By Roland Asp

Residential Sprinkler Systems – NFPA 13D

NFPA 13D, *The Standard for the Installation of Sprinkler Systems in One- and Two Family Dwellings and Manufactured Homes* was originally developed in 1975 as part of the effort to respond the residential fire problem. This problem is simply that people are dying in their homes as a result of fires. The 1973 report "America Burning" highlighted that approximately 80 percent of the structural fires in this country occur in residential occupancies along with approximately 80 percent of the fire deaths. NFPA 13D was developed to counter these staggering statistics while allowing these systems to be economical to install.

NFPA 13D has been revised many times since it was first issued but its core principles have not changed. This standard has proven effective in reducing the loss of life in residential homes.

Despite this, many of us in the sprinkler industry look upon NFPA 13D as a watered-down version of NFPA 13. We tend to view NFPA 13D as NFPA 13 - light version and dismiss the challenges of the layout of these types of structures. The fact is that residential homes, based upon their nature and the scope of NFPA 13D, provide unique challenges to the layout technician and the same care and diligence must be given to these life safety systems as we give to large high hazard commercial structures. Running pipe throughout a home is usually more difficult than doing it in an industrial or commercial building.

This article will outline the layout process for a NFPA 13D system and highlight some of the unique challenges of these specific residential occupancies. It is not the intent of this article to discuss all specific rules and requirements but will go over the overall process. By following this process, the specifics of NFPA 13D requirements and the life safety benefits of these systems will be addressed.

Before we get into the specifics and challenges of NFPA 13D layout, it is important for us to take a look at the scope of NFPA 13D and understand how it differs from the more familiar NFPA 13 standard. NFPA 13 is intended to provide a reasonable degree of protection for life and property from fire. In contrast, NFPA 13D is intended to significantly improve the chances of occupants to escape unharmed from a fire. There is no property protection claim in this standard, although in many cases, the NFPA 13D system will control or limit the fire to the room of fire origin. In a fire situation in a one or two family house equipped with a residential sprinkler system, the occupants will be able to escape injury and loss of life. This is the overriding purpose of NFPA 13D sprinkler system.

Another goal of NFPA 13D, although one that is not specifically stated in the standard, is to enable the homeowners to afford to install these life safety sprinkler systems. If these sprinkler systems were such that no one could afford to install them, the entire purpose of NFPA 13D, to save lives, would not be achieved. These cost saving were achieved by allowing the system to work as intended with a much smaller water supply then those found in NFPA 13 and by allowing sprinklers to be omitted in certain areas of the dwelling where deadly fires don't tend to start.

NFPA 13D does not require the submittal of system plans, but they are required by most jurisdictions. Those of you that are familiar with the NFSA publication "Layout, Detail and Calculation of Sprinkler Systems" are aware of the 12 step process for the layout of sprinkler systems. This same process can be used for NFPA 13D systems; however some adjustments will be needed. This 12-steps process, adjusted for NFPA 13D systems, is as follows:

Step 1 - Define the Hazard

This is simple in an NFPA 13D system. By determining that NFPA 13D is the appropriate installation standard, the hazard has been defined. The structure has been determined to be a one or two family home or manufactured home. Unlike

>> CONTINUED ON PAGE 28

Roland Asp
Manager of Technical Services

>> CONTINUED FROM PAGE 27

NFPA 13, the hazard is not subdivided into distinct hazard classifications with specific installation rules. It should be noted here that NFPA 13D does not include a size limitation to the residence being protected. A lavish 25,000 square foot home is protected by the same minimum requirements as a more modest 1,500 sq. ft. home (although the designer is certainly permitted to upgrade the provisions of the sprinkler system if property protection becomes an additional goal). Townhouses, if constructed such as the building codes recognize them as separate structures, are also within the scope of NFPA 13D.

Step 2 - Analyze the structure

This step is vital to the proper layout of any sprinkler system and in residential structures this step is equally important. The importance of this analysis cannot be overstated. Residential houses contain many design features that directly impact the layout of the sprinkler system and the layout technician must be knowledgeable of residential construction techniques.

One aspect of residential construction that creates challenges to the layout technician is the various ceiling configurations that are popular with today's residential homes. It is becoming increasing rare to find the standard flat ceilings in residences. Sloped ceilings, tray ceilings, beamed ceilings and cathedral ceilings are just some of ceiling types we must contend with. With creative thinking and the installation rules contained in NFPA 13D, these types of ceilings can be adequately protected.

As we seldom have dedicated spaces to run sprinkler pipes in residential homes, we must run our pipes within the partition stud space and ceiling joist channels. Due to this limited space available for piping, sprinklers and other necessary equipment, it is very important that the layout technician be familiar with the specific construction details of the residence. Of particular importance, aside from ceiling configuration, is joist direction and location and type of structural beams. Homeowners seldom want to see the sprinkler piping, so we must find ways to efficiently route our pipes within the confines of the specific construction. We must be able to run the piping in the internal walls and ceiling joist channels. As we are typically limited to running the sprinkler pipe within the joist spaces, the best routing would be parallel to the joist direction; however, residential structures will contain structural beams which pipes may not be able to penetrate. A careful review of the structural plans will allow us to determine efficient pipe routing while avoiding these obstructions.

Since architectural plans for residences are not always as comprehensive as those for commercial occupancies, a greater "feel" for the structure specifics can be found with a site visit. If possible, a site visit is well worth the time and will help to develop a more efficient sprinkler layout. In some existing structures, horizontal sidewall sprinklers with piping run along walls and concealed by soffits may be appropriate.

Step 3 - Determine the Water Supply:

Although NFPA 13D requires a much smaller water supply then a traditional sprinkler system, the available water supplies for these homes are also limited by their residential nature. The water supply may be a connection to the municipal water main, a tank with a pump, a pressure tank or even a well pump.

Regardless of the type of water supply chosen, it must be able to provide sufficient flow to the design sprinklers (usually 2). For stored water sources the minimum duration of the water supply must be ten minutes. This duration may be reduced to seven minutes for certain small one story homes. The challenge in choosing a water supply for NFPA 13D is cost and availability. The technicians must weigh all associated costs of the chosen supply. For example, a connection to the city main, where available, must include the costs associated with a larger water line, larger water meter and the possible addition of a backflow prevention device.

In contrast if a tank with a pump is chosen, one must account for cost of the equipment itself (tank, pump and associated appurtances). Also, although the required tanks capacity may only be 300 gallon to 400 gallons, adequate space in the residence must be available. Consideration must be given to physically fitting the tank unit through doorways to the allotted location.

Step 4 - Select System Type:

There are two basic types of sprinklers systems commonly used in NFPA 13D systems. Stand-Alone Systems and Multipurpose Piping Systems. Each type has variations and benefits. The technician needs to determine which type of system would be best suited for a particular project.

Stand alone system are systems where the aboveground piping system only serves the fire sprinklers while multipurpose system piping is intended to serve both domestic and fire sprinkler needs. A potential useful variation on the standalone system is the passive purge sprinkler system. This is system that serves a single toilet in addition to the sprinkler system. The possible advantages of this system is that the toilet will purge excess pressure from the system and the rating of the pipe can be reduced to 130 psi and it may be possible to eliminate a backflow preventer on the system.

Step 5 - Determine Freeze Protection

Protecting piping from freezing is huge issue in NFPA 13D, but is one that can be simply dealt with. In light of the antifreeze solution concerns of recent years, the use of antifreeze to provide freeze protection is not as attractive as it once was. Fortunately, a thoughtful layout of the system can provide a simple and cost effective means of protecting the water filled pipe from freezing. The best solutions to most problems are usually the simplest and this is the case with freeze protection in residential homes; simply run the piping within the insulated envelope of the building. This may include using sidewall sprinklers on the upper floors with the piping run within interior walls or the use of tented insulation over piping above the ceiling. The use of tented insulation has been proven an effective means of protecting piping from freezing but some thought must be given to its installation. It may prudent to figure in the cost of box-

>> CONTINUED ON PAGE 29

>> CONTINUED FROM PAGE 28

ing in the insulation to ensure the freeze protection capabilities of the insulation is not disturbed.

If sprinklers and piping must be run in spaces that are expected to freeze there are many options: Listed dry pipe system, antifreeze solution installed in compliance with NFPA 13D, dry sprinklers and even listed heat tracing.

It is the responsibility of the layout technician to choose the best method for a specific situation while taking into consideration, cost, complexity and maintenance of the various methods.

Step 6 - Determine Sprinkler Types.

NFPA 13D makes the decision relatively easy. The sprinklers, except in limited situations must be listed residential sprinklers. The exception is that quick response sprinklers are permitted to be used for certain spaces such as mechanical rooms, saunas and steam rooms. Additionally quick response dry sprinklers may be used when extended into unheated areas not intended for living purposes.

The more difficult decision is which residential sprinkler to use. The various manufactures offer a wide variety of residential sprinklers and the choice will depend on cost, availability, discharge characteristics and aesthetics. In residential homes aesthetics play an important role and the architect and homeowner should be consulted prior to deciding.

Step 7 - Determine Materials and System Attachments.

NFPA 13D regards a wide variety of piping as acceptable. Piping and tubing which may be considered is steel pipe, copper tube, CPVC and PEX tubing. Each of these materials has their advantages and limitations and the layout technician must carefully review the available materials to determine the best piping for a specific job. Steel piping has the advantage of being a familiar material to the installers but it may be difficult to run this pipe with it larger outside dimensions in the limited space available in 2x4 interior walls and due to its c-factor larger piping may need to be utilized. CPVC has the advantages of a favorable c-factor and reduced installation costs but care must be taken with exposure to non compatible materials. Copper is costly and PEX is limited due to its 130 psi rating.

In NFPA 13D systems, very few of the components are required to be listed, only sprinklers and special pipe. Hangers only need to be acceptable to the local plumbing code unless the special listing for the pipe used requires specific hanger types. Other types of equipment such as tanks, expansion tanks, pumps, waterflow devices and valves are not required to be listed.

Step 8 - Determine which spaces require sprinklers

NFPA 13D does not require sprinklers to be installed everywhere in the building. This results in a tremendous cost saving while maintaining the life safety provisions of the standard. NFPA 13D permits sprinklers to be omitted from the following locations:

- Bathrooms less the 55 sq ft
- Clothes closets, linen closets and pantries that meet all of the following:
  - Less than 24 sq ft
  - Least dimensions is 3 ft
  - Walls and ceiling finishes of noncombustible or limited combustible
- Garages, open attached porches, carports and similar structures
- Attics, machine rooms crawlspaces and concealed spaces that do not contain fuel fired equipment
- Covered, unheated projections at entrances and exits, as long as there is another means of exit.
- Small ceiling pockets. It should be noted that ceiling pocket rules of NFPA 13D are more restrictive than those of NFPA 13 and the volume of these unsprinklered pockets are restricted to 100 cu ft

Step 9 – Determine Local Requirements

Although NFPA 13D has well established and proven effective minimum criteria for sprinkler systems, many local jurisdictions have additional requirements that must be met.

It is common to require backflow prevention on the sprinkler system. As this is determined by the local water purveyor, the requirements for backflow prevention vary by jurisdiction. Generally, a water only standalone sprinkler system will require a double check valve assembly while a system that includes antifreeze solutions will require the more expensive Reduced Pressure Zone Assemblies. Multipurpose and passive purge type systems may not require backflow prevention because the water in these systems does not stay sitting in the pipe, which makes them more akin to domestic water systems.

Another requirement of many water purveyors is for a water meter to be installed on the sprinkler system when the water supply is the city main. While the preferred arrangement shown in NFPA 13D does not include a water meter, it is recognized that many water purveyors will require the addition of a water meter and this is acceptable in NFPA 13D. If a water meter is required, the meter must be sized to handle the flow of the sprinkler system and the friction loss taken into consideration.

Another common local requirement is the addition of waterflow alarms. NFPA 13D does not require waterflow alarms as long as the home is equipped with smoke detectors in conformance with NFPA 72 but many jurisdictions have adopted requirements for a waterflow alarm over and beyond the requirements of NFPA 13D. Many homes today are equipped with a security/fire alarm system and the sprinkler waterflow detector can be interconnected with the alarm panel.

One additional requirement may be to install sprinklers in locations not required by NFPA 13D. There are jurisdictions that require sprinklers to be located in bathrooms, closets, garages and attics regardless of what NFPA 13D says about these spaces. These requirements must be known to the layout technician. Obviously these additional areas will require more sprinklers but they may also require different freeze protection criteria. Unheated garages may be sprinklered with quick response dry sprinklers but sprinklering an unheated attic space is a significant challenge which may require the use of a listed dry system.

>> CONTINUED ON PAGE 30

>> CONTINUED FROM PAGE 29

Step 10 – Perform System Layout

We are now ready to layout the sprinkler system. We have reviewed the construction of the house, determined the water supply and system type, chosen the sprinkler type and material to use, chosen a method to protect our piping from freezing, determined which spaces require sprinklers and have researched local requirement for the system. The preparation has been completed and the sprinkler locations, spacing and pipe routing can be determined.

It is at this stage that the thorough analysis of the structure as outlined in step 2 pays dividends. The building plans and site visit will help the layout technician to properly space and locate the sprinklers and to determine the best pipe routing. Remember that it is easy to run piping on paper (or on CAD plans) but the installers must actually run the piping as per the layout. If the layout indicates the piping to run perpendicular to joist direction, the installer will need to drill holes in all the joists. Or if the plans show the piping penetrating a structural beam, the architect/engineer may need to be consulted.

One situation which is quite common in residential layouts is to run the piping within interior walls and feeding sidewall sprinklers. This layout on the top floor of homes allows all piping to be within the insulated envelope of the building and to avoid freezing conditions. However if this piping is run over door openings and the opening includes a solid header, it is not possible to run the pipe in this manner. These types of situations are better avoided in the layout process then during installation.

It is the responsibility of the layout technician to provide a system layout that results in the most efficient and cost effective layout while adhering to the installation rules of NFPA 13D and site specific conditions.

As stated earlier, NFPA 13D does not require the development, submittal or approval of sprinkler plans. However, most jurisdictions that adopts requirements for single family homes to be sprinklered, also add the requirement for sprinkler plans to be submitted and approved prior to installation.

Just like working plans for an NFPA 13 system, these plans must be clear and unambiguous and be sufficient for the plan reviewer to ensure that all applicable requirements are adhered with. There must also be sufficient detail that those in the field can install the system as designed.

Step 11 – Size Pipe and Confirm Discharge.

Once the system has been laid out, the adequacy of the water supply to provide sufficient flow and pressure must be determined. NFPA 13D allows this to be determined by hydraulic calculations such as those used in NPA 13 or by two simple estimation techniques: one is the prescriptive pipe sizing method and the other is a simple pressure loss method as outlined in NFPA 13D.

Based upon one of these calculation methods, the piping is sized and determined to be adequate to provide sufficient flow and pressure to the design sprinklers. Although the sprinkler demand for NFPA 13D is quite low compared to an NFPA 13 system, the pipe sizes are much smaller and friction loss must be carefully calculated. Water meters and backflow preventers in particular lead to significant pressure loss which must be incorporated into the calculations. The pressure loss due to elevation of the highest sprinklers must be included.

Step 12 – Add Notes and Details.

The layout plan for the NFPA 13D sprinkler system is in effect a communication tool. These plans must clearly impart the intent of the layout to the AHJ, the homeowner, the architect or design professional and most importantly the installer in the field. The plan must have sufficient details so that the AHJ can confirm that the system will meet the requirements of NFPA 13D and applicable local requirements and also provide adequate information to permit installation in the field.

Details that should be included with the plans/submittal package are:

- Water supply/Riser schematic
- Freeze protection methods
- Sprinkler data sheets including make and model, deflector distance from ceiling and maximum spacing / coverage area and mounting details
- Pipe material and sizes
- Hanger spacing and type
- Required equipment and specifications (backflow preventer, drains, etc)
- Calculation or water demand estimation

As outlined in this article it is clear that the layout of an NFPA 13D sprinkler system is a complex endeavor and one which must be approached with sufficient preparation, diligence and knowledge. NFPA 13D states in Chapter 4 that "The layout, calculation, and installation of sprinkler systems installed in accordance with this standard shall only be performed by people knowledgeable and trained in such systems". As the standard uses the word "shall" this is a requirement and one that should not be taken lightly. As NFPA 13D is primarily a life safety standard, the stakes are high. It is certainly the responsibly of all who perform layout and installation of NFPA 13D sprinkler systems to approach these projects with the same amount of preparation, knowledge and care that one would approach a NFPA 13 compliant system.

* * * * * * * * *

The NFSA has developed a variety of training resources aimed at NFPA 13D systems. In addition to the NFSA publication "Layout, Detail and Calculation of Sprinkler Systems", we have developed a series of Tech Tuesday online seminars which directly address the NFPA 13D system requirements. These online seminars may be accessed through our websites: www.nfsa.org and www.nfsa.tv.