Residential Fire Sprinkler Systems

Guidance for Water Utilities

American Water Works Association

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Introduction

Supplying water for fire protection is a valuable service provided by many water utilities in North America. As service areas grow, fire risks usually increase and place a greater burden on communities to protect human life and property. Most water utilities design additional capacity into their distribution system to ensure that large volume flows and adequate pressures are available to inundate fires. In recent decades, fire risks have been reduced through improvements in building materials and designs, and the use of fire alarm systems and internal fire sprinkler systems. Although residential fire sprinkler systems (RFSS) are less common than commercial and industrial systems, their use is growing. RFSS offer effective life safety protection in residential occupancies, including smaller dwellings, where delayed fire department response times can increase the risk of loss of life.

Fire sprinkler systems installed inside a building use less water than water streams from fire hydrants. RFSS sprinkler heads require only a modest stream of water that is targeted at a fire in its incipient stage. Used in some communities for more than 30 years, RFSS have a proven record for not only life safety—their primary purpose—but also for protecting property.

Adhering to recent revisions to international and United States building codes, more communities are establishing code requirements for the installation of RFSS in new one- and two-family dwellings and manufactured homes (see footnote below). And although state requirements for RFSS are limited, often these systems are being installed on a voluntary basis by builders or at the request of home buyers. Thus, utilities should be familiar with RFSS design and operation, and set policies and procedures to manage RFSS use in their service areas.

When providing service to customer connections with RFSS, water utilities must take care to ensure that hydraulic and water quality requirements are met at a reasonable cost and without revenue loss. The unique hydraulic requirements of RFSS, however, present a variety of design and management options that many water utilities have not previously encountered. Utilities should have proper guidance on water service connection pipe sizing, metering, permitting, and rates and charges to establish their own policies and procedures for the use of RFSS within their service area.

This guidance document provides information to help water utilities understand the purpose and features of RFSS, and guide them in setting their own policies and procedures for the design, installation, and operation of water distribution systems servicing customers with RFSS.

Note that jurisdictions (e.g., state and local governments) determine which occupancies are subject to their RFSS requirements.
Water Supply for Fire Protection: A Brief History

Water is perhaps the most widely recognized form of fire suppressant. From the early bucket brigades to high capacity water distribution systems supplying fire hydrants, fire protection is an established part of the mission for many drinking water utilities. Benjamin Franklin founded the Union Fire Company in Philadelphia in 1736. In that era, fire companies aligned with insurance companies and gave preference for fire extinguishing to subscribers of the insurance company. The “fire mark” was mounted to the building so fire fighters would know who subscribed to the insurance company. Private fire protection companies eventually receded, in recognition that fire protection must be provided to all in a community—not just to those who can afford to pay. The risk of allowing some fires to burn also became recognized for the catastrophic effects of conflagrations (such as the 1871 Great Chicago Fire) spreading rapidly from building to building.

Hydraulic design capacities increased to provide for community water needs and fire protection. Some cities—including Philadelphia, Baltimore, Boston, Cleveland, and Rochester (NY)—also installed separate high-pressure fire systems to protect high value commercial or manufacturing cores of their cities. The water inundation approach to fire protection—still used by many water utilities—was established. This approach requires significant water distribution system capacity to provide adequate water flows and pressure.

In recent decades, fire sprinkler systems were designed to bring a stream of water strategically to an emerging fire in its early stages. Internal fire sprinkler systems are used in many commercial, industrial, and multi-family residential buildings. RFSS installations in small buildings have lagged compared to the use of sprinklers in larger buildings, but modest, steady growth of installation in homes has occurred as more jurisdictions require them, and as builders install them voluntarily or at the request of the purchaser. Fire prevention and risk management have improved dramatically in recent decades due to a variety of factors, including better building and materials codes, alarm systems, and regulations. Fire sprinkler systems have also contributed to these improvements and will continue to do so, particularly as more small-residential homes are outfitted with RFSS.
Fire Safety Evolution

In modern times, fire protection authorities began to place as much emphasis on fire prevention as fire suppression. Standards and codes were established for fire safety, fire-resistant building materials, electrical systems, and hazardous materials. Newer buildings are less susceptible to fire than older buildings constructed of wood and dated materials. Fire alarms, sprinkler systems, and fire-resistant construction have been mandated in many jurisdictions for commercial and industrial buildings, fortifying these structures against fire threat.

While large buildings became better protected, fire protection officials remained vexed by the high loss of life from fires occurring in smaller residential dwellings. Statistics find that residential is the leading property type for fire deaths, fire injuries, and fire dollar loss. The National Fire Protection Association’s (NFPA) Home Structures Fire Report (2017) states that US fire departments responded to an estimated 358,500 home fires per year during 2011-2015, with average annual fire statistics of:

- 2,510 civilian fire deaths, or 93% of all civilian structure fire deaths,
- 12,300 civilian fire injuries, or 87% of all civilian structure fire injuries, and
- $6.7 billion in direct damage, or 68% of total direct damage in structure fires.

These statistics exist for the residential sector despite considerable overall progress in recent years in reducing fire deaths and injuries.

In 1986, the City of Scottsdale, AZ became one of the first cities to require RFSS in new building construction. Scottsdale has perhaps the longest-standing and best studied history of RFSS use in the United States. Data from Scottsdale overwhelmingly demonstrate the success of RFSS in reducing fire deaths (their primary purpose) and property damage. Only one fire death has occurred in Scottsdale in a sprinklered residential building in the 30 years of its RFSS ordinance. A recent evaluation reported the fire loss cost in Scottsdale to be $7.31 per capita vs. $27 per capita for the entire United States. Many states and local jurisdictions have had the opportunity to voluntarily adopt RFSS requirements into their own codes, and Scottsdale and several other communities are highlighted in this report.

A major development occurred when the International Code Council (ICC) adopted amendment RB64-07/08 to the 2009 International Residential Code (IRC). This amendment mandated that all new one- and two-family residential dwellings be equipped with RFSS. States maintaining their own uniform construction codes based on the IRC now require installation of RFSS in new residential construction. States can move to amend their codes to waive or modify the RFSS requirement, but the States of California and Maryland, along with the District of Columbia, have maintained this requirement. Other states have varying requirements. However, 31 states have no statewide building codes and include prohibitions against local jurisdictions enacting RFSS ordinances. Others have limited statewide requirements but allow local jurisdictions to implement their own RFSS ordinances. Table 1 summarizes the state RFSS requirements. Water utilities are urged to conduct their own research to become familiar with the status of RFSS requirements in their state and in any local jurisdictions that fall within their service area.
RFSS are not embraced by all and are actively opposed by some including certain members of the home building community, citing reasons such as the high cost of sprinklers and the perceived potential for water damage from system malfunctions. Although the 2009 editions of the International Building Code and the International Fire Code first established requirements for automatic sprinklers in residential structures, building groups have since successfully lobbied various states to remove this requirement when adopting this and later editions of the International Fire Code. The reason often stated is that the cost (generally estimated at $5,000—$6,000 for a 3,000-square-foot home) would make the sale of homes more difficult.

While formal legal requirements for RFSS at the state level are limited, these systems are being installed on a voluntary basis by builders or at the request of buyers. In Delaware, builders are required to give buyers a cost estimate for fire sprinklers and install them if the buyer wants the system. Therefore, even water utilities in a jurisdiction without a residential sprinkler requirement can encounter the construction of residential buildings with RFSS. Hence, utilities should be knowledgeable in RFSS design and operation and be prepared to set policies to manage their use in their service area.

### Legal Requirements and Fire Safety Codes in the USA

**International Codes:** As noted previously, the International Code Council (ICC) adopted amendment RB64-07/08 to the 2009 International Residential Code (IRC), mandating that all new one- and two-family residential dwellings be equipped with RFSS. The International Fire Code (IFC) also requires sprinkler protection for all residential occupancies.

**Uniform Construction Codes within the USA:** The States of California and Maryland, and the District of Columbia maintain a uniform construction code based on the IRC and require RFSS. The disposition of residential sprinkler requirements in building codes in other states is in Table 1.

**Individual jurisdictions within the United States:** In the absence of a state-wide mandate for RFSS, many individual jurisdictions (cities, towns, municipalities) have adopted local ordinances requiring the use of RFSS. Most states (see Table 1) prohibit local jurisdictions from adopting RFSS ordinances. However, even some of these states (New York, Massachusetts) have RFSS requirements for certain buildings, and water utilities in these states should be aware of these provisions. Some jurisdictions, such as Scottsdale, AZ, implemented their own requirements before their state enacted a prohibition against such requirements.

**National Fire Protection Association (NFPA) Codes:** NFPA 101, Life Safety Code requires sprinkler protection for all new single-family dwelling units. NFPA 5000, Building
Construction and Safety Code requires sprinkler protection for all new single-family dwelling units. NFPA 1, Uniform Fire Code references NFPA 101 for the residential sprinkler requirement. Jurisdictions that adopt these NFPA Codes would then have a requirement for residential fire systems in single family dwellings. Specific fire sprinkler design requirements are included in the NFPA 13, 13R, and 13D Standards detailed in the following sections of this report.

Water utilities should understand the status of legally mandated or optional implementation of RFSS at the state and local levels for communities within their service area. They should also stay current on the status of discussions within their state government on the topic. In the absence of legal requirements for RFSS, water utilities should monitor their community’s interest in having RFSS in new home designs. If customers are requesting these systems and builders are offering them, they will be installed. Various stakeholders—including the water utility—should have policies and procedures in place to provide designers and installers with the proper guidance on water service connection pipe sizing, metering, backflow protection, permitting, and rates and charges. Utilities should carefully coordinate policy development with fire, code enforcement, and other local officials.

**Stakeholder Perceptions and Interests**

Drinking water utilities are usually well-versed in coordinating with community agencies to meet their mission to provide safe water. Regarding fire protection, utilities typically coordinate with fire departments, fire sprinkler system designers and installers, municipal code officials, regulators, builders, and manufacturers. In learning about the adoption and implementation of RFSS requirements in their jurisdictions, water utilities may also need to work with their elected officials, fire safety advocacy groups, insurance companies, water customers, and the media. Utility staff should be mindful that some of these stakeholder groups may also be new to the use of RFSS. For example, sprinkler design companies are usually well versed in designing sprinkler systems in large buildings by applying the NFPA 13 or 13R Standard, but they may not be familiar with the unique considerations for RFSS under the NFPA 13D Standard.

When developing policies and procedures for RFSS, water utility leadership should involve key staff in the discussion with the various external stakeholders. Utility staff should represent the interests of permitting (for water meters, service/fire lines, other water system requirements), metering, rates and charges, hydraulic design and reporting of available distribution system flow and pressure, public relations, and customer service. A coherent policy for RFSS needs to be developed by the water utility and widely communicated to the various internal and external stakeholders. A lack of understanding about RFSS might exist within any stakeholder group and may require the water utility to take a proactive approach to educate stakeholders about developing water utility policies and the purposes behind them.

**Fire Sprinkler Systems and Water Supply: the Basics**

Sprinkler systems for commercial, industrial, and larger residential buildings—while connected to the same water distribution system as the domestic water supply connection—have been designed as a system that is separate—or stand-alone—from the domestic water supply inside a building. These sprinkler systems supply numerous sprinkler heads and must provide a hydraulic flow capacity notably greater than the domestic water demand of the building. Therefore, these larger buildings typically have a sprinkler supply line of size 3-inch diameter or larger.
RFSS designed to protect one- and two-family dwellings and manufactured homes, require much lower flowrates than sprinklers for commercial, industrial, and larger residential buildings. The design flowrates (typically 26–35 gallons per minute (gpm)) are only modestly greater than typical indoor domestic water demand of residential buildings. While the most common, traditional domestic service line is size ¾-inch with a ⅝-inch water meter, the most common piping sizes in RFSS applications for one- and two-family dwellings are 1-inch, 1½-inch, and 2-inch. Because this pipe sizing increase is relatively modest, these RFSS designs allow for comingling of pipes for domestic and fire supply. RFSS piping may be configured as a distinct and separate line connecting into the water distribution system, or it may be a single line connected to the water main that branches into separate domestic and fire lines inside the building. In this regard, RFSS has features of both traditional domestic water supply line designs and traditional large fire connection designs; yet, it cannot be classified as either one of these historic design configurations. Thus, these RFSS are a hybrid of the traditional separate domestic and fire sprinkler connections. Consequently, existing utility policies often do not cover the unique attributes of RFSS, and water utilities should develop new policies and procedures that address the unique function and operation of the water supply to RFSS.

Specific Standards and Guidance for RFSS

The NFPA develops and manages a host of standards for fire protection. Three standards exist for fire sprinkler systems inside buildings.

1. NFPA 13 Standard—Standard for the Installation of Sprinkler Systems: NFPA 13-protected buildings provide both life safety and protection to the facility and its assets. This means there is fire protection throughout the entire building, including unoccupied spaces (attics, closets, etc.).

2. NFPA 13R Standard—Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies: NFPA 13R buildings provide for life safety and a moderate level of building protection. NFPA 13R focuses on life safety by providing protection to allow occupants to escape the building in the event of a fire. This results in allowing some areas of the building to omit sprinkler protection such as concealed spaces, an attic not used for living purposes or storage, etc. The 13R Standard applies to a building of no more than four stories in height.

3. NFPA 13D Standard—Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes. This is a minimum requirements standard that is intended to provide life safety protection and is not intended for property protection. Certain building spaces don’t have to be sprinklered, and the water discharge requirements are the least of the three standards (13 gpm per sprinkler head). Typically, this flow should be available for a minimum of 7–10 minutes at a minimum of 7 pounds per square inch (psi). The 13D Standard exists only for life safety protection at the most reasonable cost to the construction of the building and upkeep of the sprinkler system.

This is the standard that most commonly applies to the RFSS installations that are the subject of this report.

Each of these standards describes the entire realm of sprinkler system design and operation, including features other than water supply. Table 2 provides a comparison of occupancies and sprinkler system features and requirements that should be evaluated by builders to determine which of the three sprinkler standards applies best for a given building.
### Table 2—Comparison of the Three NFPA Fire Sprinkler Standards

| Comparison of Fire Sprinkler Requirements for Installation & Building Owner Upkeep | NFPA Fire Sprinkler Standard |
|---|---|---|---|
| Provisions | 13 | 13R | 13D |
| Typical building types<sup>1,2</sup> | Industrial, commercial, and residential more than 4 stories in height | Residential: generally, up to 4 stories in height | Residential: generally, one- and two-family dwellings and manufactured homes |
| Initial inspection of sprinkler system required? | Yes | Yes | Yes |
| Annual sprinkler system certification required? | Yes | Yes | No |
| Audible alarm required? | Yes | Yes | No (if the home is equipped with smoke detectors, which act as the alarm) |
| Supervision (connection to remote security or fire monitoring center) required? | Yes | Yes | No |
| Type of water supply connection | Most commonly separate fire and domestic lines | Most commonly separate fire and domestic lines | Commonly occur as separate fire and domestic lines in some jurisdictions, or as a single line supplying both fire and domestic flows in others |
| Water meter considerations | Fire line may be metered but often is not | Fire line may be metered but often is not | For single-tapped lines supplying both fire and domestic flow, a meter is usually included on the common piping upstream of the branching domestic supply line, or on the branching domestic supply line. Metering a separate fire line is optional. |
| Backflow prevention considerations<sup>3</sup> | Backflow protection of separate fire lines is typically required | Backflow protection of separate fire lines is typically required | Backflow protection typically need not be required on domestic lines and lines supplying both fire and domestic flow. Backflow protection of separate fire lines is typically required, unless it has a passive purge configuration.<sup>4</sup> |
| Considerations for periodic certification of the backflow prevention device<sup>3</sup> | Typically, the building owner is required to obtain certification | Typically, the building owner is required to obtain certification | Residential building owners may not be familiar with backflow prevention certification requirements. Education and monitoring will likely be necessary to ensure acceptable customer compliance if the utility requires certification. |
| Considerations for permitting | Best to require that the sprinkler system design be completed before meter, service line, or other water utility permits are issued. | | |

<sup>1</sup>The NFPA 13 Standard is commonly used in industrial and commercial buildings. The 13R Standard is commonly used for larger, multi-family residential buildings. These two standards are applied less often in residential construction, since sprinkler systems designed under this standard are more complex and are costlier to install and maintain than the 13D Standard. NFPA 13D is limited to one- and two-family dwellings and manufactured homes. NFPA 13R is limited to residential building 4 stories or less in height and no more than 60 ft above grade plane. NFPA 13 must be used in residential buildings that exceed 4 stories and/or are over 60 ft above grade plane. It must be noted that NFPA 13 may be used in residential 4 stories or less and NFPA 13R could be used in one- and two-family dwellings and manufactured homes, but this would add cost to the installation.

<sup>2</sup>The International Residential Code (IRC) includes P2904, which is also an “installation standard” for residential fire sprinkler systems. Some jurisdictions allow the use of P2904 as the basis for RFSS design. The NFPA 13D Standard is believed by many fire industry professionals to be a more developed and robust document, but it is up to the local jurisdiction to determine which governing publication to apply.

<sup>3</sup>The referenced NFPA Standards (13, 13R, and 13D) do not require backflow protection. Cross connection (e.g., backflow) control requirements are generally in health codes, plumbing codes, or water utility requirements.

<sup>4</sup>The NFPA 13D Standard defines a passive purge sprinkler system as a system that serves a single toilet in addition to the sprinklers inside the customer building, which provides circulation of water in the fire line when the toilet is flushed, thereby preserving water quality and negating the need for backflow protection. The toilet should be near the end of the premise plumbing.
American Water Works Association (AWWA) guidance is available in the following publications:

- **AWWA Policy Statement on Residential Fire Sprinklers**—AWWA maintains a policy statement that supports the use of RFSS and the role of the water utility in assisting these systems (see below).

  **AWWA Policy Statement: Residential Fire Sprinklers**

  AWWA recognizes the increasing use of residential fire sprinkler systems and recommends that they be designed by licensed or accredited professionals; approved by the appropriate local agencies (water utility, fire department and/or other approval agency) to ensure adequate flow, pressure, and backflow protection; and installed by licensed fire sprinkler contractors or properly trained personnel.


- **Manual M31—Distribution System Requirements for Fire Protection.** M31 includes comprehensive guidance on traditional fire protection provided by water utilities through their water distribution systems. It also includes a separate chapter on automatic fire sprinkler systems. The next revision of the manual will likely include a chapter on fire sprinkler systems used in one- and two-family dwellings and manufactured homes.

- **Manual M22—Sizing Water Service Lines and Meters.** M22 provides guidance on determining expected water demands in customer buildings that are used to properly size and specify water service lines and water meters. Service line pipe configurations used in RFSS applications are briefly presented.

- **Manual M14—Recommended Practice for Backflow Prevention and Cross Connection Control.** M14 provides information on backflow prevention, including a brief description of recommended backflow prevention practice for residential, one- and two-family dwelling fire protection systems. M14 defines different levels of hazards that may exist in buildings of all types. Many water utilities consider small residential occupancies low hazard (i.e., non-health hazard) backflow risks, which is a potential cross-connection involving any substance that generally would not be a health hazard, but instead would constitute a nuisance. Many water utilities do not require backflow protection for typical domestic service connection piping, however, some do.

  Each water utility must determine if backflow risks from these occupancies are more significant than low hazard, and therefore warrant a requirement for backflow protection. M14 recommends that a reduced-pressure principle backflow-prevention assembly or air gap be installed where the water utility determines a hazard level of concern exists. M14 recommends that a double check valve assembly be required where a low hazard is deemed to exist. **However, the water utility must decide what type of hazard exists, and whether to follow, or not follow, the recommendations included in M14.**

  Where RFSS are employed, M14 states that only piping configurations that the NFPA 13D Standard defines as a standalone system require backflow protection. Therefore, M14 indirectly recommends that dead-ended, standalone fire-line piping installed under the NFPA 13D Standard should have backflow protection for high hazard or low hazard as previously explained. Use of the passive purge configuration avoids a dead-end configuration on a standalone fire line and negates the need for backflow
protection, assuming the sprinkler system is constructed of materials approved for potable water and chemical or antifreeze additives are not used.

Water utility personnel should not assume that requiring backflow protection is a conservative measure that errs on the side of caution, particularly if backflow devices ultimately become neglected and inoperable with the potential to obstruct water supply to fire lines. Backflow protection should be provided where high hazards clearly exist, and may be better avoided where acceptable water quality can be maintained (e.g., by using an appropriate service connection piping configuration, passive purge feature, etc.).

- **Manual M1—Principles of Water Rates, Fees, and Charges.** M1 includes guidance on setting fees and charges for service lines providing fire protection service. The latest edition (2016) includes specific guidance on setting rates for sprinklered buildings, including those designed under the NFPA 13D Standard.

- **AWWA Standard C714-13—Cold-Water Meters for Residential Fire Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes.** C714-13 sets minimum manufacturing and performance requirements for water meters to be used in RFSS applications. The NFPA 13D Standard is not prescriptive in defining the use of water meters on fire supply lines. From the perspective of the fire protection community and according to NFPA 13D, the preferable arrangement requires no meter on the fire sprinkler supply line. This arrangement limits the number of devices on the fire supply line that might restrict or shut off the water supply during a fire if the device fails. Therefore, the water utility should determine: 1) if a water meter is required on the fire supply line, and 2) the specific features and specifications of the water meter. AWWA Standard C714-13 can assist water utilities that require water meters to determine the specific features of the water meter for use in their system. Standard C714-13 details several specific conditions for water meters that the water utility can consider adopting as their water meter requirements for RFSS applications. A notable consideration is whether the water utility should require the meter manufacturer to provide an affidavit confirming that a designated water meter will continue to deliver water to the system under a locked measuring element condition. Hence, if any moving parts of a water meter fail and become immobile (locked), adequate water supply will still exist through the water meter to meet the fire flow requirements.

The NFPA 13D Standard does not require that water meters used in RFSS applications be listed under the provisions of Underwriters Laboratories, Inc. (UL), Factory Mutual Company (FM), or other insurance underwriting agency. **Each utility must decide whether to require that their water meters be listed by UL or FM.**

Per the NFPA 13D Standard and the AWWA Manual M22, standard water meters used in domestic water supply applications are acceptable for use in RFSS applications. **The water utility must decide whether to require any of the provisions from Standard C714-13.** Water utilities have several options for specification of water meters in RFSS applications. However, water utility managers should evaluate the specific factors that exist in their operations and determine the types and features of water meters to employ in RFSS applications in their service area.
Policy Considerations for Water Utilities

The leadership and technical team members of the water utility should become familiar with the residential fire sprinkler regulations, codes, and standards that apply (or will apply) to jurisdictions within their service area. Based on these requirements and existing utility policy, the water utility should define the key features of the water supply line for the RFSS. These features will form the basis of the utility’s RFSS policy and include service connection piping size and configuration; water quality management and decisions on backflow protection; metering, valving, service discontinuance (shutoff) and restoration; and rates and charges.

A. Service connection piping configuration and coverages. The NFPA 13D Standard requires that sprinkler heads be installed in all living areas of the dwellings, with the following exceptions: sprinkler heads are not required in bathrooms less than 55 sq. ft. in size, closets, linen closets, and pantries less than 24 sq. ft. in size. Sprinkler heads are not required in garages, open attached porches, carports, or similar structures. Sprinkler heads are also not required in attics, crawl spaces, elevator shafts, concealed spaces dedicated exclusively to and containing dwelling unit ventilation-only equipment, and other concealed spaces that are not used or intended for living purposes.

NFPA 13D does require, however, a sprinkler head to be installed in any closet or pantry that houses full components of heating, ventilation and air conditioning (HVAC) equipment, or washing machines and dryers. Where fuel-fired equipment is located above the occupied areas of the dwelling unit, no sprinkler protection is required in the concealed space. Where fuel-fired equipment is located below or on the same level as occupied areas of the dwelling unit, at least one quick response, intermediate temperature sprinkler must be installed above the equipment or at the wall separating the space with the fuel-fired equipment from the occupied space.

The NFPA 13D Standard includes illustrations of several acceptable piping configurations, which fall into three categories: stand-alone, multipurpose, and passive purge.

1. Stand-alone configurations. In the stand-alone configurations, dedicated fire-line piping exists inside the building to supply sprinkler heads. Four different arrangements from NFPA Standard 13-D are shown in Figures 1.A—1.D, providing water utilities several options for line configuration, metering, valving, backflow protection, and pressure measurement. Stand-alone lines can be a single tapping connection to the water main as shown Figure 1.A, 1.B, and 1.C. In these cases, the domestic and fire supply lines branch off the service line inside the building, and the fire line does not connect to any domestic water fixtures. In Figures 1.A and 1.B, the water meter is placed on the line supplying only the domestic flows. In Figure 1.C, the water meter is placed on the common section of piping that supplies both domestic and fire flows. This arrangement requires a larger meter capable of measuring the slightly higher fire flows, which might not be as accurate at recording lower-volume domestic flows, including waste such as toilet leaks. A loss of meter low flow accuracy could result in unbilled water and loss of revenue to the water utility.
As a fourth option, the water utility could require the fire line to be a separate and distinct line tapped into the water main (see Figure 1.D). Water utility managers should recognize that a separate fire line doubles the number of tapping points into the distribution system water main. Because of the separate fire line and tapping connection, backflow protection, and possibly a second water meter or a device to detect flow on the fire line, this configuration is the most costly of those shown in Figure 1. Some water utilities prefer a separate and distinctly tapped fire line because they believe that it allows them to shutoff the domestic line, if needed (e.g., for payment delinquency), without having to shutoff the fire line. However, other options for shutoff are available to the water utility, and a separate and distinct fire line is not an absolute requirement (see the “Service Discontinuance and Restoration” discussion in this section).

![Figure 1.A: Minimum Requirements for a Stand-alone Piping System from the NFPA 13D Standard (Courtesy of NFPA)](image-url)

![Figure 1.B: Acceptable Arrangement for a Stand-alone Piping System—Option 1 from the NFPA 13D Standard (Courtesy of NFPA)](image-url)
Figure 1.C: Acceptable Arrangement for a Stand-alone Piping System—Option 2 from the NFPA 13D Standard (Courtesy of NFPA)

*Optional valve: See 7.1.4.

Figure 1.D: Acceptable Arrangement for a Stand-alone Piping System—Option 3 from the NFPA 13D Standard (Courtesy of NFPA)

*Optional valve: See 7.1.4.
2. **Multipurpose configurations.** In these configurations (see Figures 2.A—2.C), a single line is tapped into the water main, and this line enters the building and extends to provide water to both domestic water fixtures and to sprinkler heads. NFPA Standard 13D includes three different multipurpose configurations:

a. Tree System—domestic supply lines branch from a single primary supply line from water main. The primary supply extends into the building to supply sprinkler heads from dead-ended branch piping off the primary supply pipe (see Figure 2.A).

b. Looped System—domestic supply lines branch from a single primary supply line from water main. The primary supply extends into the building and forms a loop of piping that supplies sprinkler heads (see Figure 2.B).

c. Network System—a unique design where each sprinkler head can be supplied water from a minimum of three different paths. Network systems are defined as a type of multipurpose system by the NFPA 13D Standard, however, these systems are no longer common because the fittings needed to establish three paths to sprinklers are no longer manufactured. This type of system is acceptable under NFPA 13D if the fittings can be obtained (see Figure 2.C).

The multipurpose configurations have an advantage of better maintaining water quality by avoiding stagnation; but lower-volume domestic flows are metered by a larger meter needed to measure the slightly higher fire flows as occurs with the configuration shown in Figure 1.C. A loss of meter low flow accuracy could occur in this instance, resulting in unbilled water and loss of revenue to the water utility.

[Photo courtesy of Gary Trachtman]
Figure 2.A: Multipurpose Piping System (Tree System)—Example 2 from the NFPA 13D Standard (Courtesy of NFPA)

Figure 2.B: Multipurpose Piping System (Looped System)—Example 1 from the NFPA 13D Standard (Courtesy of NFPA)
3. **Passive purge.** This configuration, also known as a flow through system, includes piping that serves a single toilet in addition to the fire sprinklers. The toilet connection 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 (see NFPA 13D (2016)—Section A.3.3.11.5, pg. 37). The passive purge configuration allows water to circulate throughout the entire system on a regular basis and, therefore, avoid stagnation. This approach can preserve water quality and negate the need for backflow protection.

B. **Water quality management and decisions on backflow protection.** Water quality can deteriorate over time if it becomes stagnant in fire line piping (e.g., in piping that supplies only seldom-used fire sprinkler heads). Depending on the piping configuration, this can become a hazard for poor quality water re-entering the water distribution system in a backflow or backsiphonage event. Water utilities should carefully consider the policy by which they safeguard the water distribution system from water of poor or hazardous quality. Two fundamental approaches should be considered: 1) select a piping configuration that minimizes the stagnation of water, or 2) provide acceptable backflow protection if the piping configuration used allows for stagnant or hazardous water to exist in the fire line. At least two design options exist to minimize the stagnation of water: 1) using a multipurpose configuration in which the same piping inside the customer premise supplies both domestic water fixtures and fire sprinkler heads, or 2) use a single tapped connection line in stand-alone configuration with a passive purge feature to maintain acceptable water quality. Note that to negate the requirement for backflow prevention in multipurpose and passive purge (flow through systems), the sprinkler system must be constructed of materials approved for potable water and chemical or antifreeze additives must not be used.

Many water utilities are familiar with regulations governing backflow protection in commercial and industrial buildings, particularly those that are considered to have a high hazard risk for contamination of the water distribution system. These utilities operate well-structured programs where they provide a level of oversight for the
specification, installation, and regular testing of backflow protection equipment. Most building managers of large and/or high hazard buildings are familiar with the requirements imposed on them to provide adequate backflow protection and to maintain, inspect, and test the equipment for functionality on a prescribed basis.

Unfortunately, such utility programs may not exist for residential buildings. For communities that do not have a backflow protection requirement in place for one- or two-family dwellings and manufactured homes, requiring a piping configuration that results in the need for backflow protection equipment means that homeowners will encounter a new responsibility to ensure that the equipment is maintained and regularly tested. The number of backflow prevention devices in the community will increase dramatically and will create a large maintenance burden. Absent a strong oversight role and additional work by the water utility or a third-party service provider, numerous homeowners may overlook this responsibility, resulting in backflow protection equipment that—over time—may malfunction, placing water quality at risk, and possibly restricting flow to the fire sprinkler heads. Fees for inspecting and testing backflow prevention equipment may be charged to the homeowner. Another option that many jurisdictions allow is the use of a dual check valve. This device includes two check valves and is not testable.

There are certain conditions where backflow protection is essential to the operation of an RFSS installation. The separately tapped line shown in Figure 1.D is perhaps the most obvious instance. Another definitive instance addresses the fact that the NFPA 13D Standard allows for the use of anti-freeze chemical inside sprinkler piping supplying sprinkler heads that reside in unheated building spaces (attics, etc.) that could be subject to freezing temperatures. Such a substance represents a significant risk to the water supply if a backflow or backsiphonage event occurs, and appropriate backflow protection is warranted. However, the NFPA 13D Standard generally requires sprinkler heads to be installed in the most inhabited areas of the building. Most homes likely do not need to have sprinkler heads installed in unheated areas. Still, water utilities must be mindful of the possibility that anti-freeze could be specified in certain sprinkler designs in homes in their service area, and the utility should have a backflow protection policy to address this possibility.

Because of the considerations described in A and B above, the policy decisions around RFSS piping configuration and the means to safeguard water quality should be considered first and fundamental for the water utility. These decisions have the greatest bearing on the cost and effort to install and maintain the system, and the burden on both the water utility and the customer/property owner in maintaining equipment to ensure adequate fire flow capacity and acceptable water quality. Appropriately specified backflow protection should exist where a high hazard has clearly been identified. However, the backflow protection equipment that is not maintained or operable creates additional risks if these devices obstruct the flow of water needed during a fire event.

C. Service discontinuance (shutoff) and restoration. AWWA maintains policy statements that detail situations during which water utilities should be able to discontinue service to customers (e.g., because of nonpayment or failure to address potential backflow hazards). Discontinuance of service for nonpayment should be a last-resort action taken only after prior actions have not succeeded in obtaining compliance from a customer (see Policy Statement below). Utilities should provide adequate advance notice before shutting off the water and have in place a clear and timely process for restoring service once the customer complies.
AWWA Policy Statement: Discontinuance of Water Service for Nonpayment

AWWA realizes the importance of the nondiscriminatory billing and collection procedures to ensure that each customer pays for the services rendered by the utility under its rates and tariffs. Failure on the part of the customer to pay a water bill necessitates that other customers bear the burden of paying for the service.

AWWA recognizes that certain circumstances may require some flexibility because water service is a necessity in maintaining sanitary conditions in the home, and may be required for life-sustaining equipment. It may also be a vital part of industrial and commercial operations. Discontinuance of water service for nonpayment is considered a final phase of a collection procedure and should be instituted with sufficient notification when all other reasonable alternatives have been exhausted.

For most of the RFSS piping configurations described in NFPA 13D (other than a separately tapped fire line in a stand-alone configuration), termination of water service to halt domestic supply will also halt water service for fire protection purposes. This is acceptable water utility practice for two reasons:

1. In most jurisdictions, buildings must have functional water service to obtain a certificate of occupancy. Buildings with discontinued water service invalidate their certificate of occupancy, and the building should be vacated at that time.

2. Because RFSS are intended to protect life safety, these systems are not required to function in unoccupied buildings.

Halting water service to fire lines of any kind may cause concern with local fire department or code officials. Water utilities should be proactive in meeting with local officials to discuss and coordinate policies around water service discontinuance and restoration, occupancy requirements, and notification procedures. Water utilities should preserve their right to discontinue service for nonpayment and other stated issues, while simultaneously maintaining close coordination with local officials so that fire life safety risks are not inadvertently increased. These policies and procedures should also consider ways to manage buildings with RFSS that become vacant for the long-term and to which water supply is discontinued.

D. Rates and charges. Utilities have traditionally charged for water service in a variety of manners. For many water utilities, residential service includes a fixed charge and a variable rate based on the water consumption. Larger commercial and industrial buildings are, likewise, often billed a fixed charge and variable rate for water consumption, as well as a separate standby fee for the separate fire connection supplying their sprinkler system. Typically, both the fixed charge and the separate fire system standby charge increase with the size of the water meter or fire connection piping. Service connection size has traditionally been viewed as the best measure of the potential water demand during a fire event.

Factors in setting RFSS rates and charges include whether the utility requires two lines rather than one (i.e., two tapping points into the water main), backflow prevention device(s), and water meter(s). If utility policy requires a separately tapped line for RFSS service, rates and charges for the system can be structured like those for commercial and industrial buildings.

However, the rates and charges for RFSS configurations that supply domestic and fire supply from a single connection generally should not be structured like those
for traditional domestic or traditional fire service for larger commercial/industrial buildings. As previously noted, the RFSS is a hybrid system that includes elements of both the traditional basis for domestic supply charges and for standby fees for separate fire lines. The utility should therefore strive to devise a rate structure that considers the unique hybrid nature of the RFSS and avoid rate decisions that over-charge the customer. Because of these considerations, the water utility may not be able to set fair and equitable rates under their existing rate structure’s established classes of service for domestic supply and fire supply. The water utility might, therefore, consider establishing a new class of service for RFSS systems that sets rates and charges that fall somewhere between the traditional charges for domestic service and fire service.

The water utility should be aware that merely requiring RFSS systems to fall under their existing rate structure for domestic service could be problematic. Because RFSS flows are close to—but higher—than typical domestic water supply flows, larger water service lines and meters may be required (see item C in the “Technical Considerations for Water Utilities” section below). If the traditional fixed charge scale based on meter size is applied for the RFSS, customers with meters as large as 1½-inch or 2-inch may be subject to fixed charges that are significantly higher than those of small residential buildings without RFSS, which would typically have a ½-inch meter. Such increased charges could create public relations tensions for the water utility. Following is an example of a utility—the Philadelphia Water Department—that established a RFSS class of service with rates that fairly represent the service provided.
Establishing Fair and Reasonable Water Rates for Customers with Residential Fire Sprinkler Systems (RFSS) in the Philadelphia Water Department

The Philadelphia Water Department (PWD) created new policy and procedures to manage the emergence of Residential Fire Sprinkler Systems (RFSS) in its service area in 2011. The new policy resulted in the specification of customer water meters that were larger than the traditional \( \frac{3}{4} \)-inch positive displacement water meters used in residential dwellings without RFSS. Depending upon the specific sprinkler design conditions at individual customer properties, customers with RFSS were assigned water meters in the size range of \( \frac{3}{4} \)-inch, 1-inch, 1\( \frac{1}{2} \) inch or 2-inch; with the majority being \( \frac{3}{4} \)-inch or 1-inch. In the traditional PWD rate structure, customers with RFSS receiving a larger water meter encountered a notably higher fixed charge than customers with a standard \( \frac{3}{4} \)-inch water meter. This resulted in a series of complaints and confusion for customers. PWD responded by revising its water rate structure to create a new class of service for residential fire sprinkler systems, as shown in Figure 3 (rates shown are as of 2017). PWD fixed the monthly sewer fixed charges for RFSS accounts at the value of $7.41 (same as customers with a \( \frac{3}{4} \)-inch water meter) for all four RFSS sizes. The monthly water fixed charge varies at only a modestly higher rate as the meter size increases. In its approach, PWD was able to address the problem of customer confusion around rate fairness in the new environment of RFSS by creating a new class of service in its water rates and charges structure, and communicating to customers the rationale behind the new charges and how they are fair and not excessive.

![Figure 3: Fixed Water Charges for Customers with Residential Fire Sprinkler Systems in Philadelphia](image)

Technical Considerations for Water Utilities

A. Hydraulic requirements for RFSS. The NFPA 13D Standard includes many specific hydraulic requirements including minimum operating pressure of seven psi at sprinkler heads. Typical water demand per sprinkler is 13 gpm, with a design that assumes two sprinklers are activated simultaneously. Therefore, for most applications, a maximum flow of 26–35 gpm is usually generated in the design. In some circumstances, such as those with allowances for the use of landscaping irrigation water demand, water utilities might define a maximum flow rate as much as 40 gpm.
The design sprinkler flow duration is seven minutes for smaller houses of less than 2,000 ft$^2$ and up to ten minutes for larger homes. This means that the water volume needed for an event typically varies from 260 to 480 gallons, depending on sprinkler characteristics. Data from studies conducted in Scottsdale, AZ found an average of 209 gallons used in sprinkler activation events (see Scottsdale case study on page 30). No domestic water demand allowance is required in the NFPA 13D Standard unless a single RFSS supplies two dwelling units (duplex housing). Some utilities apply a five-gpm domestic water demand allowance to the fire demand, however, and may add a greater demand requirement if landscape irrigation systems are prevalent in homes in the service area.

B. **Metering policy and procedures.** The use of a water meter on a fire supply line of any kind is a water utility choice. The preference in the NFPA 13D Standard is to not have a water meter on a fire supply line, because fire lines are best left free from any devices that could potentially obstruct water flow if the device fails. For reasons of water accountability and customer billing efficiency, however, water utilities generally prefer to meter the water being used by customers for any purpose.

C. **Sizing customer service lines and meters.** Utilities should be cautious when defining the size of service lines and meters because this impacts fire flow capacity. The size of service lines and meters may also impact customer rates and charges and meter accuracy (e.g., larger meters may be less accurate at low flow rates).

1. **Minimum pipe sizes.** NFPA 13D states that the fire line pipe can be sized based on static water pressure if the public water supply pipe is 4-inch diameter or larger. If the water main is less than 4-inch diameter, the system design and fire line sizing is best determined by conducting a fire flow test. Typically, fire flow tests are conducted by opening a fire hydrant and measuring the flow from the fire hydrant and the reduction in pressure from the starting (static) pressure to the pressure under flow conditions (residual pressure), as measured from a nearby building or fire hydrant. Because fire hydrants are not typically connected to water mains smaller than 4-inch diameter, flow will need to be generated from another device, such as a flushing unit or household irrigation system, and measuring the residual pressure near the subject building. Calculations can be used to estimate the flow that should be available from the fire hydrant, which should be a minimum of 20 psi under all conditions. If the utility has a calibrated hydraulic model of its water distribution system, the model can be used to predict the residual pressure at flows that include the RFSS demand. RFSS piping inside the protected building must have a minimum diameter of 1-inch for steel pipe and ¾-inch for pipe of any other material. Section 10.4.3 of the NFPA 13D Standard identifies four techniques that can be used to determine the appropriate pipe size—water utilities should become familiar with these techniques. The RFSS design process requires communication between the designer and utility so that available water pressures and flow to the fire sprinkler system can be determined and the design meets utility requirements.

2. **Water pressure levels and impact on the sprinkler design.** The RFSS design process in the NFPA 13D Standard prescribes a minimum sprinkler operating pressure of seven psi. However, if the pressure listed by an underwriter such as the Underwriter’s Laboratory or Factory Mutual is used and results in a minimum pressure value more than seven psi, the greater pressure value must be used as the minimum required pressure. In designing the RFSS per NFPA 13D, fire sprinkler system designers need to consider meeting the system water demand and pressure requirements for the sprinkler heads throughout the
building. By ensuring adequate pressure to all sprinkler heads, designers need to obtain the static water pressure available from the utility’s distribution system water main. This is usually provided by the water utility on request from the fire system designer. If a fire flow test that is representative of the supply to the protected building has been conducted, the designer should use the results of that test. When determining if adequate pressure is available per NFPA 13D, fire system designers need to consider building dimensions, particularly the height of the building, and the length of service piping from the tapping connection at the water main to all the sprinkler heads. The available incoming pressure from the water main and the expected head loss in the pipe, water meter, and fittings during the design maximum water demand are the most important factors in assuring adequate pressure in the RFSS design. Table 3 below from NFPA 13D lists pressure losses for specific flow rates through different sized water waters.

To meet pressure requirements, fire system designers may need to consider upsizing service pipe and meter sizes so there is less pressure loss or, in some cases, specify that a pump and/or water storage tank be installed in the building to boost water pressure. When evaluating system designs, the impacts of larger water service lines and meters on installation costs and potential loss of meter low flow registration/accountability should be considered. The fire designer should apply their calculations in specifying the service line and meter size, consistent with specific line and meter sizing criteria established by the water utility.

Table 3—Pressure Losses in Water Meters (psi)

<table>
<thead>
<tr>
<th>Diameter (in.)</th>
<th>Flow (gpm) (l/min)</th>
<th>Flow (gpm) (l/min)</th>
<th>Flow (gpm) (l/min)</th>
<th>Flow (gpm) (l/min)</th>
<th>Flow (gpm) (l/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18 or less</td>
<td>23</td>
<td>26</td>
<td>31</td>
<td>39</td>
</tr>
<tr>
<td>3/4 (19 mm)</td>
<td>9 (0.67 bar)</td>
<td>14 (0.97 bar)</td>
<td>18 (1.2 bar)</td>
<td>26 (1.8 bar)</td>
<td>38 (2.6 bar)</td>
</tr>
<tr>
<td>1 (25 mm)</td>
<td>7 (0.48 bar)</td>
<td>11 (0.76 bar)</td>
<td>14 (1.5 bar)</td>
<td>22 (1.5 bar)</td>
<td>35 (2.4 bar)</td>
</tr>
<tr>
<td>1 1/2 (40 mm)</td>
<td>2 (0.14 bar)</td>
<td>3 (0.21 bar)</td>
<td>5 (0.35 bar)</td>
<td>7 (0.48 bar)</td>
<td>10 (0.69 bar)</td>
</tr>
<tr>
<td>2 (50 mm)</td>
<td>1 (0.07 bar)</td>
<td>1 (0.07 bar)</td>
<td>2 (0.14 bar)</td>
<td>2 (0.14 bar)</td>
<td>3 (0.21 bar)</td>
</tr>
</tbody>
</table>

For SI units, 1 gpm = 3.785 L/min; 1 in. = 25 mm; 1 psi = 0.07 bar.
*Above maximum rated flow of commonly available meters.
(Courtesy of NFPA)

3. **Minimum meter sizes.** Determining a minimum meter size for RFSS installation is one of the most important, and challenging, tasks for a water utility in establishing RFSS policy. When determining appropriate meter sizing, water utilities need to consider specifying a meter that is large to handle the maximum design flows of the RFSS application, and should also consider the meter’s ability to measure very low flows (e.g., flows from toilet leaks and other low water demands). Specifying a meter that is too large could result in a loss of flow registration if the meter does not have good low-flow accuracy and a loss of revenue and accountability for the water utility.

Typical designs using the NFPA 13D Standard specify maximum sprinkler water demands of 26 gpm (two sprinkler heads at 13 gpm). Some utilities require allowances for additional demands such as landscape irrigation systems, resulting in maximum demand designs of more than 40 gpm. These designs exceed the recommended high flow capacity of most ½-inch positive displacement water meters commonly used in one- and two-family residences.
in the U.S. Thus, some water utilities may require a ¾-inch or larger meter for these designs.

Table 4 below lists normal operating ranges for positive displacement meters as defined by most major water meter manufacturers. These ranges may differ from those for other meter types (e.g., velocity meters). Each water utility should conduct their own research to determine the normal operating range for water meters that they are considering for RFSS installations.

<table>
<thead>
<tr>
<th>Size</th>
<th>Low Flow, gal/min</th>
<th>High Flow, gal/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>⅝-inch</td>
<td>0.5</td>
<td>20.0</td>
</tr>
<tr>
<td>¾-inch</td>
<td>0.75</td>
<td>30.0</td>
</tr>
<tr>
<td>1-inch</td>
<td>1.0</td>
<td>50.0</td>
</tr>
</tbody>
</table>

*Gathered from standard manufacturer product literature

Based on the ranges in Table 4, a ¾-inch meter would be needed to meet the maximum water demand requirements for many RFSS designs. However, the Residential Fire Sprinklers-Water Usage and Water Meter Performance Study, conducted by the Fire Protection Research Foundation, found that domestic water meters can attain flows above their maximum rated flow successfully and without damage to the meter, particularly because the high flowrates are experienced infrequently and for short durations. Using this rationale, some water utilities allow ⅝-inch positive displacement meters in RFSS applications when pressure requirements can be met and the design flows are not in the upper ranges of the sprinkler requirements. Assigning a minimum meter size under specific RFSS hydraulic designs is a decision that each water utility—possibly in conjunction with the fire system designer and code officials—needs to make individually based on its knowledge and judgment. The decision about minimum meter sizing includes trade-offs between potential reliability in delivering the needed RFSS flowrate, cost of water meters, and low flow accuracy of the water meter.

There are also other considerations when sizing meters in RFSS designs, including the water pressure available and the expected head loss thru water meters of different sizes and types. Each water utility should conduct its own research into meter size and performance criteria, establish a rational basis for setting a minimum meter size, and define criteria that allows for exceptions, if justified, to the minimum size.

East Bay Municipal Utility District (EBMUD) conducted a water demand and meter sizing study and arrived at a minimum one-inch size meter. Residential landscape irrigation systems are common in their service area, however, and a 15-gpm irrigation allowance is included in their hydraulic design resulting in a design maximum water demand of 41 gpm. Many other utilities use a ¾-inch water meter as either a prescribed or de facto minimum water meter size.

D. Piping materials. NFPA 13D includes information on a variety of piping, or tubing, materials, including copper, steel, chlorinated polyvinyl chloride (CPVC) and cross-linked polyethylene (PEX). CPVC and PEX are nonmetallic materials that are now commonly used in RFSS installations. Copper, CPVC and PEX are typically considered potable water piping material, which may impact the decision on whether to require a backflow prevention device.

1. Copper. Copper is the most commonly used residential piping material, coming into regular use after 1960. It is now installed as a rigid material with soldered
fittings. It is very resistant to chlorine and is unaffected by sunlight. Copper, being metallic, is fire resistant and has a very long and successful installation history. Copper is also relatively expensive, can corrode in certain situations, and is likely to burst if exposed to freezing temperatures. Copper pipe can handle pressures and temperatures much higher than normally found in residential applications, with pressures over 200 psi, and temperatures of 250 degrees Fahrenheit, depending on size and solder used.

2. **Steel.** Steel pipe is the most common material used for smaller diameter fire sprinkler systems, and is normally black iron or black steel, indicating it is not galvanized. The unprotected iron is acceptable for fire sprinkler use because it does not have flowing water, and so corrosion is not an issue. Steel pipe for potable use is not normally used because of corrosion concerns. While steel pipe is most often used for fire sprinkler service and is not normally used for potable water applications, it would not normally be used for passive purge systems. Steel pipe pressure ratings are typically 300 psi in light-wall, schedule 30 applications. Connections are often threaded but can also be roll groove joints or welded.

3. **CPVC.** CPVC is a thermoplastic material that has been used since the 1960s. It has gained popularity as copper prices have increased. It is assembled with solvent welds to connect fittings and adapters. CPVC does not scale or corrode and is considerably cheaper than copper. It is more fragile than copper and cannot handle physical impacts as well as copper. Like copper, CPVC is likely to be damaged by freezing temperatures. CPVC is typically limited to 100 psi at 180 degrees Fahrenheit, but pressures to 175 psi are available for fire sprinkler systems. Because it is a nonmetallic material, it may need to be protected from flames, and this is normally accomplished with a gypsum board encasement. CPVC for sprinkler systems are generally limited to where ambient temperatures do not exceed 150 degrees Fahrenheit.

4. **PEX.** PEX is a cross-linked polyethylene, flexible, piping material that is typically assembled with crimp or push on fittings. PEX has been available in the United States since around 1980. There are three different manufacturing methods to produce PEX, often called PEX-A, PEX-B, and PEX-C. These are different manufacturing methods, and not an indication of quality or performance, although there are some different mechanical property differences such as flexibility and coil memory. PEX does not scale or corrode and is considerably cheaper than copper. PEX is unlikely to be damaged from freezing, is flexible, and does not normally require fittings for bends. It is often run as a manifold system with continuous individual runs from a central manifold to each end use. PEX for residential applications is normally used in copper tubing size, with outside diameter (CTS-OD) sizes that match copper pipe outside diameters. The thicker material requirements mean that the inside diameter of PEX pipe may be smaller, and therefore flow capacities may be reduced. This is not normally an issue for residential potable service, especially when installed with a manifold installation. However, this could be an issue for fire service, so sizes must be properly evaluated. PEX also must be stored correctly to ensure chlorine resistance. If exposed to sunlight, the resistance to chlorine may be significantly affected, and lifespan significantly reduced. If outdoor material storage is avoided, this should not be an issue. PEX pressure rating varies depending on temperature. For residential service, it is rated at 100 psi at 180 degrees Fahrenheit, or 80 psi at 200 degrees Fahrenheit. Because it is a nonmetallic
material, it may need to be protected from flames, and this is normally accomplished with a gypsum board encasement.

E. **Valving and shut-off control.** Valves are the most common device used to provide water utilities, property owners, and their contractors the ability to control flow in piping systems. Valves are used primarily to provide the ability to shut off flow to piping to allow for maintenance and repair activities and, if needed, service shutoff. Options for the placement of valves are shown in Figures 1.A—1.D, with valves shown on both domestic and fire lines.

While the need for valves is well understood by water utility staff, there is an important distinction between the role of valves on domestic lines vs. fire lines. Valves on domestic lines are freely available for operation by the property owner or their contractors such as plumbers. It is obvious when these valves are closed because water supply to domestic fixtures will be halted, and property owners will strive to return closed valves to the open position as soon as possible to restore water service. Conversely, a valve on a dedicated fire line that is inadvertently closed will halt water supply to the fire system in a manner that may go unnoticed by the property owner. For this reason, valves installed on fire lines should generally be lockable (restricted from casual operation) or supervised (operated remotely). These provisions help avoid inadvertent valve closures that could unknowingly disable fire supply and, thereby, provide the property owner with a false sense of security.

The NFPA 13D Standard includes depictions of acceptable valve locations and operability controls in the piping configurations (see Figures 1A—1D). Water utilities and RFSS designers should be aware of the concern about the placement and operation of valves and design their location to reduce the risk of inadvertent and unnoticed deactivation of the fire sprinkler line.

**Implementing the Use of RFSS in the Water Utility Service Area**

A. **Design.** In the United States, most fire sprinkler systems are designed by licensed fire protection design companies. However, because most states have not adopted the 2009 provisions of the IRC, many fire system designers who have experience with the NFPA 13 and 13R Standards do not have the same level of familiarity or experience with the features of NFPA 13D systems. If a state or local jurisdiction adopts a residential sprinkler requirement that uses the NFPA 13D Standard, the utility should coordinate with the fire protection design and installation community, along with fire departments, code and building officials, so that utility policy and procedures for RFSS are developed in a coordinated manner and all parties are aware of the processes and design requirements unique to the NFPA 13D Standard. In particular, designers should become familiar with the distinct provisions and applications of the NFPA 13, 13R, and 13D Standards (see Table 2) and how they apply in the utility’s jurisdictions.
B. **Permitting.** Most cities and water utilities in the U.S. have extensive permitting processes for all aspects of the built environment. In any jurisdiction, builders may need to obtain multiple permits to install a RFSS. These could include separate permits for water connection (tapping), metering, and backflow protection. These permits are usually in addition to other related municipal permits required by building, plumbing, or fire codes, such as a fire design permit after a fire or code official approves the RFSS system design. Water utilities should meet with municipal stakeholders to review the extent of permit requirements to devise a permitting process for RFSS that meets the needs of the water utility to approve and document new RFSS systems, as well as one that does not place unreasonable administrative burdens on builders, RFSS designers, or installers. Utilities should ensure that the proper sequence for issuing permits is defined. For example, the water utility should ensure that the fire system design for the RFSS is approved before tapping, service lines, and water meter permits are issued. In this way, the sizes of the service line and meter are specified as part of the fire system design, and permits are issued only after the design is completed and approved.

C. **Installation, testing, and commissioning.** Jurisdictions typically have regulations that prescribe the credentials and experience requirements for professionals involved in the design, installation, testing, and upkeep of fire sprinkler systems. Such requirements usually include licensing for engineers, plumbing and mechanical contractors, fire sprinkler installers, and other building trades providers. An example of one certification is that from the National Institute for Certification in Engineering Technologies (NICET). NICET-certified layout technicians frequently serve as fire sprinkler designers in the U.S. While established trades such as plumbers may also serve as RFSS installers, their plumbing credentials may not automatically assure that they have knowledge of RFSS installation requirements. A specific training program may need to be offered to those in the plumbing trades to qualify them as RFSS installers.

Water utilities should review with local code and enforcement officials the licensing and credentialing requirements of the local jurisdictions within their service area to ensure that the RFSS policies developed by the water utility do not conflict with any standing requirements. In this process, the water utility should understand the roles of each type of contractor in the RFSS installation. The utility should also understand the process for testing and commissioning RFSS installations and the role of such in issuing a Certificate of Occupancy for a building. The water utility should ensure that the process confirms the proper installation and function of water supply equipment, including the water meter, backflow protection devices, valves, pressure gauges, and other appurtenances.
D. System maintenance and upkeep. The water utility, customer, and possibly certain code officials typically play a role in conducting and tracking maintenance and upkeep on RFSS infrastructure. The foremost concern for fire sprinkler systems is that they remain functional and ready-to-serve, despite being in standby mode most of the time. If the water utility requires backflow protection equipment in their policy, this will place a burden on the customer to maintain the device and, perhaps, the water utility to play an oversight role. Some utilities require backflow protection for all their residential customers as a matter of course. In such cases, the addition of RFSS may not add any new workload to the utility or new processes to the customer. However, if backflow protection is specified as part of the new RFSS policy, the water utility must define the maintenance requirements of the backflow protection equipment and recordkeeping for required annual inspection and testing.

Valves must be kept open, except in certain circumstances when a utility discontinues service, and in working condition. In addition to locating valves strategically so they shutoff both domestic and fire flow, the NFPA 13D Standard prescribes that a warning sign be posted on the main shutoff valve for multipurpose systems, as noted below.

6.3.4 A warning sign, with minimum ¼ in. (6 mm) letters, shall be affixed adjacent to the main shutoff valve and shall state the following:

**WARNING:** The water system for this home supplies fire sprinklers that require certain flows and pressures to fight a fire. Devices that restrict the flow or decrease the pressure or automatically shut off the water to the fire sprinkler systems, such as water softeners, filtration systems, and automatic shutoff valves, shall not be added to this system without a review of the fire sprinkler system by a fire protection specialist. Do not remove this sign.

As stated in the warning sign, customers must be cautious when making changes to water fixtures in their residence, and they must be mindful of the need to consult a fire protection specialist when having work conducted. Unlike sprinkler systems designed under the NFPA 13 and 13R standards, 13D systems do not have a requirement for annual certification of the system. Thus, customers must be aware of the system needs and the steps to keep them operational.

Communication Plan for Water Utilities

A. Customers. Educating customers and keeping them informed of changes in utility policies should be a top priority. The water utility can help educate their customers on the capabilities and features of RFSS by providing information on their website, in bill stuffer flyers and by other means of customer communication. The utility—perhaps in conjunction with the fire department and code officials—might hold a series of information sessions for customers to attend. Educational and informational resources are available from many sources (e.g., online videos and other resources on the Home Fire Sprinkler Coalition’s website).

The water utility should proactively inform customers about changes in water rates due to implementation of RFSS policies in their communities. RFSS installations typically incur higher rates and charges than buildings without these systems, and customers will note this difference. Customers should also be made aware of their responsibilities in the maintenance and testing of RFSS components. Perhaps the most important responsibility is to ensure that backflow protection devices (if employed) are maintained, tested, and kept in good working order.
B. **Fire Departments.** Water utilities should coordinate closely with the fire department(s) located in their service area. Fire Departments should be included in discussions that formulate utility policy and procedures so that they know the specific features of the RFSS installations in the community. In responding to fire events, fire departments should be aware of the existence of RFSS in certain buildings and know what features and performance are expected to be found when responding to a fire.

C. **Builders.** Water utilities can enhance their efforts in setting RFSS policies by reaching out to local building trades councils or associations and ensuring that they have input in the process. The piping configurations, metering, permitting, and inspection requirements set by the water utility can have a direct bearing on home construction practices, schedules, and costs. Therefore, the building community should be brought into the discussion at the early stages.

D. **Fire sprinkler system designers and installers.** These professionals work together with the building community and, therefore, should also be included in the utility policy-setting process as a partner. The water utility should consider the comments and concerns of fire sprinkler system designers and, once procedures are in place, the utility must ensure that the new approaches are widely communicated.

The designers of fire sprinkler systems are not always local companies that have a routine working relationship with the water utility. Therefore, the water utility should clearly state and post its policies/procedures on the website and provide the same information to the local code and fire departments, so that designers become aware of the RFSS requirements in the utility service area. Water utility staff should be mindful that some fire system designers may not be familiar with the RFSS design requirements in NFPA 13D. These professionals are usually well versed in the design requirements and practices under the NFPA 13 and 13R Standards used in commercial, industrial, and larger multi-family buildings. Unless they are provided clear information on the unique provisions of the NFPA 13D Standard and utility policies for RFSS, these designers may develop residential sprinkler designs that include many elements of the 13 and 13R Standards, such as separate fire lines of minimum size 2-inch. These designs are generally oversized and may not align with the intentions of the water utility. The policy-setting process should also consider whether specific training courses should be provided in the jurisdiction to provide those in the plumbing and other trades with the specific RFSS installation requirements in the NFPA 13D Standard.
Case Studies

RFSS requirements exist in California and Maryland, the District of Columbia, and many local jurisdictions in the U.S. Many of these jurisdictions have a long and successful history of using RFSS and improving fire safety in their communities. Several notable examples of the successful use of RFSS and the policies established by water utilities are given below.

A. Scottsdale, AZ. One of the earliest adopters of RFSS, Scottsdale began implementation in 1986 at the outset of a long period of continuous residential home building. Today, most of the residential building stock has RFSSs, and the impacts of RFSS use have been widely studied and notable successes documented. A detailed account of the Scottsdale experience is below.

Residential Fire Sprinkler System Use in Scottsdale, AZ: A Case Study

The City of Scottsdale, Arizona is a nationally recognized innovator and leader in built-in automatic fire sprinkler systems. A 1985 ordinance requires that newly built or significantly remodeled single-family residences (SFR) must have an approved residential fire sprinkler system (RFSS).

In 30-plus years of the sprinkler requirements, Scottsdale recorded only one fatality in a sprinklered SFR, which occurred when a disabled person was smoking near an oxygen tank. In the same time frame, Scottsdale reported more than a dozen fatalities in buildings without sprinklers. In fires that occurred in sprinklered SFRs, 95 percent were extinguished by only one or two flowing sprinkler heads.

While intended for life safety, Scottsdale has found additional benefits in limiting property damage during fire events. Studies found that Scottsdale registered $2,166 average property loss per fire incident in sprinklered properties, compared to $45,000 average loss per non-sprinkled building fire events. Scottsdale estimated that 209 gallons are used to suppress a sprinkler-controlled SFR fire incident, whereas 3,290 gallons are used from a fire line system.

Specific Scottsdale SFR sprinkler design requirements include:

- NICET-certified SFR fire sprinkler system designer required
- No UL listing of water meters required. Scottsdale uses mechanical, positive displacement, nutating disc type meters
- Meter sizing is based on plumbing fixture count and peak demand plus fire sprinkler demand for two sprinkler heads
- Minimum water meter size for SFRs with sprinklers is ¾ inch
- Use of copper, CPVC, and PEX potable system-rated piping
- No special water rates for fire sprinklered SFRs
- Electric water flow alarm required-exterior bell
- No backflow prevention device required
- No sprinkler line passive purge to toilet required
- Distribution ‘tee’ after the water meter with rubber-faced check valve on sprinkler piping
- Fire Department does sprinkler system plan review and inspection

Scottsdale recognizes that SFR fire sprinkler systems are only effective if maintained in working order and recommends the following maintenance procedures:
B. East Bay Municipal Utility District (EBMUD). California retained the RFSS requirements of the 2009 International Residential Code (IRC) in the California Residential Code, Section R313 (2010). EBMUD has been proactive in setting RFSS policy and procedures and in communicating their approach throughout the drinking water industry. EBMUD conducted a study of water demands in residential properties and established requirements that include a demand of 15 gpm for landscape irrigation systems added to the fire flow demand. The typical demand is 26 gpm for fire flow plus 15 gpm for irrigation for a total design demand of 41 gpm. Based on this, EBMUD requires a minimum service line size of 1.5 inches and minimum water meter size of 1 inch. EBMUD maintains a requirement for a check valve on the RFSS line.

The District also has a formal process to provide flow and pressure information for residential fire sprinkler designers free of charge. Based on a hydraulic model, they provide both static pressure and a residual pressure at 100 gpm at the street main connection location under a projected maximum day demand scenario.

Residential Fire Sprinkler System Use in Scottsdale, AZ: A Case Study (cont.)

- Visually check the sprinkler system monthly to assure no obstructions to heads and spray patterns
- Do not hang anything from sprinkler heads
- Do not paint or tamper with sprinkler heads
- Do not change factory-adjusted sprinkler head flow actuator settings
- Test functionality annually
- Keep main drain valve closed after test
- If piping is subjected to freezing, insulate it
- Use a certified contractor to replace sprinkler heads
- Test smoke alarms

The original 1985 ordinance was required to be economically favorable to the City. As of July 1, 2016, Scottsdale had 50,321 sprinklered SFR units out of 87,023 total SFRs, or 58 percent of all SRF in the City. In achieving such as high penetration of use of sprinklered properties, the benefits envisioned by the ordinance have been realized in the form of

- Increased fire hydrant spacing for both commercial (330 feet to 700 feet) and residential (660 feet to 1,200 feet) development
- Reduced water main sizes and fire flows
- Removed requirement for 360-degree access to allow more developed property
- Reduced street widths
- Increased cul-de-sac lengths
- Increased housing development density by four percent

Scottsdale estimates that fire sprinkler systems cost less than one percent of total construction cost of a new residence. In Scottsdale, where semicustom homes are the norm, this amounts to a range of $1.50 to $2.50 per square foot. One study estimated that water system savings of $7 million to $8 million would be realized with a full population of sprinklered SFRs in Scottsdale.
C. **Prince Georges County, MD.** Maryland also retained the RFSS requirements of the 2009 IRC. With a residential sprinkler requirement in effect since 1992, Prince Georges County has a long—and much studied—history on the use of RFSS. A large portion of the county, along with most of neighboring Montgomery County, MD, are supplied drinking water by the Washington Suburban Sanitary Commission (WSSC). The fire marshalls of the two counties have established a requirement that the fire water demand for RFSS be based on water flow from three sprinkler heads flowing simultaneously. This flow requirement exceeds that in the NFPA 13D Standard, which is based on flow from two sprinkler heads. As a result, WSSC has set a minimum service connection pipe size of 1½ inches, and minimum water meter size of 1 inch, notably larger than the ¾-inch piping and ⅝-inch water meter that is standard on homes without fire sprinklers throughout the U.S. Some of the key provisions set by WSSC to supply water to RFSS in these counties include:

1. WSSC has traditionally required the use of mechanical positive displacement meters for services of ⅝ inch through 2 inches, but is investigating the use of solid state meters for RFSS applications to have meters with no moving parts and potentially greater low flow accuracy in the larger sizes (i.e., 1 inch and more).

2. WSSC requires that a single service line be tapped into the water main to supply both domestic water supply and fire supply. The tee branch feeding the residential fire sprinkler system must be located on the outlet side of the meter.

3. Potable water systems must be protected against backflow from automatic fire sprinkler systems by a minimum of a dual check valve. Passive purge configurations are not allowed.

4. Chemical additives are prohibited in residential fire sprinkler systems.

5. No valve may be installed on the tee branch supplying the fire sprinkler system.

Prince Georges County, MD, along with neighboring Montgomery County, MD, have a long track record of successful implementation of residential fire sprinkler systems. These counties have set a water flow demand requirement that exceeds the two-sprinkler guideline established in the NFPA 13D Standard. The majority water supplier for these counties—the WSSC—has correspondingly set relatively large service piping and meter size minimums to meet these flow requirements. However, they are investigating innovative metering technology to obtain meter capabilities that allow for the unobstructed flow of a relatively high fire water demand, while still accurately registering the low flows that occur most of the time.
Residential Fire Sprinkler Systems (RFSS) have been developed to address fires in smaller one- and two-family dwellings and manufactured homes. These occupancies experience the largest number of fire deaths, injuries, and property value loss. Fire sprinkler systems are common in many commercial, industrial, and multi-family residential structures. RFSS installations designed according to the NFPA 13D Standard are less common but are being adopted in a growing number of jurisdictions in the U.S. As use of RFSSs emerges in the service area of a water utility, utility staff need to be aware of the unique design, installation, maintenance, and upkeep requirements of these systems. Water utilities must also coordinate with fire department staff, code enforcement officials, and fire sprinkler designers and installers, as well as with customers, fire safety advocacy groups, elected officials, and the media as they create their specific policies and procedures for the infrastructure supplying water to these systems.
References


Related AWWA Resources

- M31 Distribution System Requirements for Fire Protection
- M1 Principles of Water Rates, Fees and Charges
- M22 Sizing Water Service Lines and Meters
- C714-13 Cold-Water Meters for Residential Fire Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes
- M14 Backflow Prevention and Cross-Connection Control
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Project Team:

Roland Asp, National Fire Sprinkler Association
Kathle Bulloch, City of Houston Public Works
Steve Davis, Metering Technology Consultants (Lead Consultant)
Neil Kaufman, Truckee Donner Public Utility District
George Kunkel, Kunkel Water Efficiency Consulting (Primary Author)
Juneseok Lee, Manhattan College
Peter Mayer, Water Demand Management
Allan Morris, Arcadis (Lead Consultant)
Jim Siriano, AWWA
Travis Smith, Xylem Inc.
Gary Trachtman, Arcadis (Lead Consultant)

AWWA Customer Metering Practices and Fire Protection Committees