APPLICATION DATA SHEET

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Residential Fire Sprinkler Systems

INTRODUCTION

Automatic fire sprinkler systems are the most effective and economical way to control or extinguish a fire.

The same copper tube and fittings used in plumbing and heating systems for more than 50 years have been used in automatic fire sprinkler systems since 1961. Installations range from residential such as single family homes, apartments and hotels, to large industrial plants and commercial high rise buildings.

The standards governing fire sprinkler systems in residential units are primarily focussed on achieving a level of performance that will save lives. Although property protection is very much a concern, life safety is of paramount importance. Property owners, system designers and installers, and fire and building officials should be aware of this fundamental distinction.

SCOPE

This publication answers many of the questions asked by plumbing, mechanical and sprinkler contractors about the design and installation of residential fire sprinkler systems using copper tube. These answers are based upon 1991 editions of the following:

NFPA*-13R, "Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and including Four Stories in Height."

NFPA-13D, "Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes."

The guidelines of NFPA-13R form the main body of this text. The requirements of NFPA-13D are the same or less restrictive than those of NFPA-13R. Where NFPA-13D is less restrictive, its requirements are italicized.

State and local governments may impose additional requirements. Such requirements should be obtained from local building and/or fire departments. Residential buildings over four stories and non-residential buildings of any height are covered in NFPA-13, "Standard for the Installation of Sprinkler Systems."

HOW SPRINKLERS WORK

A sprinkler consists of a heat-actuated element and a nozzle connected to a tube or pipe supplied by water under pressure. The heat-actuated element is either a fusible link or a frangible glass bulb. Since fusible link actuated sprinklers are more common in the USA, this term is used throughout.

Under non-fire conditions, the fusible link acts as a closed valve, preventing water flow from the nozzle. In a fire, the hot gases generated rise to the ceiling directly above the fire and spread radially in all directions. The gases heat the fusible links of sprinklers, opening the sprinkler nearest the fire first. Should the fire continue to grow, other sprinklers within the compartment open, discharging more water to extinguish or control the fire. A sprinkler schematic is shown in **Figure 1.**

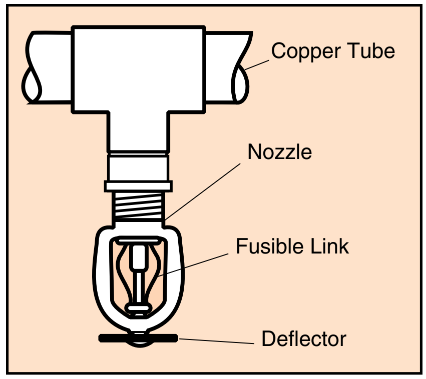

Figure 1. Fire Sprinkler Schematic

SPRINKLER TERMINOLOGY

The following list defines frequently used sprinkler terms.

AHJ: Authority having jurisdiction.
Antifreeze System: A system of automatic sprinklers containing an antifreeze solution. The system is fed from a water supply. The antifreeze solution, followed by water, discharges immediately from sprinklers opened by a fire.
Approved: Acceptable to the "authority having jurisdiction" (AHJ).
Automatic Sprinkler: A fire suppression device which operates automatically when its heat-actuated element is heated to or above a preset temperature, allowing water to discharge over a specific area.
Backflow Preventer: A device or means to prevent backflow of contamination into the potable water piping system.
Branch Line: Lines of pipe or tube on which sprinklers are mounted, running from the cross main (or similar connection) to the end sprinkler.

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Check Valve: A valve that allows flow in one direction only.
Compartment: A space completely enclosed by walls and a ceiling. The compartment enclosure is permitted to have openings to an adjoining space if the openings have a minimum lintel depth of eight inches (203mm) from the ceiling.
Control Valve: An indicating valve employed to control (open/close) the supply of water to a sprinkler system.
Cross Main: A pipe supplying branch lines, either directly or through risers.
Design Discharge: Rate of water discharged from an automatic sprinkler, expressed in gallons per minute (gpm).
Design Sprinkler: The sprinkler(s) which receives the least hydraulic pressure in the system.
Dry System: An automatic sprinkler system where the piping normally contains air under pressure. Loss of pressure, triggered by fire detection or opening a sprinkler, releases water into the piping system and out the open sprinkler.
Currently, no residential sprinklers are specifically listed for use in dry systems.
Dwelling Unit: One or more rooms arranged for the use of one or more individuals living together, normally providing cooking, living, sanitary and sleeping facilities.
Feed Main: The pipe supplying cross mains, either directly or through risers.
Fire Department (F.D.) Connection: A supplemental water supply source achieved by connecting fire department pumping apparatus to the system riser.
Intermediate Temperature Rated Sprinklers: Sprinklers with a temperature rating of 175°F to 225°F (79°C to 107°C).
Listed: Equipment or materials, acceptable to the AHJ, that have met appropriate standards or have been tested and found suitable for specific use.
Multipurpose Piping System: Piping system within residential occupancies serving both domestic and fire protection needs.
Ordinary Temperature Rated Sprinklers: Sprinklers having a temperature rating of 135°F to 170°F (57°C to 77°C).
Residential Sprinkler: A type of sprinkler that meets the definition of fast response as defined in NFPA 13 that has been specifically investigated for its ability to enhance survivability in the room of fire origin, and that is listed for use in the protection of dwelling units.
Residential Occupancies: Occupancies, that include the following as defined by NFPA 101® : (1) Apartment buildings, (2) Lodging and rooming houses, (3) Board and care facilities (slow evacuation type with 16 or fewer occupants and prompt evacuation type), and (4) Hotels, motels, and dormitories.
Riser: The vertical supply pipe in a sprinkler system.
Sprinkler System: An integrated system of piping, connected to a water supply, with listed sprinklers that automatically initiate water discharge over a fire area. Where required, the sprinkler system also includes a control valve and a device for actuating an alarm when the system activates.
System Riser: The aboveground, horizontal or vertical pipe between the water supply and the mains (cross or feed) that contains a control valve (either directly or within its supply pipe) and a waterflow alarm device.
Water Demand: Design discharge multiplied by the number of design sprinklers.
Waterflow Alarm: A sounding device activated by a waterflow detector or alarm check valve.
Waterflow Detector: An electric signaling indicator or alarm check valve actuated by waterflow in one direction only.
Wet System: A system employing automatic sprinklers that are attached to a piping system containing water and connected to a water supply so that water discharges immediately sprinklers opened by a fire.

DESIGN

Designing a copper tube residential sprinkler system or multipurpose system is a matter of determining the minimum tube size for each part of the total system by balancing the available water supply and the design sprinkler demand. Local regulations may require that sprinkler systems be designed by licensed engineers.

The sprinkler contractor may be hired to design and install a system or to install a system designed by others. The design process is summarized here to provide familiarization with the concept, not to explain the design process in detail (See **Reference 4**).

Upon completion of the design, working drawings must be submitted for the approval of the AHJ. Working drawings should be drawn to scale on sheets of uniform size, with each floor shown. The information required is listed in Section 6.1.7 of NFPA-13R. *Working plans and specifications are not required by NFPA-13D;* however, most AHJs require drawings for review and approval.

DESIGN STEPS

The design of a copper tube residential fire sprinkler system requires determination of the following:

- Water supply adequacy.
- Type of sprinklers.
- Location of sprinklers.
- Piping arrangement.
- Tube size and water demand.
- Comparison of demand and supply.

WATER SUPPLY ADEQUACY

Connection to any of the following basic water sources is acceptable:

- A reliable water works system.
- An elevated tank.
- A pressure tank installed in accordance with NFPA-13 and NFPA-22, "Standard for Water Tanks for Private Fire Protection."
- A stored water source with an automatically operated pump, installed in accordance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

When stored water is used, the minimum quantity must equal the water demand rate times 30 minutes (*times 10 minutes for NFPA-13D*). When a tank is used for both domestic and sprinkler systems, a low water alarm is recommended which sounds when the water level falls below 110 percent of the minimum quantity required for sprinkler system use.

When a public water system is used, the pressure and flow capacity of the water supply must be determined. Testing is usually done by the local water department. The results of such tests should be obtained for use by the system designer.

TYPES OF SPRINKLERS

Numerous types of fire sprinklers are marketed. The selection of sprinklers for residential use is subject to the following restrictions:

- Use only listed new sprinklers.
- Use only listed residential sprinklers in dwelling units.
- Do not use residential sprinklers in dry systems unless specifically listed for that purpose.

- Use intermediate temperature rated sprinklers under glass or plastic sky lights exposed to direct sunlight.
- Use intermediate temperature rated sprinklers in unventilated concealed spaces, such as attics, with non-insulated roofs.
- Use ordinary temperature rated sprinklers when maximum ambient ceiling temperature does not exceed 100°F.
- Use intermediate temperature rated sprinklers when maximum ambient ceiling temperature is between 101°F and 150°F.

Manufacturers' data for the sprinklers selected must be obtained for use during hydraulic calculations.

LOCATION OF SPRINKLERS

Locating sprinklers in any space follows six simple rules:

1. Space residential sprinklers so that the maximum area protected by a single sprinkler, does not exceed 144 square feet.
2. Limit the distance between adjacent sprinklers to between 8 and 12 feet.
3. Limit the maximum distance from a sprinkler to a wall or partition to 6 feet.
   (Often, due to room dimensions and spacing limitations, more sprinklers are needed than one for every 144 square feet. For example, a 20 ft x 20 ft room requires four sprinklers, an actual coverage of 100 square feet per sprinkler.)
4. Areas of coverage and distances, other than those specified in rules 1-3, may be used with special sprinklers listed for such specific conditions.
5. Provide sprinklers for all areas within the building, except:
   a. Bathrooms with noncombustible fixtures, less than 55 square feet in plan area.
   b. Closets where the least dimension does not exceed three feet and the area is less than 24 square feet.
   c. Open attached porches, balconies, corridors and stairs.
   d. Attics, penthouse equipment rooms, crawl spaces, floor/ceiling spaces, elevator shafts and other concealed spaces that are not used or intended for living purposes or storage.

   In addition to the above, NFPA-13D does not require sprinklers in garages, carports, and similar structures. Sprinklers may also be omitted from entrance foyers that are not the only means of egress.
6. Locate sprinklers under the ceiling in accordance with their listing, or for sprinklers without specific positioning criteria as follows:
   a. Deflectors of pendent and upright sprinklers 1 to 4 inches below the ceiling; 4 to 6 inches for side-wall sprinklers.
   b. Away from ceiling obstructions, such as ceiling slope, beams, or light fixtures in accordance with Section 6.7.1.5.3 of NFPA 13R. Where obstructions occur, additional sprinklers may be needed to achieve proper response and coverage. See manufacturers' installation guides for additional details.

PIPING ARRANGEMENTS

Once sprinklers are located on the plan, connect all sprinklers to the water supply. Determine tube lengths, and type and location of fittings and valves at this stage. These data are used to determine the required tube diameters as explained under **Tube Size and Water Demand** on page 4.

Tube and Fittings

While drawing the piping, use the shortest practicable routes both to save materials costs and to reduce pressure loss in the system. For larger buildings, follow these general guidelines:

- Use short branch lines, normally four to six sprinklers, rarely more than eight.
- Supply dead end branch lines as close as practicable to their midpoint.
- Branch lines connected to cross or feed mains at both ends (gridded) can roughly double the length of similar diameter dead end branch lines.
- Branch lines may all be of the same diameter provided they are large enough to supply simultaneously all the design sprinklers.
- Branch lines may run through two or more compartments.
- Long, cross and/or feed mains should be looped or gridded where practicable. This saves materials costs, since smaller diameter tube is used.

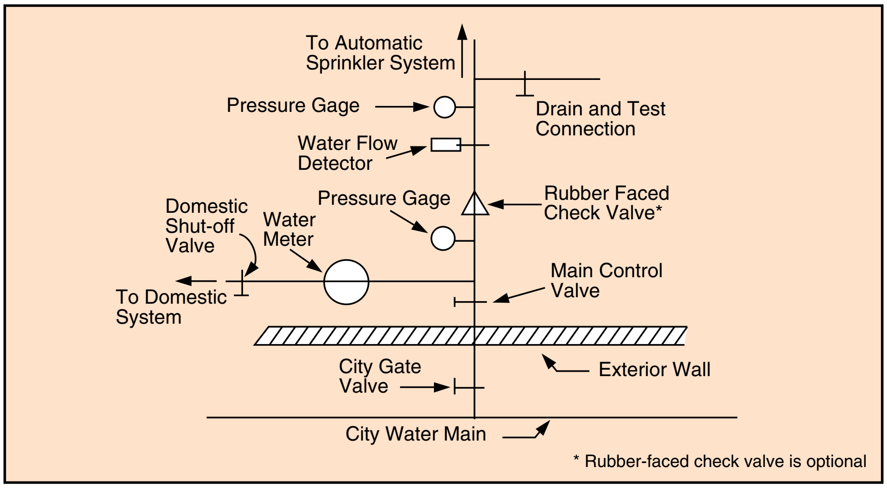

Figure 2a. Preferred System Arrangement

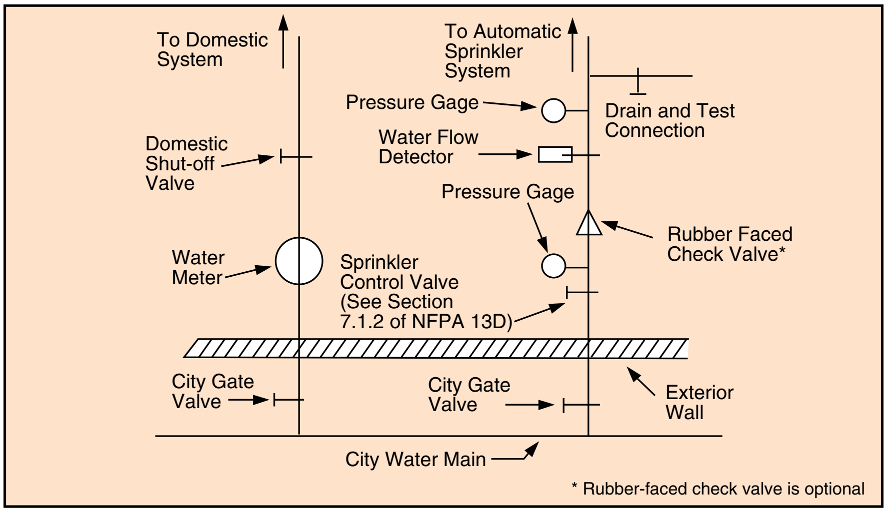

Figure 2b. Acceptable System Arrangement

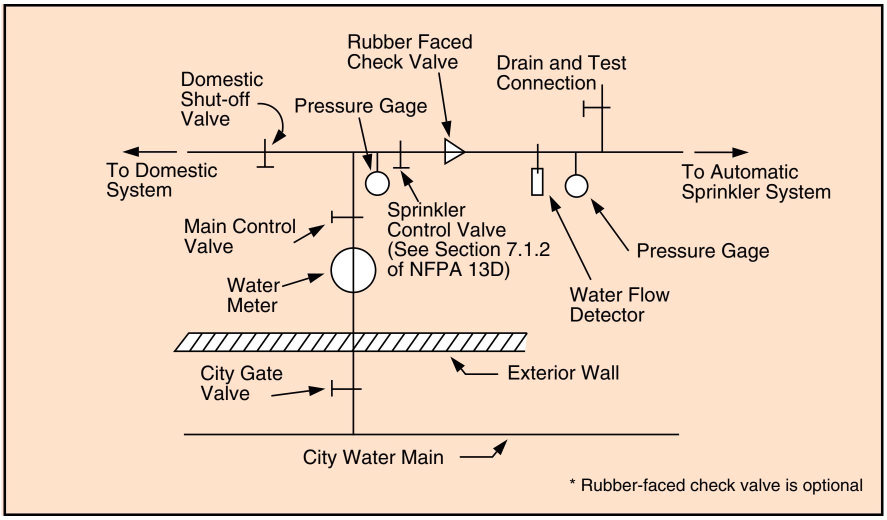

Figure 2c. Acceptable System Arrangement

- Interconnect risers in multistory buildings using looped or gridded mains where practicable. This also saves materials costs, since smaller diameter tube is used.

Valves and Other Devices

Connection of fire sprinkler systems to city water supplies is often subject to local regulations concerning metering and valving. **Figure 2a** shows the preferred arrangement. **Figures 2b** and **2c** represent acceptable alternatives.

Most local plumbing codes require a backflow preventer to preclude the flow of nonpotable water from the sprinkler piping back into the potable water supply. A simple backflow preventer uses two check valves in series.

Where a system supplies more than 20 sprinklers, a $1^1/_2$-inch or a $2^1/_2$-inch fire department pumper connection is required. The provision of a fire department connection does not affect the calculated tube sizes.

TUBE SIZE AND WATER DEMAND

Sizing a residential sprinkler system or multipurpose system is a matter of determining the minimum tube size needed throughout the total system in order to adequately supply the design sprinklers in the most remote compartment. In order to accomplish this: 1) determine the water demand, and 2) size the tube and fittings to meet the demand flow and pressure.

Water Demand

Sprinkler system water demand is equal to the design discharge multiplied by the number of design sprinklers. The number of design sprinklers includes all sprinklers within a compartment up to a maximum of four adjacent sprinklers (*a maximum of two sprinklers for NFPA-13D*). The design discharge is not less than 18 gpm for one operating sprinkler and not less than 13 gpm per sprinkler for multiple sprinklers operating. If the manufacturer's listing specifies a flow rate of more or less than 13 gpm, use the listed flow rates and corresponding listed pressures.

For multipurpose systems, the water demand is the total of domestic demand and sprinkler system demand. The domestic demand can be determined by using Tables Table A.6.5.5(a) and (b) of NFPA-13R. *For NFPA-13D domestic demand, add 5 gpm only if more than one dwelling unit is served*. Where long-term use of lawn sprinklers is common, local regulations may require inclusion of such use in the total demand.

Domestic demand need not be added to sprinkler demand if provision is made to prevent flow automatically in the domestic water system upon sprinkler operation. This can save piping costs in relatively large buildings where domestic outlets and sprinklers are widely separated.

Determination of water demand in occupied areas other than dwelling units is subject to the following rules:

1. For areas larger than 500 square feet, the design discharge, number of sprinklers, water demand of the system, sprinkler coverage, and position of sprinklers must be in accordance with NFPA-13.
2. For areas divided into compartments of 500 square feet or less (by means of 30-minute fire-rated construction), and protected by standard or quick response sprinklers not exceeding 130 square feet per sprinkler, the system demand may be limited to the number of sprinklers in the compartment, but not fewer than four sprinklers. Discharge density must be determined according to NFPA-13 hazard classification. Openings with a lintel depth of 8 inches or more are allowed in the compartment perimeter, but the total area of such unprotected openings may not exceed 50 square feet.
3. Lobbies (in other than hotels and motels), foyers, corridors, and halls with flat, smooth ceilings and not exceeding 10 feet in height may be protected with residential sprinklers based upon a maximum system demand of four sprinklers.

Tube Size

As water flows through a tube, friction between water and the tube interior produces a pressure loss (friction loss). Similar pressure losses result from water flow through fittings, valves and other devices. Friction loss is undesirable, but unavoidable.

Four factors have major impact in reducing friction loss: 1) decreasing the overall tube length; 2) selecting a material with a smooth interior surface, such as copper; 3) increasing the tube diameter; and 4) decreasing the water flow rate (gpm). Since factors one, two and four have already been determined, tube diameter (based on the following design guidelines) is used to balance supply and demand.

- Determine the available water supply pressure and flow before beginning calculations.
- Calculate tube sizes based on water demand in accordance with procedures set by NFPA-13.
- Try to minimize the range of tube sizes used throughout the system. Although $^3/_4$-inch copper tube is permitted, setting the minimum diameter at 1 inch may result in a more cost effective system design.
- Set the minimum operating pressure of any sprinkler in accordance with its listing for the required flow.
- Determine pressure loss in fittings, valves and water meters using Tables 8.4.4(d), (e), (f), and (g) of NFPA-13D. For backflow preventers, the pressure loss should be obtained from the manufacturer.
- Recognize that where water meters are required, the smallest practicable meter size is 1 inch.

Hydraulic Calculations

Hydraulic calculations can be performed using existing computer programs or the guidelines for manual calculations in Chapter 14 of NFPA-13. A proven computer program is usually faster and more reliable.

Manual calculations involve the following steps:

1. Assign arbitrary diameters to the tube lengths.
2. Determine the largest and most distant compartments; identify the farthest sprinkler within the compartment.
3. Calculate the demand flow at the farthest sprinkler, based upon its listed pressure and flow rate.
4. Determine the friction loss from this sprinkler to the next sprinkler or junction.
5. Calculate the flow at the next sprinkler using the new pressure.
6. Repeat the calculations to cover all design sprinklers. Note that the pressure and, hence, the flow increase as calculations proceed. When design sprinklers are located on different branch lines, the calculations are more involved.
7. After all the design sprinklers are covered, keep the flow constant and calculate the friction loss back to the water source. The supply water pressure at the demand flow must equal or exceed the pressure determined by the hydraulic calculations. If supply pressure far exceeds demand pressure, repeat the calculations using smaller size tube. If the supply is less than the demand, repeat the calculations using larger tube diameters. In some instances, a booster pump may be needed to provide the pressure required to meet the demand.
8. Repeat calculations for other floors.

Cost Saving Design Tips:

- In larger buildings, compound loop configurations can reduce tube sizes. The design is more involved, but lower tube and fittings costs usually result.
- Use listed side-wall sprinklers, where appropriate, to reduce tube lengths.
- Use Type M tube to achieve greatest flow capacity for any given diameter.
- Where practicable, the use of side-wall or dry pendent sprinklers can avoid the added cost of antifreeze or dry-pipe systems.
- Check local regulations for less restrictive requirements.

For NFPA-13D, a simplified hydraulic calculation replaces the above procedure except for gridded or looped systems where complete hydraulic calculations, using either computer programs or manual procedures, is essential. Local regulations may allow this type of calculation to be performed by other than licensed engineers. This method involves the following steps:

1. *Determine water pressure in the street.*
2. *Select arbitrary tube sizes.*
3. *Deduct meter pressure losses.*
4. *Deduct pressure loss for elevation.*
5. *Deduct pressure losses for piping from the city main to the control valve and from the control valve to the farthest sprinkler on the highest floor.*
6. *Deduct pressure losses for fittings.*
7. *In multilevel buildings, repeat all of the above steps for lower levels. Usually, the lower floors require smaller tube sizes throughout the floor.*
8. *If the remaining pressure is less than the listed operating pressure for the specific sprinklers used, a redesign is necessary. If this pressure is higher than required, smaller diameters may be used when justified by calculations.*

UNHEATED SPACES

Sprinklers installed in unheated areas subject to freezing must be protected in accordance with Section 8.3.2 of NFPA 13D. Protection methods may include use of dry-pipe systems, anti-freeze systems, or other protection methods.

DESIGN EXAMPLE FOR A ONE-FAMILY HOME

Situation: A single-family home is shown in **Figure 3a**. A specific sprinkler has been selected to be used in the building at a spacing of 14 ft x 14 ft.
Wanted: Complete design of an automatic sprinkler system for this building.
Solution:

Locating the Sprinklers

- Since it is a single-family home, use NFPA-13D.
- Bedroom 1 requires one sprinkler, since its area is less than 14 ft x 14 ft. The same applies to Bedrooms 2 and 3.
- The bathroom requires a sprinkler, since it is more than 55 square feet.
- The kitchen requires two sprinklers, since its length of 18 feet exceeds 14 feet, the listed spacing.
- The two kitchen sprinklers are spaced at 8 feet, the minimum allowable spacing. The sprinkler closest to the range is 3 feet away laterally (1 ft-6 in minimum is allowed in the listing.)
- The living/dining room presents a special problem. Were it not for the beams, six sprinklers would adequately protect the room. The 10-inch depth of the beams (**Figure 3d**) disrupts the sprinkler water flow pattern across the length of the room (based on Section A.8.2.4 of NFPA 13D of NFPA-13D). Therefore, a sprinkler is needed in each bay to provide the required coverage. And because the room width, 17 ft - 6 in, exceeds 14 feet, two sprinklers are required per bay for a total of ten sprinklers.
- The fireplace has to be considered. The manufacturer's installation guide requires sprinklers to be at least 3 feet laterally from the side of the fire box. Also the shaded area in front of the fireplace in **Figure 3b** shows where sprinklers are not to be installed. The only solution is to position the two sprinklers in this bay as shown.
- The garage need not be sprinklered, based on Section 8.6.4 of NFPA-13D.
- The attic need not be sprinklered based on Section 8.6.5 of NFPA-13D.
- The closets need not be sprinklered, see Section 8.6.3 in NFPA-13D.
- The hall requires one sprinkler as shown in **Figure 3b**. Make sure the spacing between sprinklers is 8 feet or more.

Number of Design Sprinklers

- The dining/living room and the kitchen are protected by two or more sprinklers. All other rooms contain only one sprinkler. Therefore, based on Section 8.1.2 of NFPA-13D, the number of design sprinklers is two.

Location of Design Sprinklers

- Since the water supply connection is in the garage, the sprinkler in the hall and the sprinkler nearest to it on the same branch line in the dining/living room are the most remote (based upon developed length plus fittings equivalent length) and, therefore, the two design sprinklers selected.

Piping Arrangement

- A flow switch-activated fire alarm is desired in lieu of smoke detectors to signal system operation. The sprinkler supply used to accomplish this is shown in **Figure 3e**. Installation of a flow switch-activated alarm does not preclude the installation and maintenance of smoke detectors.

Water Supply Requirements

- In the manufacturer's literature, the design discharge and pressure requirements for the $^{7}/_{16}$-inch (K=4.2), residential, pendent sprinkler model chosen at a maximum 14 ft x 14 ft coverage are:
  - 18 gpm at 18.8 psi for one sprinkler operating;
  - 13 gpm per sprinkler at 9.8 psi for two sprinklers operating.

The hydraulic calculations are run for both conditions to ensure that the tube sizes selected are adequate.

Tube Sizing

One sprinkler Operating:

For single sprinkler operation, the most hydraulically remote sprinkler is located in bedroom 1. Therefore, that sprinkler is used for the following check calculation.

- Assume 1-inch Type M copper tube is used throughout (0.07 psi/ft loss at 18.0 gpm; Table 8.4.4(b); NFPA 13D).
- Given: water pressure of 45 psi.
- Meter loss = 4.0 psi (Table 8.4.4(g); NFPA 13D).
- Elevation loss: 10 ft x .434 psi/ft = 4.3 psi.
- Loss from street main to control valve (23 feet of tube + 3 feet for one elbow): 26 ft. x 0.07 psi/ft = 1.8 psi.
- Total tube length from control valve to most remote sprinkler (including riser in garage) = 72 feet.
- Total pressure loss for tube within house: 72 ft. x 0.07 psi/ft. = 5.0 psi.
- Equivalent length of tube for valves and fittings:

1 1-in Gate Valve:	1 x 0 ft =	0 ft
7 1-in Tees (run):	7 x 3.0 ft =	21 ft
2 1-in Tees (br.):	2 x 8.0 ft =	16 ft
3 1-in Elbows:	3 x 3.0 ft =	9 ft
	TOTAL	46 ft

- Loss in valves and fittings: 46 ft x 0.07 psi/ft = 3.2 psi
- Total pressure loss: 4.0 + 4.3 + 1.8 + 5.0 + 3.3 = 18.3 psi.
- Pressure remaining: 45.0 – 18.3 = 26.7 psi.

The remaining pressure, 26.7 psi is more than the 18.8 psi required to flow one sprinkler at 18 gpm. Therefore, the 1-inch Type M copper tube selected is adequate.

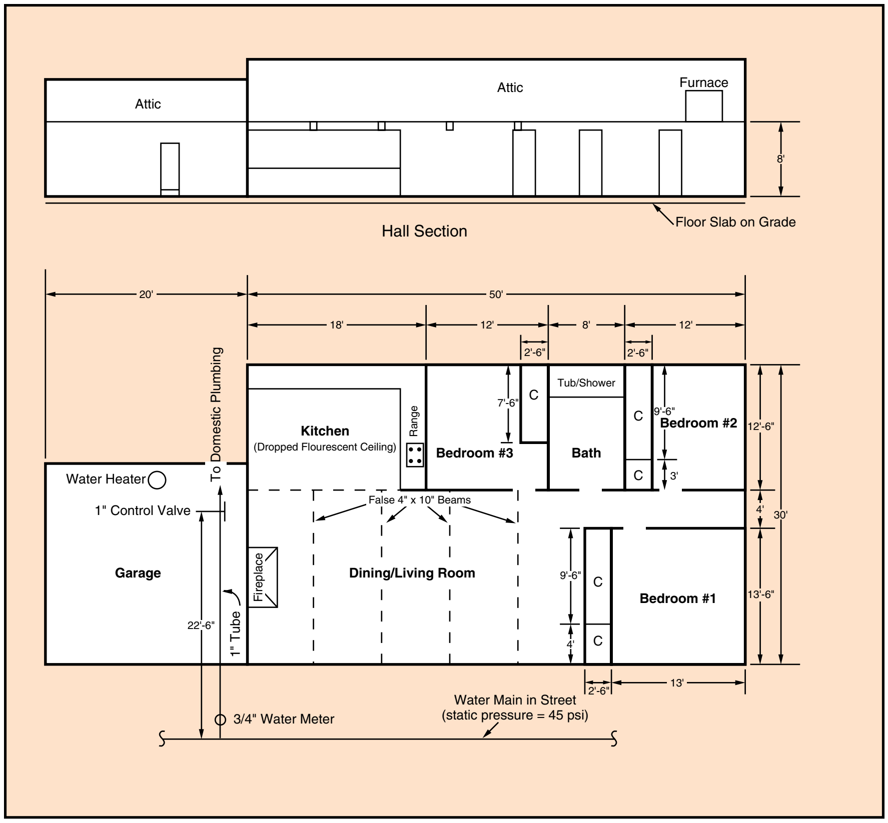

Figure 3a. Floor Plan **Source: Central Sprinkler**

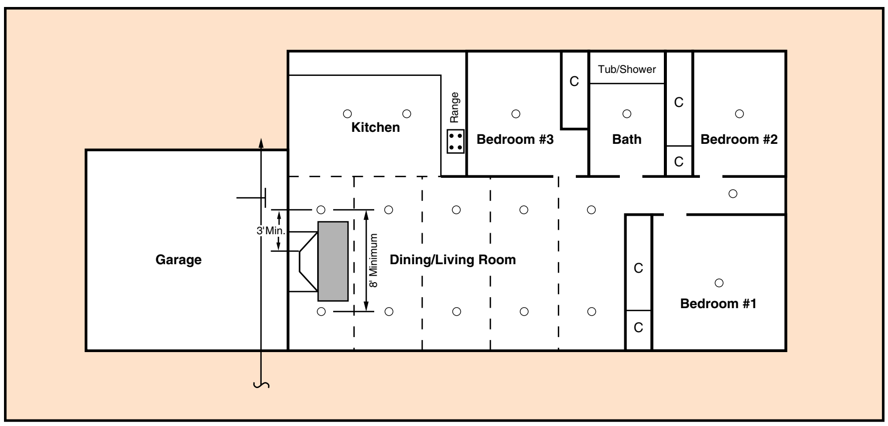

Figure 3b. Sprinkler Locations

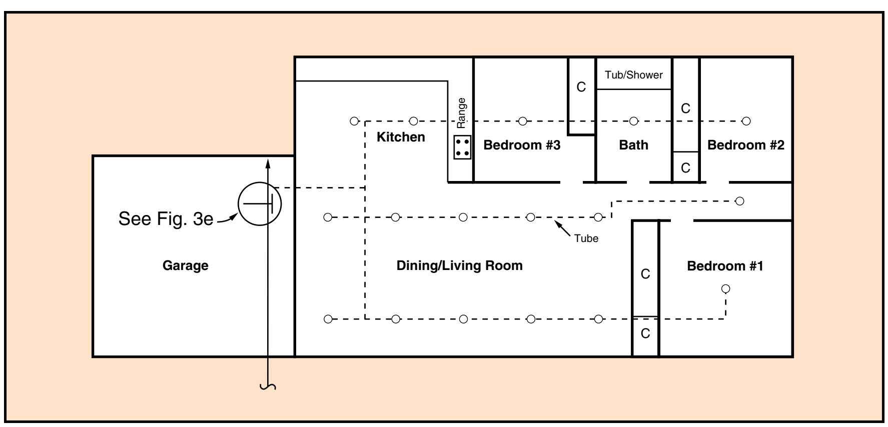

Figure 3c. Layout

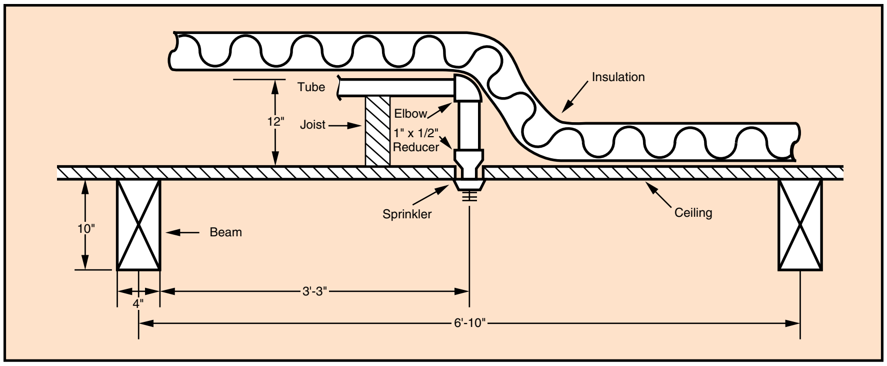

Figure 3d. Beam Obstructions

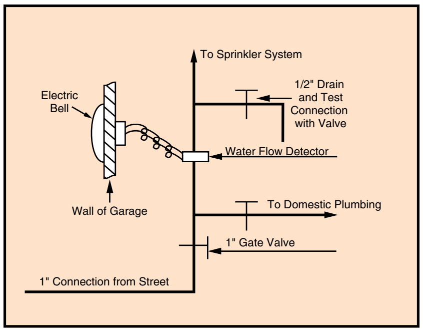

Figure 3e. Elevation, at Connection to Water Supply (N.T.S.)

Two Sprinklers Operating:

For two sprinklers operating, the most remote design sprinklers, as noted above, are the one in the hall and the next sprinkler in the dining/ living room on the same branch line.

- Total flow is 26 gpm; 2 x 13 gpm.
- Assume 1-inch Type M copper tube is used throughout (0.14 psi/ft at 26 gpm; Table 8.4.4(b); NFPA 13D).
- Meter loss = 9.0 psi (Table 8.4.4(g); NFPA 13D)
- Elevation loss = 4.3 psi.
- Loss from street main to control valve: 26 ft x 0.14 psi/ft = 3.6 psi.
- Total pressure loss for tube within the house: 61 ft x 0.14 psi/ft = 8.5 psi.
- Equivalent length of tube for valves and fittings:

1 1-in Gate Valve:	1 x 0 ft =	0 ft
5 1-in Tees (run):	5 x 3.0 ft =	15 ft
3 1-in Tees (br.):	3 x 8.0 ft =	24 ft
4 1-in Elbows:	4 x 3.0 ft =	12 ft
	TOTAL	51 ft

- Loss in valves and fittings: 51 ft. x 0.14 psi/ft. = 7.1 psi
- Total pressure loss: 9.0 + 4.3 + 3.6 + 8.5 + 7.1 = 32.5 psi.
- Pressure remaining: 45 – 32.5 = 12.5 psi.

The remaining pressure, 12.5 psi, is more than the 9.8 psi required to flow each of the two design sprinklers at 13 gpm. Therefore, the 1-inch Type M copper tube selected is adequate.

Conclusion

The 1-inch Type M copper tube meets both the 18 gpm and 26 gpm design flows without exceeding the available water supply pressure of 45 psi. Should the designer wish, portions of tube feeding a single sprinkler may be reduced to $^3/_4$-inch when justified by calculations including that change.

Note that the equivalent lengths in feet of tube as presented in Table 8.4.4(f); NFPA 13D are significantly larger than equivalent lengths, based upon actual tests, which the copper industry has published for decades. In instances where the calculated pressure losses for a system are marginal with respect to the available supply source pressure, the designer may wish to use the industry values as published in the CDA *Fire Sprinkler Systems Design Guide;* Table 3, page 10, before electing to increase the tube size initially selected.

Layout

Figures 2b and **2c** show the layout at the connection to the water supply. Included are:

- A control valve as called for by Section 7.1.1 in NFPA-13D. The existing 1-inch Gate valve serves this purpose.
- A $^1/_2$-inch drain and test connection with valve on the system side of the control valve as called for by Section 7.2.1 of NFPA-13D.
- A water flow alarm (flow detector and bell) as called for in Section 7.6 in NFPA-13D.

Temperature Rating

- The highest annual temperature within the house is not expected to exceed 100 F. Section 3-5.2 in NFPA-13D calls for a sprinkler temperature rating not less than 35°F above this; 100 + 35 = 135°F, the minimum allowable temperature rating. The selected sprinkler is available in ratings of 145°F and 160°F. The 145 F rating is satisfactory.

INSTALLATION

The installation of a copper residential sprinkler system is quite similar to copper plumbing work.

SOLDER AND FLUX SELECTION

Soldering

Soldering is the basic process used for joining copper tube and fittings.

Soldering is distinguished from brazing by the temperature at which the solder melts — below 840°F. (Above 840°F is considered brazing and, by definition is the temperature needed to melt the filler metal completely.)

Sound soldering results from attention to detail including: proper mechanical cleaning; use of a suitable flux to prevent oxidation; adequate support of the assembly during soldering; and, maintaining the temperature of the joint assembly above the solder melting point.

The solder provides a watertight seal. To achieve optimum mechanical strength, the tube must be fully inserted into the fitting. The fit should be tight, since a loose fit produces weak joints.

Solder use is limited to wet pipe systems. Only 95-5 TA (95% Tin, 5% Antimony) solder may be used.

Flux

Fluxes suitable for soldering copper tube usually contain an active acid ingredient which provides some degree of chemical cleaning as well as oxidation protection. This cleaning action cannot replace mechanical cleaning for the proper removal of scale and oxidation.

For long-term, corrosion-free performance, follow the guidance provided by the flux manufacturer and the fittings and tube manufacturers to insure proper flux selection and application.

Specific liquid and paste fluxes qualified under the procedures of (ASTM B 813) are suitable for soldering copper tube and fittings.

Careless workmanship, especially during flux application, can result in corrosion of tube and sprinklers long after the sprinkler system has been installed. If excessive flux is used, the residue inside the tube can cause corrosion. In an extreme case, residual flux can actually lead to perforation through the tube wall causing leakage. To guard against this danger, it is important to (1) use only fluxes meeting the require-

ments of ASTM B 813, and (2) use only the minimum amount actually needed to make the joint.

Brazing

Brazing is distinguished from soldering by the temperature at which the filler metal melts completely — above 840°F but less than the melting temperature of the metal being joined.

Two brazing filler metals are approved for copper residential sprinkler systems, BCuP-3 and BCuP-4.

Copper tube and wrought copper fittings can be brazed using BCuP filler metals without the aid of a brazing flux. Where cast brass fittings are employed, use of a brazing flux is mandatory in order to achieve sound joints and avoid cracked or porous fittings. Since brazing flux is an excellent temperature indicator, its use in all instances is valuable in minimizing overheating and thus increasing the probability of sound joints.

Brazing fluxes are different from soldering fluxes and are usually some form of water based borates.

TUBE AND FITTINGS SELECTION

Types K, L and M tube, to ASTM B 88, are listed by NFPA-13R and NFPA-13D. When properly installed, such tube should withstand working pressures up to 175 psi. Some localities limit the use of copper tube to types K and L.

Acceptable fittings for residential sprinkler systems include: wrought copper and copper alloy solder-joint pressure fittings to ASME B16.22 and cast copper alloy solder-joint pressure fittings to ASME B16.18.

HANGERS AND SUPPORTS

Hanging and bracing methods for fire sprinkler systems are usually more stringent than those required by local plumbing codes. This is largely due to the tube size and length, short term pressure surges and water hammer anticipated in sprinkler systems. NFPA-13R requires hanging and bracing methods to comply with NFPA-13 standards. *Because tube sizes and lengths are usually smaller for sprinkler systems serving one-and two-family dwellings, NFPA-13D permits supporting the tube from structural members using methods comparable to those permitted by local plumbing codes.*

OTHER CONSIDERATIONS

Residential sprinkler systems may require details not usually encountered in plumbing work. These details include:

- Provision of a single control valve to shut off both the sprinkler and domestic systems.
- Provision of a 1-inch or larger drain valve and test connection on the system side of the control valve, *1/2-inch or larger for NFPA-13D*.
- Provision of 1/2-inch drains for trapped portions of a dry system.
- Pressure gauges mounted on the supply and system sides of main check valves, dry-pipe valves, and pressure tanks.
- Sprinklers factory painted by the manufacturer, but never field painted.
- System control valve must be of the indicating type.

COST SAVING INSTALLATION TIPS

When smoke detectors are provided in compliance with NFPA-74, "Standard for the Installation, Maintenance and Use of Household Fire Warning Equipment," the sprinkler water flow alarm can be eliminated.

ACCEPTANCE TESTS

Most local authorities require acceptance tests based upon the procedures set forth in NFPA-13R and NFPA-13D.

NFPA-13R requires the following:

- Flushing of underground mains and lead-in connections to the system riser before final connection to the sprinkler system.
- The flushing operation must be carried out at or above the water demand calculated for the system and must continue until the water is clear.
- The system must be tested for leakage at 50 psi above the maximum system design pressure. The test pressure must be at or above 200 psi when Fire Department Connections are provided.
- Dry systems must be tested using air at a 40 psi pressure for 24 hours. The pressure should not drop more than 2 psi during this period.
- Testing can be accomplished using visual inspection for leakage.

NFPA-13D requires the following:

- *Testing for leakage at normal system operating pressure.*
- *If the owner provides a Fire Department Connection, the test pressure must be at or above 200 psi.*

REFERENCES

The following publications provide further information and pertinant details on residential fire sprinkler systems.

1. NFPA-13R, "Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and including Four Stories in Height."*
2. NFPA-13D, "Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes."*
3. NFPA-13, "Standard for the Installation of Sprinkler Systems."*
4. "Fire Sprinkler Systems," Copper Brass Bronze Design Guide, Copper Development Association Inc.**
5. "Comparison of Several Computer Hydraulics Programs for the IBM PC and Compatibles", SFPE Technology Report 87-1, 1986.***
6. "Soldering and Brazing Copper Tube," Application Data Sheet, Copper Development Association Inc. **
7. Local Building and Plumbing Codes.

* National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

** Copper Development Association Inc., 260 Madison Avenue, New York, NY, 10016

*** Society of Fire Protection Engineers, 60 Batterymarch Street, Boston, MA 02110

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