Residential Fire Sprinklers
Problems with NFPA 13D

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Executive Summary: The subject of residential fire sprinkler systems for one and two family dwellings is complex and dynamic. There are many problems and issues in addition to those presented below and very few clear solutions. One of the underlying problems is that there are many types of residential sprinklers systems, each with its unique set of problems and solutions. The fire sprinkler manufacturers have done a good job of creating alternative systems for different applications, but have done a poor job of integrating these systems into one and two family dwellings. Until solutions for these problems are clearly identified and guidelines are available as to which systems integrate best under different circumstances, mass adoptions of mandates to install fire sprinklers in one and two family dwellings would only lead to mass confusion and increased costs of construction.

Fire sprinklers are not typically installed in one and two family dwellings throughout the United States. However, in recent years their use has grown as they have become mandated in some municipalities. The most obvious objection to sprinkler systems is their cost, but cost is not the only issue. There are many technical issues that must be resolved before considering installing sprinklers. The problems vary based on the type of water supply system (public vs. well) and with geographic location, primarily due to outdoor temperatures.

1. **Public Water Supply:** A typical domestic water supply for one and two family dwellings includes a 5/8" water service and meter and may include a water pressure regulator and/or a backflow preventer. All of these devices are designed for a typical residential water flow rate of 5 to7 gallons per minute (gpm). They cannot deliver the 26 gpm required by a residential fire sprinkler system. At a minimum, all of these devices need to be increased in size, typically to 1¼". Increasing the size of these devices is a hidden cost that is often overlooked because it is part of the plumber's job, and is therefore not included in the fire sprinkler contractor's bid. In addition there are technical problems that must be addressed as follows:
   A. A residential water pressure regulator (pressure reducer) that is increased in size to handle the higher fire flows will not properly reduce the water pressure when operating at the low flow rates that are typical in one and two family dwellings.
   B. A water meter that is increased in size to handle the higher fire flows will not accurately register the low flows that are typical in one and two family dwellings. Additionally, many water purveyors' rates increase with the size of the water meter.

A simple solution to both of these problems is to connect the fire sprinkler system to the water service before both the pressure regulator and the water meter and to install a typical size residential pressure regulator and water meter to supply the home. However, most water purveyors' require that the pressure regulator be installed before the water meter, and because they also require that all water be metered, the fire sprinkler connection cannot be before the pressure regulator. Unfortunately, water purveyors' are not regulated by building codes and short of an act of Congress this is not a viable solution.

Another solution to these problems is to install a seconded larger water service dedicated to the fire sprinkler system. This solution is not only expensive initially, but will have ongoing cost because many water purveyors' have a minimum monthly rate per meter (even when there is no consumption). Also rates typically increase with the size of the water meter, so the fire sprinkler meter rates will be more then the rates for the domestic water meter. Again, adding a seconded larger water service and meter is a hidden cost that is often overlooked because it is part of the plumber's job, and is therefore not included in the fire sprinkler contractor's bid.

2. **Private Water Supply (Wells):** Water supplied from a private well is similar to that of a public water system in that the required flow rate is the same 5-7 gpm, however the source of the water is from a well that is typically 100 – 600 ft deep. A pump near the bottom of the well pumps the water into a small pressurized water storage tank (typically 40 gallons) located in the home. Again, increasing the size of these devices is a hidden cost that is often overlooked because it is part of the plumber's job, and is therefore not included in the fire sprinkler contractor's bid. In addition there are technical problems that must be addressed as follows:
   A. Similar to a public water supply, the well system components are sized for residential flow rates. If these devices are increased to handle the higher flow requirements of a residential fire sprinkler system they will not function properly for the home.
   B. It is often difficult or impossible to increase the capacity of a well to accommodate the demand of a fire sprinkler system. If the capacity of the well cannot be increased, the capacity of the storage tank will need to be increased such that it can store a minimum of 260 gallons. Because only a third of the volume of a pressurized water storage tank is stored water (the balance of the tank being occupied by pressurized air), this would require a tank that is approximately 780 gallons. Not only is such a tank expensive, it would be very large and may be difficult to fit into a home.

      An alternative to a pressurized water storage tank is an open (not pressurized) storage tank. The advantage to an open tank is that all of the tank's capacity is available to store water, and therefore 260 gallons of water can be stored in a 260 gallon tank. This type of tank is significantly less expensive and smaller than the pressurized tank. The disadvantage of this type of tank is that water is stagnant and therefore can only be used to supply a stand-alone or independent fire sprinkler system and not a multipurpose system (see descriptions of system types below). Another disadvantage of this type of tank is that it requires a separate electrical pump dedicated to the fire sprinkler system. This pump not only adds to the cost, but will not function in the event of a power failure (see discussion about backup power supply below).

C. Water from a well is pumped into the storage tank with an electric pump and because a backup power supply is NOT required by the code, a fire sprinkler system on a well would not function in the event of a power failure. A homeowner who did not realize this would have the false expectation that their fire sprinkler system was operational (when in fact it would not be). According to the Unites States Fire Administration, there is a greater concern for residential fires during or after a natural disaster or power outage since occupants will turn to optional sources of heat or power that could be hazardous. A simple solution to this problem would be to change the code to require a back-up power supply; however there is nothing simple about a backup power supply. A backup power supply would be either a generator or a battery system, both of which are expensive and require frequent maintenance.

3. **Water Softeners:** Residential water softeners are designed for low flow rates and not the higher flow rates required by residential fire sprinklers. This causes technical problems that must be resolved as follows:

   A. At the high flow rate required for sprinklers, the drop in water pressure through a residential water softener would be so significant that a fire sprinkler system would not function. On more than one occasion, design professionals for fire sprinkler systems have informed me that there is a device that would cause the water to bypass the water softener in the event of water flow in the fire sprinkler system. In all such occasions, I have thoroughly researched their claims and have found no such device that would solve this problem. Although I believe this device is theoretically possible, I am not aware of anyone that is working on designing it.

   B. Water softeners regenerate often, typically once a day. During regeneration, almost all of the water flow is used to backwash the softener (much the same as a swimming pool's sand filter). If a fire were to occur during this regeneration, the fire sprinkler system would be rendered inoperative due to a lack of water. A simple solution to this problem would be a water softener that would bypass itself during regeneration. Although I believe this water softener design is theoretically possible, I am not aware of anyone that is working on it.

4. **System Design Issues:** There are many different types of residential fire sprinklers, each with their own set of advantages and disadvantages. Fire sprinkler heads are simple devices that allow water to flow when the temperature at the head exceeds a preset limit. Each head functions independent of the other (they do not go off all at once as is often depicted in Hollywood films). Some of the different system types and associated problems are as follows:

   A. **Wet Systems:** In a wet system the fire sprinkler piping is always full of water. The advantage to this system is that it responds quickly to a fire and is less expensive than a dry system. The disadvantage to a wet system is that the water in the system could freeze if subject to below-freezing temperatures.

      I. One solution to this problem is to run all sprinkler piping inside interior walls and use wall mounted sprinkler heads instead of ceiling mounted sprinkler heads when the space above the ceiling is subject to freezing temperatures. A limitation to this is that sprinkler heads must be installed near the ceiling level, but in the case of a sloped or cathedral ceiling, the ceiling will continue to rise above the wall and may be too far from the sprinkler head. Another limitation to the wall mounted sprinkler heads is that

they must meet performance requirement for wetting the opposite wall near the ceiling level. In larger rooms, this may require increased water pressure or an increase in the number of sprinklers heads to adequately protect the room. In some cases it is simply not possible to adequately cover large rooms with wall mounted sprinkler heads.

II. Another solution is to mix antifreeze into the water. A problem with this solution is that over time the antifreeze level in the system decreases and must be maintained. Maintaining the proper level requires periodic draining of the system and refilling with the proper mixture. This is not as easy as it sounds because the piping will not drain unless all the sprinkler heads are removed and compressed air is blown into the system to force out the water. This maintenance is not only expensive but potentially very messy and difficult to perform in a finished house full of furniture. In addition, antifreeze systems that are connected to potable water supplies must be equipped with a back flow preventer. This back flow preventer is in addition to the back flow preventer that may be required by the water company and will have to be large enough to handle fire flows. It will also require regularly scheduled inspections and maintenance, all of which add to the hidden cost of residential fire sprinklers.

III. Another solution to prevent freezing is to install the fire sprinkler piping beneath the ceiling insulation. This requires the insulation to be installed flawlessly. Even a small uninsulated area would have catastrophic consequences. Although such a flawless job is theoretically possible it is impractical and can be easily compromised by other trades or the occupants if they disturb the insulation. Additionally, some people believe that installing insulation around the piping will prevent freezing; but this not so, insulation only slows down heat transfer and after prolonged exposure to very cold temperatures the pipes will eventually freeze. This is why the *International Residential Code* and the *International Plumbing Code* specifically prohibit any domestic water systems from being installed in exterior walls or unconditioned spaces.

B. **Types of Wet Systems:** There are two types of wet systems that are commonly used for residential fire sprinklers. The stand alone system and the multi-purpose system. The advantages and disadvantages are as follows:

I. **Stand Alone System:** The stand alone system utilizes sprinkler piping that is completely independent from potable water piping.

a) The advantage to this system is as follows:

i. Antifreeze can be used to prevent piping from freezing if a backflow preventer is installed or if the water supply is from an open storage tank that is not connected to the potable water system (see discussion of open tanks above).

ii. Problems related to public water supplies, such as size of the water service, water meter, water pressure regulator, backflow preventer and water softeners can be eliminated with the use of an open storage tank and pump.

b) The disadvantages of this system are as follows:

i. The system is more expensive than the multipurpose system.

ii. Unless an open storage tank is used to supply the water, the system is subject to the problems related to size of water service, water meter, water pressure regulator, backflow preventer, and water softeners.

iii. The system is rendered inoperable with the loss of power.

II. **Multipurpose System:** The multipurpose system utilizes the cold water piping that serves the plumbing fixtures in the home to supply the sprinkler heads. The advantage to this system is the reduced cost of installation. The disadvantage of this system are as follows:

a) Antifreeze cannot be used to prevent piping from freezing because the sprinkler piping and potable water piping are interconnected.

b) Cannot be used with well water unless large pressurized tanks are installed (see description of pressurized tanks above under Private Water Supply).

c) Cannot be used in conjunction with water softeners.

d) Sprinkler heads need to be NSF approved because most sprinkler heads contain lead which is incompatible with potable water systems.

C. **Dry Systems:** In a dry system the sprinkler piping is filled with compressed air. If a sprinkler head is activated by a fire, the air escapes and a control panel detects the loss of air pressure and opens a valve that allows water to enter the piping. The advantage to this system is that it is not subject to freezing. The disadvantage to this system is that it takes longer to respond to a fire (the air must be expelled before water can enter the piping) and it is significantly more expensive than a wet system. Additionally, dry systems require regularly scheduled inspections and maintenance and increase the overall complexity of the system. They also decrease design flexibility and available equipment choices and create a greater potential for internal corrosion of piping and equipment, all of which add to the hidden cost of residential fire sprinklers. Another limitation to dry systems is that NFPA 13D requires that they be approved for installation in one and two family dwellings. According to the National Fire Sprinkler Association no such system is currently approved. This is largely because the time needed to expel air from the system increases the response time and prevents it from meeting the requirements of residential sprinklers.

5. **Hidden Costs:** The installation cost is not the only cost for residential fire sprinkler systems. There are many hidden costs that have been identified throughout this document. In addition the following hidden cost must also be accounted for:

A. Architectural plans for one and two family dwellings do not typically include a reflective ceiling plan. To properly design a residential fire sprinkler systems one needs to create a reflective ceiling plan showing the following:

I. Heating supply register locations

II. Heating supply duct locations

III. Light Fixture locations

IV. Ceiling Fan locations

V. Changes in ceiling heights

VI. Locations of soffits, drop beams, ceiling slopes, etc.

B. A fire sprinkler system design that shows the location of all sprinkler heads, the sizing of all piping, tanks, pumps, etc. The code is not clear as to the qualifications required to be a designer of a residential fire sprinkler system. This creates potential liability for builders as they cannot prove compliance with the requirements.

6. **Inspection**: The code is not clear on who should perform inspections and how many and at what stage of construction the inspections should take place. This creates potential liability for builders as they cannot prove compliance with the requirements.

7. **Miscellaneous Problems**: There are many problems that need to be addressed when designing a residential fire sprinkler system. Solutions for most problems are known if the designer has the appropriate experience. For example, heat from a dryer in a small laundry room has been know to falsely trigger sprinkler heads when the door to the laundry room is closed and the dryer is running; the solution is to install a sprinkler rated for a higher temperature. There are other problems that the fire sprinkler industry has yet to determine solutions for, such as a home with a two story foyer adjoining a two story family room; tests have shown that fire sprinklers installed in the family room ceiling will not activate fast enough to meet the requirements of a residential fire sprinkler system. One would think there must be a solution for this problem because fire sprinklers have been used for two story spaces in commercial buildings for years. However this is not so because the performance requirements for residential fire sprinklers are different than for commercial buildings; a definitive solution for this problem has yet to be found. This is a major issue for builders because in the event of a serious injury or death, the builder could be held liable if the sprinkler system did not meet the performance standards of the code.

   There are many other problems and issues in addition to those presented herein. Until solutions for these problems are clearly identified and guidelines are available as to which systems integrate best under different circumstances, mass adoptions of mandates to install fire sprinklers in one and two family dwellings would only lead to mass confusion and increased costs of construction.

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