many different models of many different flow meters at greater than rated flows for 20 minutes. During the tests, friction losses through the meters were obtained. The report showed that regular water meters had no problem with significantly higher flows than rated flow for the 20-minute duration. An example of the data from the experiments is shown in Figure A.10.4.4(6), which shows the results from testing four different ⅝ in. positive displacement meters. The dark curve on the graph represents the friction loss information from Table 10.4.4(a) of NFPA 13D. The full report of the FPRF

Table A.10.4.4(a) Pressure Losses in psi/ft for Schedule 40 Steel Pipe (C = 120)

	Flow Rate (gpm)											
Pipe Size (in.)	**10**	**12**	**14**	**16**	**18**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
1	0.04	0.05	0.07	0.09	0.11	0.13	0.20	0.28	0.37	0.47	0.58	0.71
1¼	0.01	0.01	0.02	0.02	0.03	0.03	0.05	0.07	0.10	0.12	0.15	0.19
1½	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.05	0.06	0.07	0.09
2	—	—	—	—	—	0.01	0.01	0.01	0.01	0.02	0.02	0.03

For SI units, 1 gal = 3.785 L; 1 psi = 0.0689 bar; 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Table A.10.4.4(b) Pressure Losses in psi/ft for Copper Tubing — Types K, L, and M (C = 150)

Tubing Size (in.)	Type	Flow Rate (gpm) 10	12	14	16	18	20	25	30	35	40	45	50
¾	M	0.08	0.12	0.16	0.20	0.25	0.30	0.46	0.64	0.85	—	—	—
	L	0.10	0.14	0.18	0.23	0.29	0.35	0.53	0.75	1.00	—	—	—
	K	0.13	0.18	0.24	0.30	0.38	0.46	0.69	0.97	1.28	—	—	—
1	M	0.02	0.03	0.04	0.06	0.07	0.08	0.13	0.18	0.24	0.30	0.38	0.46
	L	0.03	0.04	0.05	0.06	0.08	0.10	0.15	0.20	0.27	0.35	0.43	0.53
	K	0.03	0.04	0.06	0.07	0.09	0.11	0.17	0.24	0.31	0.40	0.50	0.61
1¼	M	0.01	0.01	0.02	0.02	0.03	0.03	0.05	0.07	0.09	0.11	0.15	0.17
	L	0.01	0.01	0.02	0.02	0.03	0.03	0.05	0.07	0.10	0.12	0.16	0.19
	K	0.01	0.01	0.02	0.02	0.03	0.04	0.06	0.08	0.11	0.13	0.17	0.20
1½	M	—	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.05	0.06	0.08
	L	—	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.05	0.07	0.08
	K	—	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.05	0.06	0.07	0.09
2	M	—	—	—	—	—	—	0.01	0.01	0.01	0.01	0.02	0.02
	L	—	—	—	—	—	—	0.01	0.01	0.01	0.01	0.02	0.02
	K	—	—	—	—	—	—	0.01	0.01	0.01	0.01	0.02	0.02

For SI units, 1 gal = 3.785 L; 1 psi = 0.0689 bar; 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Table A.10.4.4(c) Pressure Losses in psi/ft for CPVC Pipe (C = 150)

Nominal Pipe Size (in.)	Actual Pipe Size (in.)	Flow Rate (gpm) 10	12	14	16	18	20	25	30	35	40	45	50
¾	0.874	0.05	0.07	0.10	0.13	0.16	0.19	0.29	0.40	0.53	0.68	0.85	1.03
1	1.101	0.02	0.02	0.03	0.04	0.05	0.06	0.09	0.13	0.17	0.22	0.28	0.34
1¼	1.394	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.04	0.05	0.07	0.09	0.11
1½	1.598	0	0	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.04	0.04	0.05
2	2.003	0	0	0	0	0	0	0.01	0.01	0.01	0.01	0.01	0.02

can be downloaded from the NFPA website at http://www.nfpa.org/research/fire-protection-research-foundation/reports-and-proceedings/suppression.

A.10.4.9.2(6)(d) The required pressure is provided in the sprinkler manufacturer's published data for the specific sprinkler model based on the selected flow rate.

A.11.2.1 Fire department connections are not required for systems covered by this standard but can be installed at the discretion of the owner. In these cases, hydrostatic tests in accordance with NFPA 13 are necessary.

Dry systems should also be tested with air at the pressure value intended to be maintained within the system during service. This testing should be conducted in accordance with the guidance provided in the manufacturers' instructions for the dry system components. Any leak that results in a drop in system pressure greater than 1½ psi (0.14 bar) in 24 hours should be corrected. Leaks should be identified using soapy water brushed on each joint or coupling. The presence of bubbles indicates a leak. This test should be made prior to concealing the piping. The soap should be compatible with all contacted sprinkler system components.

A.11.2.2 The flow of water is necessary to make sure that the pump does not get damaged during testing. The use of a timer to keep the pump running is not recommended because the timer will allow the pump to run when no water is flowing. The

Table A.10.4.4(d) Pressure Losses in psi/ft for PEX Pipe (C = 150)

Nominal Pipe Size (in.)	Actual Pipe Size (in.)	Flow Rate (gpm) 10	12	14	16	18	20	25	30	35	40	45	50
¾	0.68	0.18	0.25	0.33	0.43	0.53	0.64	0.97	1.36	1.81	2.32	2.88	3.50
1	0.875	0.05	0.07	0.10	0.12	0.16	0.19	0.28	0.40	0.53	0.68	0.84	1.03
1¼	1.07	0.02	0.03	0.04	0.05	0.06	0.07	0.11	0.15	0.20	0.26	0.32	0.39
1½	1.263	0.01	0.01	0.02	0.02	0.03	0.03	0.05	0.07	0.09	0.11	0.14	0.17
2	1.653	0	0	0	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.04	0.05

		Individual Loss	Net Total
(1) Water pressure in street	______	______	______
(2) Arbitrarily select pipe size	______		
(3) Deduct meter loss (size)	______	______	______
(4) Deduct head loss for elevation [______ ft (m) × 0.433 psi/ft (0.098 bar/m)]	______		
(5) Deduct pressure loss from city main to sprinkler system control valve*	______		
____ Pipe ______ ft (m)		______	______
____ Valves ______ ft (m)		______	______
____ Elbows ______ ft (m)		______	______
____ Tee ______ ft (m)		______	______
____ Total ______ ft (m) ×	______	______	______
(6) Deduct pressure loss for piping control valve to farthest sprinkler*			

Size	Quantity	Description	Total Equivalent (ft) (m)
____	____	90 degree elbow	____
____	____	45 degree elbow	____
____	____	Tee	____
____	____	Check valve	____
____	____	Valve (____)	____
____	____	Total	____ ft (m) × ____ = ____

Size	Quantity	Description	Total Equivalent (ft) (m)
____	____	90 degree elbow	____
____	____	45 degree elbow	____
____	____	Tee	____
____	____	Check valve	____
____	____	Valve (____)	____
____	____	Total	____ ft (m) × ____ = ____

Remaining pressure for sprinkler operation ______

* Factors from Table 10.4.3(a) through Table 10.4.3(e).

FIGURE A.10.4.4(a) Calculation Sheet.

pump needs to run for the entire duration without interruption, including not tripping the circuit breaker.

A.11.2.2.1.1 There should be no delay in the activation of the pump upon flow of water.

A.12.1 These instructions should include the following:

(1) Information regarding the necessary system inspection, testing, and maintenance as described in this standard
(2) The manufacturers' installation, care, and maintenance instructions for the installed sprinkler system components

	Individual Loss	Net Total
Water pressure at supply outlet		
(1) Deduct head loss for elevation	______	______
[______ ft (m) × 0.433 psi/ft (0.098 bar/m)]	______	______
(2) Deduct pressure loss from piping within building*	______	______
Remaining pressure for sprinkler operation	______	______

*Factors from Table 10.4.3(a) through Table 10.4.3(g).

FIGURE A.10.4.4(b) Calculation Sheet — Elevated Tank, Booster Pump, Pump Tank Supply.

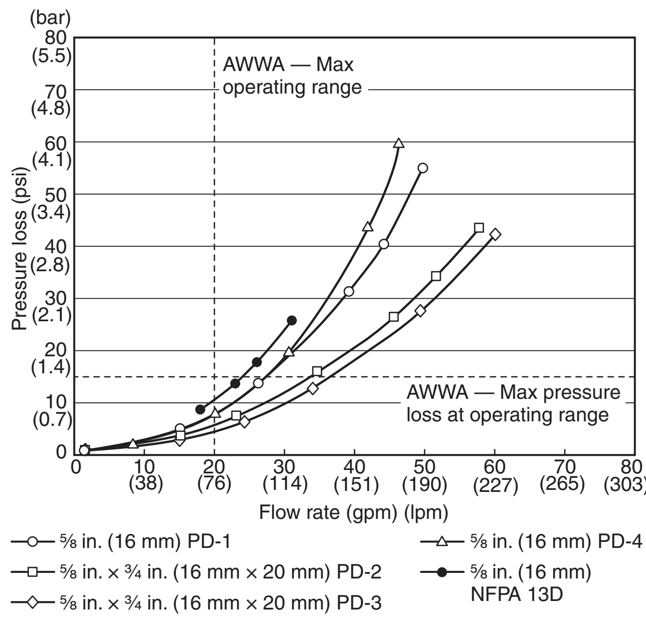


FIGURE A.10.4.4(6) ⅝ in. Water Meter Data from FPRF Tests.

(3) Name, address, and phone number of the installing contractor of the fire sprinkler system
(4) Name, address, and phone number of a fire sprinkler system service company if different than the installing contractor

The occupants of a home with a sprinkler system should understand that maintaining a sprinkler system is mostly about common sense. Keeping the control valve open, not hanging items from the sprinklers, and making sure that the sprinklers do not get painted or obstructed are the most important items. It is also important to know the function of the main control valve and where the control valve is located.

A.12.2 The building owner or manager should understand the sprinkler system operation and conduct periodic inspections and tests to make sure that the system is in good working condition. A recommended inspection and testing program includes the following:

(1) Monthly inspection of all valves to ensure that they are open
(2) Monthly inspection of tanks, if present, to confirm they are full
(3) Monthly testing of pumps, if present, to make sure they operate properly and do not trip circuit breakers when starting
(4) Testing of all waterflow devices, when provided, every 6 months including monitoring service (note that notification of the monitoring service is essential to make sure that the fire department is not called due to testing)
(5) Ongoing visual inspection of all sprinklers to make sure they are not obstructed, damaged, corroded, covered with foreign materials, field painted, or showing signs of leakage, and that decorations are not attached to them
(6) Annually, fully open the test connection downstream of any pressure-reducing or pressure-regulating valve, and make sure that the pressure gauge reads a reasonable value
(7) Inspect systems by individuals knowledgeable and trained in such systems when there is a change in ownership

A.12.3.2.1 It is recognized that the flow and pressure available to the replacement sprinkler might be less than its current flow and pressure requirement.

A.12.3.3.2 Whenever painting or home improvements are made in the dwelling unit, special attention should be paid to ensure that sprinklers are not painted or obstructed either at the time of installation or during subsequent redecoration. This is as important for the cover plates of concealed sprinklers as it is to the sprinklers themselves. Special paint is used for cover plates and can only be applied by the manufacturer. Applying paint to cover plates outside of the factory can cause the sprinkler to malfunction and possibly not operate during a fire. When painting is occurring in the vicinity of sprinklers, the sprinklers should be protected by covering them with a bag, which should be removed immediately after painting is finished. For concealed-type sprinklers, the cover plates should be removed (most are designed to be unscrewed) and then the sprinklers should be protected underneath from paint and overspray with a bag. After the painting is finished, the bags should be removed from the sprinklers and the cover plates should be replaced.

A.12.3.4 See Figure A.9.1.1(a) through Figure A.9.1.1(d) for possible methods used by the installer to insulate sprinkler piping in unheated areas. It is important that this insulation not be disturbed or removed. Disturbing or removing this insulation could result in sprinkler pipes being frozen during winter months that would not only block water flow to the sprinklers but could cause broken pipes and fittings.

A.12.3.5 Sampling from the top and bottom of the system helps to determine if the solution has settled. Antifreeze solutions are heavier than water. If the antifreeze compound is separating from the water due to poor mixing, it will exhibit a higher concentration in the lower portion of the system than in the upper portions of the system. If the concentration is acceptable near the top, but too low near the water connection, it could mean that the system is becoming diluted near the water supply. If the concentration is either too high or too low in both the samples, it could mean that the wrong concentration was added to the system.

On an annual basis, test samples should be drawn from test valve B as shown in Figure 9.2.3.1.1, especially if the water portion of the system has been drained for maintenance or repairs. A small hydrometer can be used so that a small sample is sufficient. Where water appears at valve B, or where the sample indicates that the solution has become weakened, the entire system should be emptied and refilled with acceptable solution as previously described.

Table A.12.3.5 Properties of Glycerine and Propylene Glycol for Existing Systems

Material	Solution (by volume) (%)	Specific Gravity at 77°F (25°C)	Freezing Point °F	Freezing Point °C
Glycerine (C.P. or U.S.P. grade)	0	1.000	32	0
	5	1.014	31	-0.5
	10	1.029	28	-2.2
	15	1.043	25	-3.9
	20	1.059	20	-6.7
	25	1.071	16	-8.9
	30	1.087	10	-12
	35	1.100	4	-15.5
	40	1.114	-2	-19
	45	1.130	-11	-24
	50	1.141	-19	-28
Propylene glycol	0	1.000	32	0
	5	1.004	26	-3
	10	1.008	25	-4
	15	1.012	22	-6
	20	1.016	19	-7
	25	1.020	15	-10
	30	1.024	11	-12
	35	1.028	2	-17
	40	1.032	-6	-21

C.P.: Chemically Pure. U.S.P.: United States Pharmacopoeia 96.5%.

Where systems are drained in order to be refilled, it is not typically necessary to drain drops that are less than 36 in. (900 mm) in length. Most systems with drops have insufficient volume to cause a problem, even if slightly higher concentration solutions collect in the drops. For long drops with significant volume, consideration should be given to draining drops if there is evidence that unacceptably high concentrations of antifreeze have collected in these long drops.

When emptying and refilling antifreeze solutions, every attempt should be made to recycle the old solution with the antifreeze manufacturer rather than discarding it.

See Table A.12.3.5. The manufacturer's technical data sheets can include specific information on the properties of their antifreeze solutions.

Table A.9.2.2.1 was moved by a tentative interim amendment (TIA). See page 1.

A.12.3.5.1.1.3 If not already present, test connections (valves) for collection of solution samples should be installed at the highest and lowest practical locations of the system or portion of the system containing antifreeze solution.

A.12.3.5.1.3 In the past, for some existing systems subject to extremely low temperatures, antifreeze solutions with concentrations greater than what is now permitted by NFPA 13D were used. Such high concentrations of antifreeze are no longer permitted. In situations where extremely low temperatures are anticipated, refilling the fire sprinkler system with a concentration of antifreeze solution currently permitted by the standard might not provide sufficient freeze protection without additional measures. Such measures might include converting the antifreeze system to another type of sprinkler system.