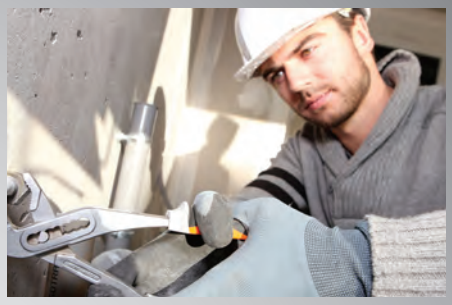
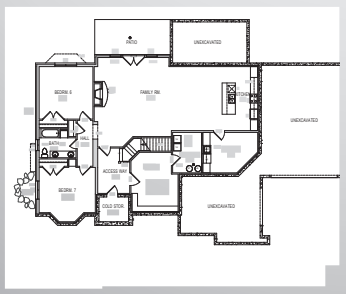


DESIGN GUIDE FOR INSTALLING PARTIAL SPRINKLER PROTECTION IN UNFINISHED BASEMENT AREAS

March 2014

This document is not intended to advocate nor discourage the installation of residential sprinkler systems in one-and two-family dwellings. The intent is to provide guidance related to the installation of partial sprinkler protection to fulfill the requirements of Exception 1 to §R501.3 of the 2012 edition of the International Residential Code (IRC).

The use of sprinkler protection in accordance with IRC §R501.3(1) in an open area having both finished and unfinished floor/ceiling or roof/ceiling assemblies was not anticipated in the development of this guide. It is anticipated that full height partitions (walls) will be installed to separate finished and unfinished areas.

Photos used in this guide courtesy of Boise Cascade Company and Hughes Associates, Inc.

Floor plans used in this guide courtesy of Henry Walker Homes™.

About Hughes Associates, Inc.

Now celebrating more than 33 years in business, Hughes is a global leader of fire protection engineering and fire science research services. Hughes' staff, consisting of 190 engineers, scientists, and computer programmers, has earned an international reputation in the application of advanced technologies to solve both standard and unique fire protection problems. Hughes' services include fire protection design, code consulting, fire hazard and risk analysis, fire modeling, and smoke control consulting. **www.haifire.com**

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The American Wood Council (AWC) is the voice of North American traditional and engineered wood products. AWC develops state-of-the-art engineering data, technology, and standards on structural wood products for use by design professionals, building officials, and wood products manufacturers to assure the safe and efficient design and use of wood structural components.

AWC also provides technical, legal, and economic information on wood design, green building, and manufacturing environmental regulations advocating for balanced government policies that sustain the wood products industry.
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DESIGN GUIDE FOR INSTALLING PARTIAL SPRINKLER PROTECTION IN UNFINISHED BASEMENT AREAS

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SECTION R501
GENERAL

R501.1 Application. The provisions of this chapter shall control the design and construction of the floors for all buildings including the floors of attic spaces used to house mechanical or plumbing fixtures and equipment.

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R501.2 Requirements. Floor construction shall be capable of accommodating all loads according to Section R301 and of transmitting the resulting loads to the supporting structural elements.

R501.3 Fire protection of floors. Floor assemblies, not required elsewhere in this code to be fire-resistance rated, shall be provided with a 1/2-inch (12.7 mm) gypsum wallboard membrane, 5/8-inch (16 mm) wood structural panel membrane, or equivalent on the underside of the floor framing member.

Exceptions:

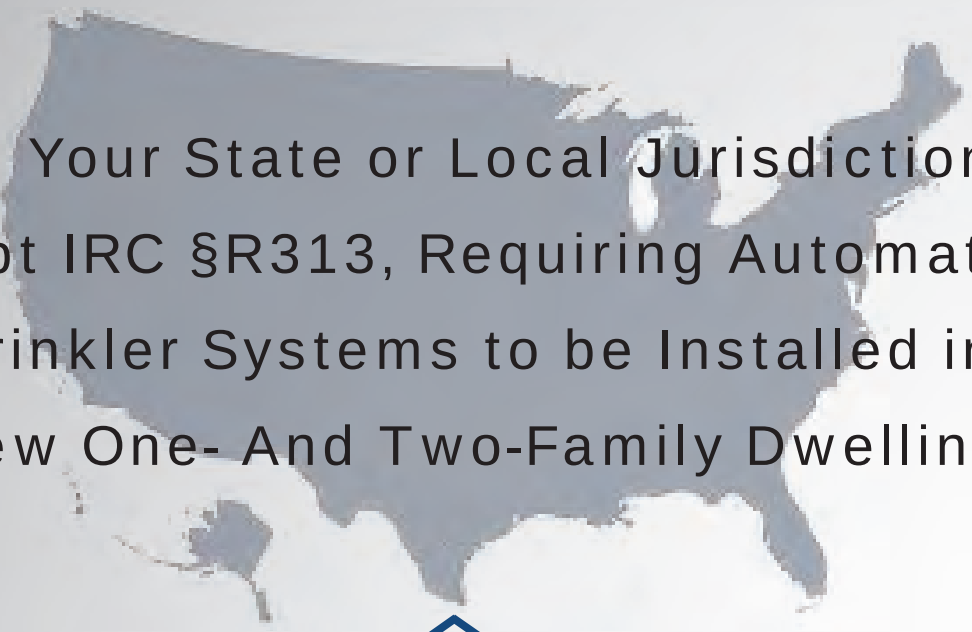
1. **Floor assemblies located directly over a space protected by an automatic sprinkler system in accordance with Section P2904, NFPA13D, or other approved equivalent sprinkler system.**
2. Floor assemblies located directly over a crawl space not intended for storage or fuel-fired appliances.
3. Portions of floor assemblies can be unprotected when complying with the following:
   - 3.1. The aggregate area of the unprotected portions shall not exceed 80 square feet per story
   - 3.2. Fire blocking in accordance with Section R302.11.1 shall be installed along the perimeter of the unprotected portion to separate the unprotected portion from the remainder of the floor assembly.
4. Wood floor assemblies using dimension lumber or structural composite lumber equal to or greater than 2-inch by 10-inch (50.8 mm by 254 mm) nominal dimension, or other approved floor assemblies demonstrating equivalent fire performance.

The 2012 Edition of the International Residential Code (IRC) (§R501.3) requires floor assemblies be "provided with a 1/2 inch gypsum wallboard membrane, 5/8 inch wood structural panel membrane, or equivalent on the underside of the floor framing member." This requirement applies to new homes with unfinished areas having exposed wood light frame construction. Four exceptions to the requirement are provided; however, **this guide will focus on Exception 1, the use of sprinklers.**

This document provides information and guidance on how to design and install sprinkler protection to comply with IRC §R501.3(1).

This guide is intended to be an educational document for **building code officials, homebuilders, homeowners, and contractors who are interested in code compliant partial sprinkler protection.**

The flow chart on page 4 identifies applications in which this guide can be used.



Did Your State or Local Jurisdiction Adopt IRC §R313, Requiring Automatic Sprinkler Systems to be Installed in All New One- And Two-Family Dwellings?

YES

You are required to install a full sprinkler system in accordance with NFPA 13D or IRC §P2904.

You do not need to follow this guide.

NO

Did your state or local jurisdiction adopt §R501.3 of the International Residential Code (IRC), 2012 Edition?

YES

You can follow this guide for instructions on how to install a partial sprinkler system in accordance with IRC §P2904.

NO

You do not need to follow this guide.

PARTIAL vs. FULL SPRINKLER PROTECTION SYSTEMS

2012 IRC §R501.3 allows sprinklers to be used In lieu of passive protection of framing members. **This is fulfilled through the installation of sprinkler systems in one of two options.**

OPTION #1
PARTIAL SPRINKLER PROTECTION

For all jurisdictions where residential sprinkler systems are not required, a partial system is permitted to be installed to protect unfinished areas having lightweight framing members without using passive protection (gypsum board or wood structural panel).

IRC §P2904 states,

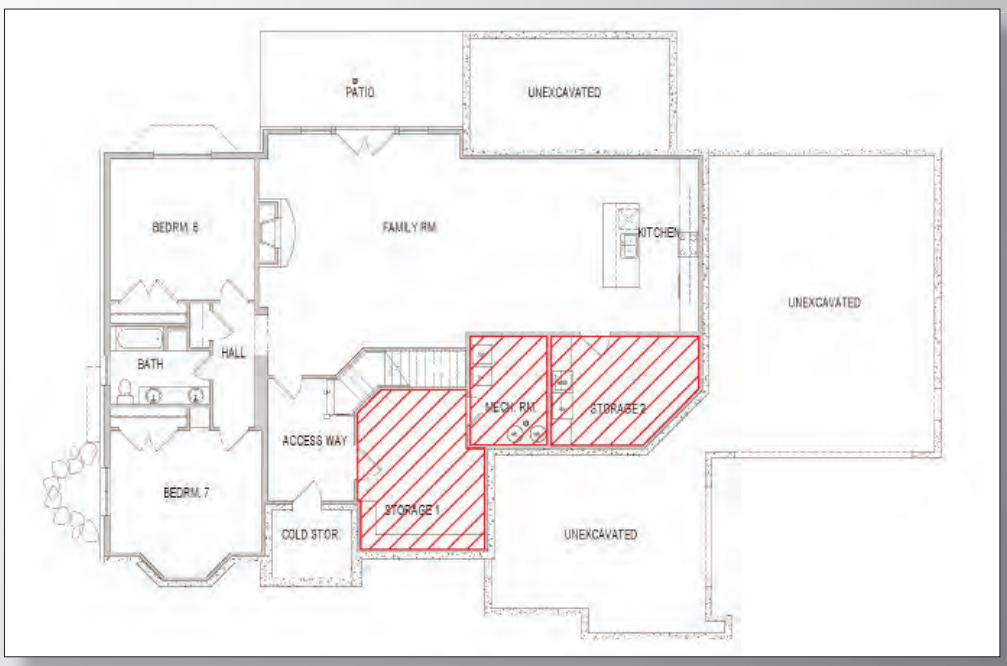
> ***"Partial residential sprinkler systems shall be permitted to be installed only in buildings not required to be equipped with a residential sprinkler system."***

FIGURE 1
Example of wood lightweight framing unfinished floor assembly

FIGURE 2
Right: Graphic shows an example of an unfinished area in the basement, as identified by the hatching.

It is recommended to apply the sprinkler protection option in unfinished areas separated from adjacent finished areas by a full height wall or partition extending from the floor to the ceiling.

The installation of a sprinkler system throughout the basement level without installing sprinklers throughout upper levels would also be considered partial sprinkler protection.



OPTION #2
FULL SPRINKLER PROTECTION

In jurisdictions where a sprinkler system is mandatory or in instances where a home owner voluntarily elects to install a sprinkler system, homebuilders may leave the floor assemblies "unfinished," as this exception is inherently met through the installation of the sprinkler system.

For more information regarding full sprinkler protection, see NFPA 13D or IRC §P2904.

STAND ALONE

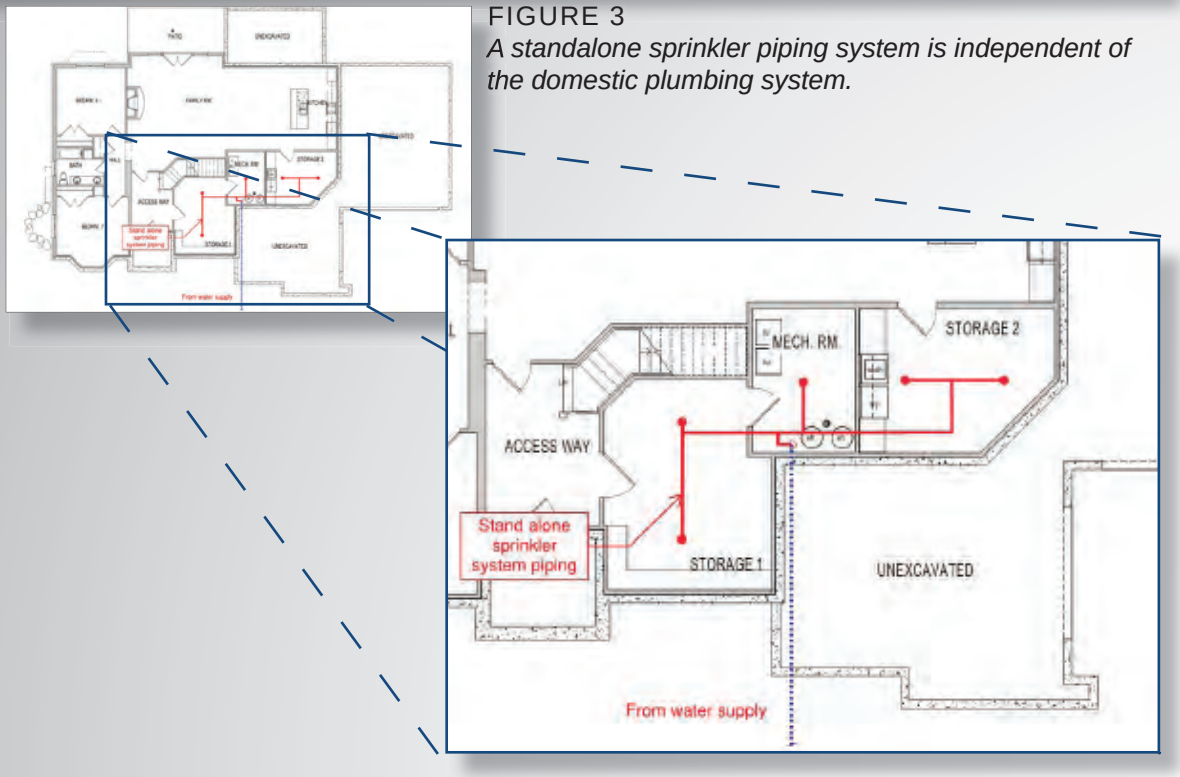


FIGURE 3
A standalone sprinkler piping system is independent of the domestic plumbing system.

MULTI-PURPOSE

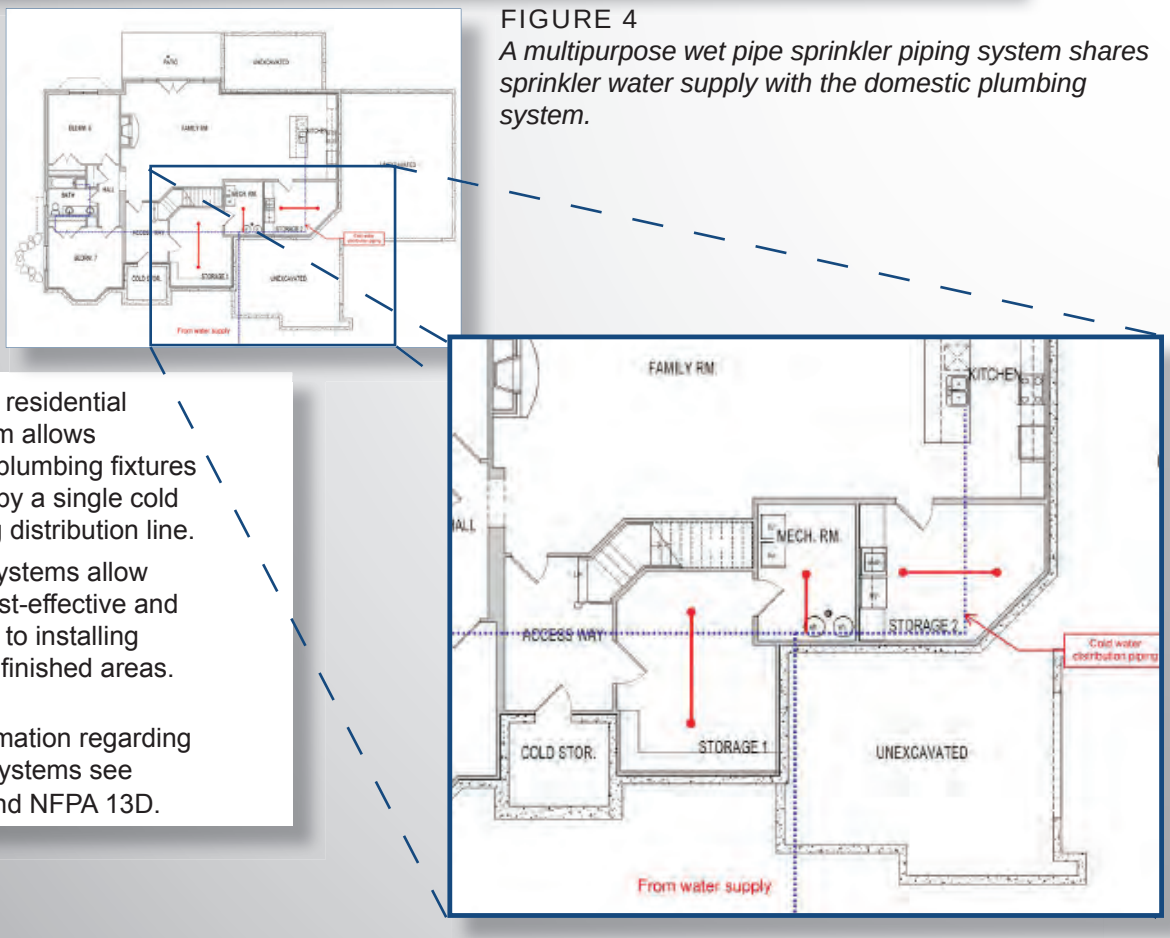


FIGURE 4
A multipurpose wet pipe sprinkler piping system shares sprinkler water supply with the domestic plumbing system.

- A multipurpose residential sprinkler system allows sprinklers and plumbing fixtures to be supplied by a single cold water plumbing distribution line.
- Multipurpose systems allow for the most cost-effective and simple solution to installing sprinklers in unfinished areas.
- For more information regarding multipurpose systems see IRC §P2904 and NFPA 13D.

The intended application of this guide is for unfinished spaces with exposed wood lightweight framing construction. As such, the use of quick response standard spray sprinklers is recommended. NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2013 edition requirements for obstructed construction define installation criteria for standard spray upright and pendent sprinklers.

Sprinklers can be installed up to a maximum of 16 inches below the underside of the floor above, with deflectors located no more than one inch below the bottom of the framing member as shown in **Figure 5.** When sprinklered areas exceed 300 ft^2, the framing must be draftstopped. Draftstopping must extend from the underside of the floor above to the bottom of the framing members. Each draftstopped area must be limited to a maximum of 300 ft^2. Suitable draftstopping materials are 1/2-inch gypsum board, 3/8-inch wood structural panels or other approved materials. In most applications, solid wood joists and prefabricated wood I-joists will serve as the required draftstopping.

In applications where sprinklers are provided throughout an entire basement, the protection area per sprinkler should be limited to 168 ft^2. In applications where sprinklers are installed in limited areas without full protection, areas should be limited to 130 ft^2. In both cases, the maximum spacing for sprinklers should not exceed 15 ft. In combustible construction with wood members spaced less than three feet on center, coverage areas and maximum spacing are limited to 130 ft^2 (NFPA 13 Table 8.6.2.2.1(a)). Minimum separation distances from sprinklers to commonly found heat sources can be found in **Table 1**.

The coverage area per sprinkler is determined as the maximum spacing between sprinklers along a branch line times the maximum spacing between branch lines. The maximum sprinkler spacing is defined as the greater of the distance between sprinklers or twice the distance from sprinklers to walls.

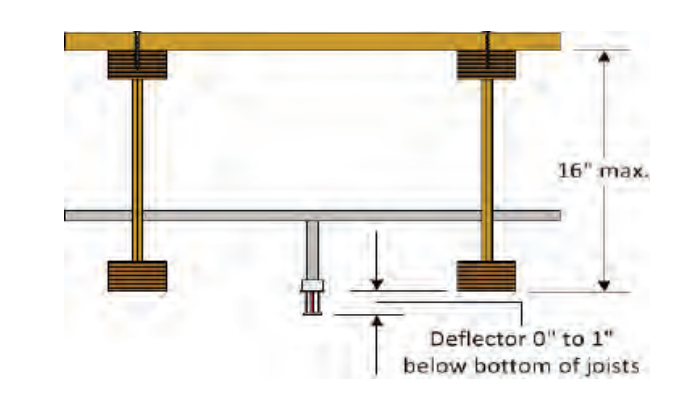
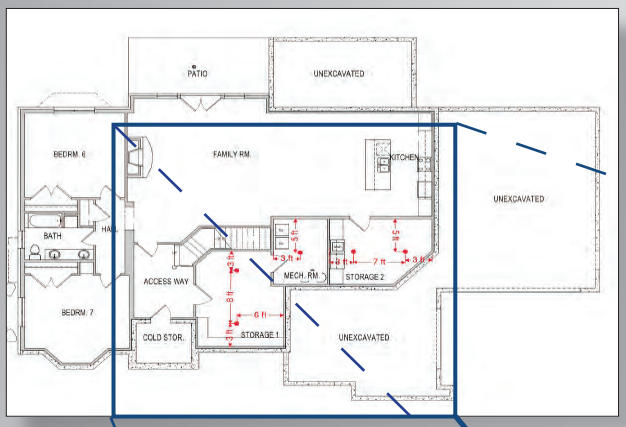


FIGURE 5
Acceptable locations for sprinkler installation.

Table 1 - Required Separation From Heat Sources (inches)

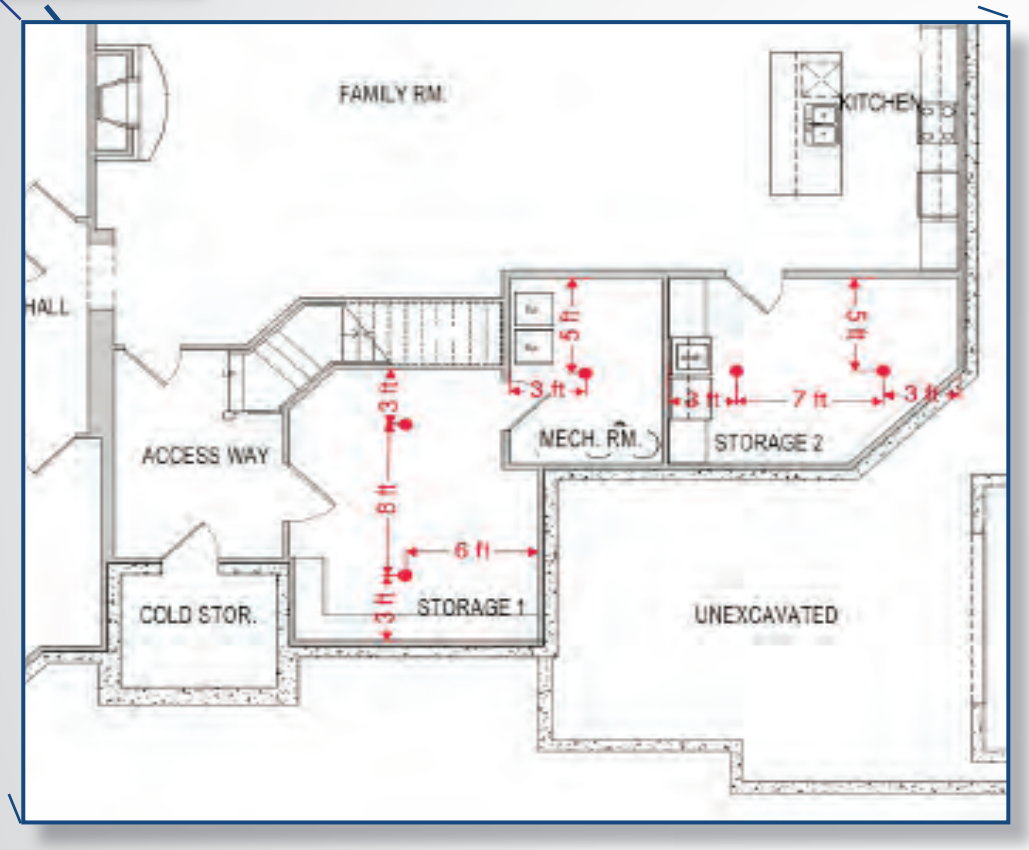
HEAT SOURCE	MINIMUM	INTERMEDIATE TEMPERATURE SPRINKLERS	ANY LISTED SPRINKLER
Fireplace, side of open or recessed fireplace	12	12 to 36	> 36
Fireplace, front of recessed fireplace	36	36 to 60	> 60
Coal and wood burning stove	12	12 to 42	> 42
Vent connector or chimney connector	9	9 to 18	> 18
Heating duct, not insulated	9	9 to 18	> 18
Hot water pipe, not insulated	6	6 to 12	> 12
Side of ceiling or wall warm air register	12	12 to 24	> 24
Front of wall mounted warm air register	18	18 to 36	> 36
Water heater, furnace or boiler	3	3 to 6	> 6
Luminaire up to 250 watts	3	3 to 6	> 6

Quick Response Sprinklers - Reliable, exceed 95% “fail-safe” status in lab testing (from USFA), simple to install and low cost!



Sprinklers have been placed in the three unfinished rooms in the basement floor plan provided in **Figure 6**.

From these placements, the protection area for each sprinkler can be calculated, as follows:



Storage 1:
Protection Area =
(6x2)x8 = 96 ft²

Mechanical Room:
Protection Area =
(3x2)x(5x2) = 60 ft²

Storage 2:
Protection Area =
7x(5x2) = 70 ft²

FIGURE 6
Basement floor plan with sprinklers located in unfinished areas.

Once the protection areas for the sprinklers have been established, the flow rate for each sprinkler can be determined, which allows you to determine the design flow rate for the system, as explained in the next section.

For arrangements with obstructions or sloped ceilings, please see either NFPA 13D or ICR §P2904 for further guidance.

Exposed piping permitted for use in fire sprinkler systems has different requirements than normal home cold water plumbing distribution piping. **Table 2** provides information regarding materials acceptable for exposed sprinkler pipe applications.

Table 2 — Pipes Approved for Exposed Use Applications and Support Requirements per 2012 IRC P2605.1

PIPE MATERIAL	REFERENCE STANDARD	ACCEPTABLE FOR EXPOSED	MAX HORIZONTAL SUPPORT DISTANCE
Steel Pipe, Black and Hot-Dipped, Zinc-Coated, Stainless, Welded and Seamless	ASTM A 53 ASTM A 312; ASTM A 778	Yes	12
Brass Pipe	ASTM B 43	Yes	10
Copper/Copper Alloy Pipe	ASTM B 42; ASTM B 302	Yes	12
Copper/Copper Alloy Tubing Diameter <1 ¼” Diameter >1 ½”	ASTM B 88; ASTM B 75; ASTM B 251; ASTM B 447	Yes	6 10
CPVC Pipe Diameter <1” Diameter >1 ¼”	ASTM D 2846; ASTM F 441; ASTM F 442; CSA B137.6	Yes	3 4
Ductile Iron or Cast Iron Pipe Pipe length <10’ Pipe length =10’	AWWA C 151; AWWA C 115; ASTM A 74; ASTM A 888; CISPI 301	Yes	5 10
PEX-AL-PEX Pipe	ASTM F1281 ASTM F2262 CSA B137.10M	No	2.67
PEX-AL-HDPE	ASTM F 1986	No	2.67
ABS Pipe	ASTM D 1527; ASTM D 2282	No	2.67
PB Pipe or Tubing	ASTM D 3309	No	2.67
PE-AL-PE Pipe	ASTM F 1282; CAN/CSA-B137.9M	No	2.67
PE-RT Pipe	ASTM F 2769	No	2.67
PP Pipe or Tubing Diameter <1” Diameter >1 ¼”	ASTM F 2389 CSA B137.11	No	2.67

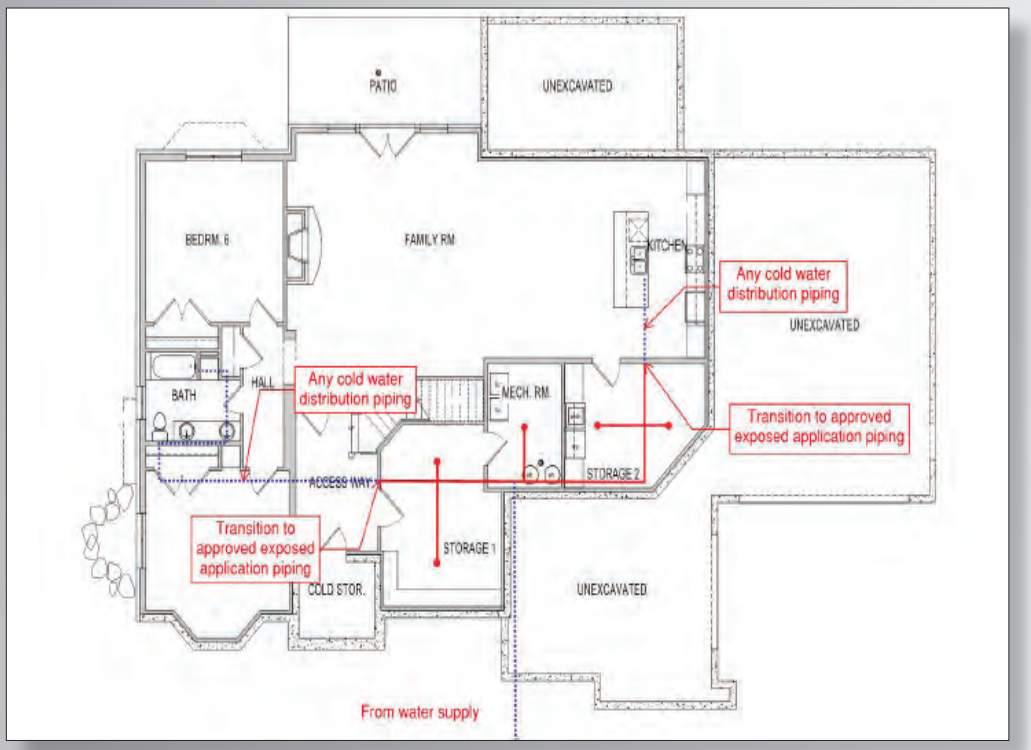


FIGURE 7
A multipurpose system showing the transitions between permitted sprinkler pipe and plumbing pipe.

If pipe or tube materials are used in a multipurpose system which are not identified in **Table 2** as acceptable for use in exposed applications, a transition to an acceptable material will be needed.

This transition to an acceptable material is recommended to be made prior to the entrance of piping into the unfinished area.

IRC §P2904 requires sprinkler system piping to be supported in accordance with the requirements for cold water distribution piping (§P2605).

FIGURE 8
Right: A residential sprinkler system showing pipe routing and support.

NFPA 13D simply states that all supports for the sprinkler piping must be in accordance with listing limitations of the pipe, manufacturer's recommendations and from structural members using support methods comparable to those required by applicable local plumbing codes.

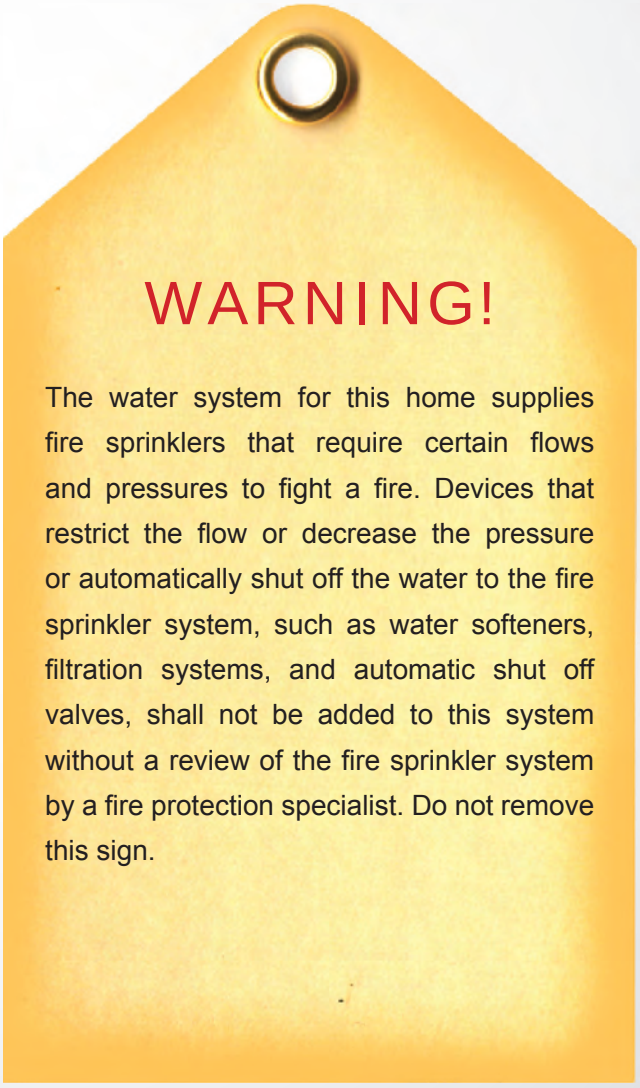
Piping has the same requirement for protection against freezing as the domestic water system piping.

SHUT OFF VALVE PLACEMENT

A shutoff valve is only permitted to be installed for the shut down of the entire water distribution system. A separate sectional isolation valve is not permitted to be installed in any manner where the valve can isolate one or more sprinklers without shutting off the domestic supply (IRC §P2904.3.2).

Requirements for backflow preventers vary by local jurisdictions and should be verified per location.

FIGURE 9
Example valve.



IRC §P2904.7 INSTRUCTIONS & SIGNS

IRC §P2904.7 requires instructions and signs for sprinkler installations as: "*An owner's manual for the fire sprinkler system shall be provided to the owner. A sign or valve tag shall be installed at the main shutoff valve to the water distribution system stating the following:*"

FIGURE 10
Provide a sign or tag in accordance with IRC §P2904.7.

FIRE SPRINKLER SHUT-OFF VALVE

DESIGN FLOW RATE

The design flow rate for the system is based on the following:

1. The design flow rate for a room with one sprinkler will be the flow rate required for that sprinkler. The flow rate for a sprinkler is based on the protection area of coverage for the sprinkler and can be determined in one of two ways; using the area density method or by using the information provided in **Table 3**.
2. The design flow rate for a room having more than one sprinkler is the flow rate for the sprinkler with the highest flow rate multiplied by two.
3. The design flow rate for the sprinkler system is determined by the room with the largest flow rate.

An Example of How to Determine the Design Flow Rate of a System

The sprinklers in this layout have coverage areas less than 100 ft², resulting in flow rates of 15 GPM for each sprinkler. Because Storage 1 and Storage 2 contain two sprinklers, the highest sprinkler flow rate in the room, 15 GPM, is doubled to become 30 GPM. From this, the design flow rate for the system becomes either Storage 1 or Storage 2 at 30 GPM.

Table 3 - Sprinkler Flow Rates and Pressures

COVERAGE AREA PER SPRINKLER, A_{sp} (ft²)	SPRINKLERED AREA			
	ENTIRE BASEMENT (Based on p=0.10 gpm/ft²)		**PORTIONS OF BASEMENT (Based on p=0.15 gpm/ft²)**	
	Flow Rate, Q (gpm)	Pressure at Sprinkler, P_{sp} (psi)	Flow Rate, Q (gpm)	Pressure at Sprinkler, P_{sp} (psi)
A ≤ 100	14.8	7.0	15.0	7.2
100 < A ≤ 110	14.8	7.0	16.5	8.7
110 < A ≤ 120	14.8	7.0	18.0	10.3
120 < A ≤ 130	14.8	7.0	19.5	12.1
130 < A ≤ 140	14.8	7.0	---	---
140 < A ≤ 150	15.0	7.2	---	---
150 < A ≤ 160	16.0	8.2	---	---
160 < A ≤ 168	16.8	9.0	---	---

Table 3 was developed using the area and density method. A density of 0.1 gpm/ft² was used to develop the flow rates and pressures where sprinklers are provided throughout the entire basement. A density of 0.15 gpm/ft² was used to develop the flow rates and pressures where localized sprinkler protection is provided in an unfinished portion of a basement having both finished and unfinished portions.

CALCULATION METHOD

A minimum operating pressure is required at the sprinkler during flow conditions. The information provided in Table 3 is based on the use of quick response standard spray sprinklers with a nominal K-factor of 5.6. If using the area density method, the following equations should be used:

$Q = k \sqrt{P_{sp}}$ $Q = \rho \times A$
Q = flow
k = sprinkler k-factor (gpm/psi ½)
ρ = density (gpm/ft²) = 0.15
P_{sp} = pressure (psi) > 7

Example 1: For an unfinished storage room with an area of 90 ft² and a sprinkler with a k-factor of 5.6, the following pressure and flow would be needed.
$Q = \rho \times A = 0.15$ gpm/ft² x 90 ft² = 13.5 gpm

Next, solving:
$Q = k \sqrt{P_{sp}}$ for P_{sp}, the following equation is used:
$P_{sp} = (Q/k)^2 = (13.5\text{gpm}/5.6\text{gpm/psi}^{1/2})^2 = 5.81$psi; which is less than 7.0 psi; therefore, P_{sp} = 7 psi and $Q = 5.6 \sqrt{7} = 14.81$gpm

Example 2: Using the same information provided in Example 1 for a room with an area of 130 ft²:
$Q = \rho \times A = 0.15$ gpm/ft² x 130 ft² = 19.5 gpm
$P_{sp} = (Q/k)^2 = (19.5/5.6)^2 = 12.1$ psi
since P_{sp} > 7.0 psi
Q = 19.5 gpm and P_{sp} = 12.1 psi

PRESSURE

The following pressure loss calculation is necessary to determine that the minimum operating pressure needed for the sprinkler(s) is provided. The pressure available to overcome the friction loss of the sprinkler piping can be determined from the following equation:

$$P_t = P_{sup} - PL_{svc} - PL_m - PL_d - PL_e - P_{sp}$$

Pt = Total pressure loss
P_{sup} = Pressure available from the water supply source
PL_{svc} = Pressure loss in water-service pipe
PL_m = Pressure loss in the water meter
PL_d = Pressure loss from devices other than the water meter
PL_e = Pressure loss associated with changes in elevation
P_{sp} = Minimum pressure required by the sprinkler(s)

CALCULATION PROCEDURE (IRC §P2904.6.2.2)

Use this worksheet to determine the maximum allowable pipe length for the sprinkler system. The final pipe length determined by this worksheet should not exceed the length of pipe between the control valve and the most remote sprinkler.

Fittings and their associated friction losses can be ignored, as the maximum allowable pipe length tables contain a built in safety factor to account for these losses.

STEP 1 Determine P_{sup}

Obtain the static supply pressure that will be available at the water main from the water purveyor. If the supply is from an individual source (e.g., a tank, a private well system, etc.), the available water supply shall be based on the minimum pressure control setting for the pump.

STEP 2 Determine PL_{svc}

The pressure loss of the water-service pipe depends on the size of the water service, which can be found in IRC Table P2904.6.2(1) or NFPA 13D Table 10.4.9.2(a).

STEP 3 Determine PL_m

The pressure loss from the water meter can be found in IRC Table P2904.6.2(2) or NFPA 13D Table 10.4.3(a).

STEP 4 Determine PL_d

The pressure loss from other devices installed in the system piping supplying the sprinklers, such as pressure-reducing valves, backflow preventers, and water softeners or filters, can be determined from the manufacturer's specifications. The flow rate used to determine pressure loss will be the flow rate determined earlier in this guide.

STEP 5 Determine PL_e

The pressure loss from changes in elevation can be found in IRC Table P2904.6.2(3) or NFPA 13D Table 10.4.9.2(b). The elevation used is the difference between the elevation where the water source pressure was measured and the height of the highest sprinkler.

STEP 6 Determine P_{sp}

The minimum pressure required by an individual sprinkler as determined earlier in this guide.

STEP 7 Determine P_t

Once all the variables have been determined, simply plug the values into the equation to determine the pressure available to offset the friction loss in the piping.

STEP 8 Determine the maximum allowable pipe length

IRC Tables P2904.6.2(4) through P2904.6.2(9) or NFPA 13D Tables 10.4.9.2(c) through 10.4.9.2(h) show available pressure (Pt) values for given types of piping materials and lengths.

WATER SUPPLY FLOW RATE

The water supply should be capable of supplying the required fire demand flow for **seven minutes**.

Depending on the sprinkler system and types of sprinklers used, most stored water systems will need less than 300 gallons of water.

Example:
For a system with a required flow rate of 30 gpm and a seven minute water supply, a tank with a useable capacity of 210 gallons would be needed (30 gpm x 7 minutes = 210 gallons).

FREQUENTLY ASKED QUESTIONS

Q: How long have fire sprinklers been in existence?
A: Automatic fire sprinklers have been in use since 1874.

Q: Are fire sprinklers prone to accidental discharge?
A: The odds of a sprinkler activation due to a manufacturing defect are about 1 in 16 million. Fire sprinklers have a long history of proven dependability and reliability. Although sprinklers can be damaged and activated through intentional or accidental abuse, this is rare. Sprinkler piping is no more likely to leak than existing plumbing piping in every home and building.

Q: Won't fire sprinkler systems freeze in colder climates?
A: With proper installation, home sprinkler systems will not freeze in cold settings. NFPA13D sets forth guidelines on proper insulation to avoid pipes freezing. The Chicago area is a great example of a cold weather region where many jurisdictions have passed sprinkler mandates for new homes with limited to no problems with systems freezing.

Q: Don't fire sprinkler activations result in a lot of water damage?
A: No, fire sprinklers are designed to control a fire in its early stages where less water is required. Most fires are completely controlled with the activation of only one or two sprinklers. Fire hoses, on average, use more than eight times the water that sprinklers do to contain a fire. According to the *Scottsdale Report* (a ten year study conducted in Scottsdale, Arizona), a residential fire sprinkler uses, on average, 341 gallons of water to control a fire. Firefighters, on average, use 2,935 gallons. Reduced water damage is a major source of savings.

Q: Is there a 200 psi pressure test required for residential sprinkler systems as is required for commercial fire sprinkler systems?
A: No. Both multi-purpose and stand-alone systems may be hydrostatically tested at normal system operating pressure as required for domestic plumbing.

Q: Will my insurance premiums go up?
A: No, Generally insurance rates will go down because fire sprinklers will keep damage low.

Q: How do I take care of my fire sprinkler system?
A: A residential fire sprinkler system is basically maintenance free. Some basic precautions to safeguard your fire sprinkler system are:

- Avoid painting or otherwise covering the fire sprinkler devices, as that will affect their sensitivity to heat.
- Do not hang decorations, plants, or other objects from the sprinkler or piping.

Q. Will sprinklers activate when a fire is detected?
A: No. Sprinklers are heat activated, so only the sprinklers near the fire will discharge water (usually one or two) during a fire.

Q: Will the reaction time of a fire sprinkler system be quick enough to extinguish a fire completely?
A: Because the fire sprinklers react so quickly, they can dramatically reduce the heat, flames, and smoke produced from a fire. This increases your chance of survival. Overall, a fire can engulf an average house in about five minutes, compared to the 90th percentile national average response time of a fire response team, being eleven minutes. If the sprinkler system does not completely extinguish the fire, it will help prevent it from spreading throughout the home.

FINAL INSPECTION CHECKLIST FOR CODE COMPLIANCE

Item	Yes	No
Are sprinklers installed in all required areas? (reference IRC R501.3(1)) Comment:	❑	❑
Are the sprinklers obstructed by construction features, luminaries or ceiling fans? (reference IRC §P2904.2.4.2) Comment:	❑	❑
Are sprinklers the correct temperature rating and installed at or beyond the required separation distances from a heat sources? (reference IRC §P2904.2.1 and §P2904.2.2) Comment:	❑	❑
Does the pipe size equal or exceeds the size used in applying Tables §P2904.6.2(4) through §P2904.6.2(9)? Comment:	❑	❑
Does the pipe length not exceed the length permitted by Tables §P2904.6.2(4) through §P2904.6.2(9)? Comment:	❑	❑
If nonmetallic pipes are used are they listed for use in an exposed configuration? Comment:	❑	❑
Are the pipes supported in accordance with IRC Table §P2605.1? Comment:	❑	❑
Was the piping system tested in accordance with IRC §P2503.7? Comment:	❑	❑
Are sprinkler heads painted, damaged or otherwise hindered from operation? Comment:	❑	❑
If a pump is required to provide water to the system, does the pump start automatically upon system demand? Comment:	❑	❑
Are pressure reducing valves, water softeners, water filters or other impairments to water flow installed that were not part of the original design? Comment:	❑	❑
Is the sign or valve tag required by IRC §P2904.7 installed and the owner's manual for the system present? Comment:	❑	❑

Inspection requirements are similiar to those for the cold water distribution system.

Inspection can be completed by the same person inspecting the cold water distribution system (plumbing inspector.)