e-TechNotes

Editor-Kenneth E. Isman, P.E. *Issue No. 238* *Issued: May 1, 2012*

Best Questions of April 2012

This month, we have selected the following "baker's dozen" of questions as the "Best of April 2012" answered by the engineering staff as part of the NFSA's EOD member assistance program:

Question 1 – Obstructed Construction less than 12 inches Deep

We are working on a job where we have concrete tee construction where the tee stems are 9-1/2" deep and the beams are 6 feet apart. Even though this meets the definition of obstructed construction under section 3.7.1, the sprinklers could be located 12 inches below the deck and clear of the obstruction created by the tees since the tees are only 9-1/2 inches deep. Instead, the contractor is proposing the installation of the sprinklers 6 inches below the bottom of the tees (which would put them 15.5 inches below the deck). We typically see the obstructed construction rules (deflectors 6 inches below the structural members and not more than 22 inches below the deck) where they are needed (where structural members exceed 12 inches in depth), but not in situations like this. Is there any other portion of NFPA 13 that would force the use of the 12-inch maximum rule for these types of situations?

Answer: Given that this is obstructed construction, it is up to the sprinkler technician to decide where they want to put the sprinklers as long as they meet the rules for obstructed construction. As long as they keep the sprinklers within 6 inches of the bottom of the tees (which in this case would put them 15.5 inches down from the deck), they have met the rules.

While it is true that sprinklers closer to the ceiling might react faster in a fire and help limit the damage to a more confined area, the purpose of NFPA 13 is not to optimize the sprinkler system. The purpose of NFPA 13 is to lay out a series of minimum rules that everyone must follow to achieve an acceptable sprinkler system, not the best possible sprinkler system.

This is one of the reasons that a building owner should have an engineer familiar with fire sprinkler systems writing good design specifications before the sprinkler contractor ever starts laying out the system. If the building owner would benefit from sprinklers being closer to the ceiling, either by getting better fire protection or just getting more vertical space to use in the building, then this kind of issue needs to be brought up at the beginning of a project, before the sprinkler contractor even bids the system. This is where engineers can add value to the design of a system.

But you can't use NFPA 13 as a tool to force people to install the best possible sprinkler system. It was not written with that goal in mind. A sprinkler system installed in accordance with NFPA 13 will control a fire beneath it in an acceptable manner. A sprinkler system with sprinklers 6 inches below a solid structural member and 15.5 inches down from the deck meets the minimum rules of NFPA 13.

Question 2 – Obstructed Construction More Than 22 Inches Deep

We have a situation where steel structural members are 28 inches deep and approximately 30% open with an 8 inch wide flange being installed 4 ft on center. Where can we put the sprinkler in relation to the ceiling deck and/or the bottom of the structural members.

Answer: Unfortunately, this type of construction meets the definition of "obstructed construction" under section 3.7.1 of NFPA 13 because it is not open enough to be considered "unobstructed construction" by section 3.7.2. As such, section 8.6.4.1.2 only leaves you with three options because the depth of the members is more than 22 inches. Your options are:

1. Put sprinklers in every channel created by the structural members. Note that since the members are only 4 ft on center, you will need to stagger the spacing or be careful where the sprinklers end up in each channel so that you do not violate the minimum 6 ft distance required between sprinklers by section 8.6.3.4.1.

2. Install 6 inches of insulation at the deck within each channel. This effectively lowers the deck so that you can install sprinklers 22 inches under the bottom of the insulation, which would be flush with the bottom of the structural members. See section 8.5.4.1.3 for more information on locating sprinklers below insulation.

3. Install at least 2.5 inches of insulation at the deck within each channel. This effectively lowers the deck so that you can install sprinklers 22 inches under the bottom of the insulation, which would out the deflectors 3.5 inches above the bottom of the structural members. You could then center the sprinklers in the channel and clear the near edges of the flanges to both sides using Table 8.6.5.1.2. This would allow you to put sprinklers in every other channel at 8 ft spacing or every third channel at 12 ft spacing if the spacing in the direction parallel to the structural members allowed such distances.

Question 3 – Vertical Stacking of Two Different Rack Storage Commodities

If a ceiling sprinkler system provides the necessary flow and pressure for storage of a low flammability commodity to a tall storage height and the same flow and pressure can protect a higher hazard to a lesser height, is it permitted for the owner to build racks to the higher height allowed for the lower commodity and then put the higher commodity to its limit and put the lower commodity on top? For example, if the sprinkler system can protect 10 ft high storage of Group A plastics or 16 ft high storage of Class IV commodity, would the building owner be allowed to arrange the rack such that the lower level 10 ft are Group A plastic and above that are Class IV commodity up to 16 ft?

Answer: No. The sprinkler discharge for the lesser commodity, in the provided example, Class IV, is based on the burning characteristics and the heat release when that commodity is burning. The discharge from the sprinkler(s) needs to be sufficient to absorb the heat being released from the fire. The density/area curves are designed to provide that level of fire protection, but not more. If there is a higher commodity, in the provided example, Group A plastic, below the lower commodity the overall heat release of the fire will be higher. The higher hazard commodity will also help the lower commodity to pyrolize faster. The sprinkler system may not be capable of dealing with this hotter burning fire.

In addition, enforcement of this setup could create a problem. Building owners and occupants easily understand that they are not allowed to store over a specific height. Racks can also be installed to limit the height appropriately for the planned storage. It is much harder to explain (and transfer the information to those using the space throughout the operations of the building) why some items can only be stored up to certain heights and others have different height requirements. Most AHJs will also be concerned with the arrangement because someone would need to confirm periodically that the higher flammability product was stored where it should be.

Question 4 – Dry-Pipe System for Flammable and Combustible Liquids Storage

Are we permitted to install a dry-pipe sprinkler system to protect a flammable or combustible liquid storage situation in accordance with NFPA 30?

Answer: No. Section 16.4.2 of NFPA 30 specifically says that sprinkler systems have to be wet, preaction or deluge. Dry-pipe systems are intentionally not allowed. Experience has shown that the delay in getting water to the fire when using dry-pipe systems is unacceptable.

Question 5 – Preaction Sprinkler System for Flammable and Combustible Liquids Storage

Are we permitted to install a preaction sprinkler system to protect a flammable or combustible liquid storage situation in accordance with NFPA 30?

Answer: Yes. Section 16.4.2.1 of NFPA 30 says that if you are going to use a preaction system, the water needs to discharge as soon as the sprinkler opens. This means that you cannot use a double-interlock preaction system. Also, this means that you have to know the worse-case water transit time from the preaction valve to the sprinkler and you have to use detectors that are sufficiently more sensitive than the sprinklers in order to make sure that the water has arrived at the sprinkler prior to the sprinkler opening. Some careful heat transfer calculations may need to be done to prove that this performance-based criterion can be met.

Question 6 – Dwelling Units in a Fraternity House Using NFPA 13R

In a fraternity house with individual sleeping rooms and common bath and kitchen facilities being protected in accordance with NFPA 13R, is each sleeping room considered its own dwelling unit? If so, what kind of sprinklers should be used in the corridors, common bathrooms and common kitchen facilities?

Answer: The answer will depend on the building code and the design concept of the original building. If the building was originally constructed as a multi-family residential occupancy, then multiple dwelling units would be expected throughout the building and each sleeping room would probably be considered its own dwelling unit, with sufficient separation from other dwelling units (typically 1-hr rated walls). A single family home converted to a fraternity house may not have the fire resistance separation between bedrooms necessary to call them individual dwelling units, in which case the whole building might be considered a single dwelling unit. It is important to discuss this with the AHJ to ensure that all parties are on the same page with the approach to the building's protection. The Automatic Sprinkler Systems for Residential Occupancies Handbook indicates that dormitory rooms are an example of a dwelling unit, but many local codes further clarify that dwelling units may need minimum fire resistance ratings between units in order to meet the definition.

If it is decided that the sleeping rooms are dwelling units, then the corridor, common bathrooms and common kitchen would be considered as areas outside the dwelling unit. NFPA 13R allows residential sprinklers to be used in areas outside the dwelling unit that are similar to the fire load in a residential occupancy. Common bathrooms and corridors are easily shown to be similar to residential areas and could be sprinklered with residential sprinklers. A common kitchen that is similar to the kitchen in a home would also be similar to residential fire loading and could use residential sprinklers. A kitchen with commercial cooking equipment and significant storage would be closer to Ordinary Hazard Group 1 for protection and would not be able to use residential sprinklers. NFPA 13R always permits the use of quick response sprinklers for the areas outside of a dwelling unit, so those could be used in any of the corridor, bathroom or kitchen spaces.

Question 7 – NFPA 16 and "Balancing to the Water Supply"

Section 7.4.2.2 of NFPA 16 requires the hydraulics to be "balanced to the available water supply". What does this mean?

Answer: This requirement is only important for sizing the foam concentrate tank (see section 7.4.2.3). Once the sprinkler system demand has been calculated in the normal fashion and the pipe sizes have been determined, the system will fall on or below the water supply when plotted on a graph. The water supply for performing this comparison to the system demand should be the reasonable worse-case based on daily and seasonal fluctuations.

Then section 7.4.2.2 of NFPA 16 requires this additional calculation where the flow demand is "balanced" to the water supply that will more likely be available (not the reasonable worse case) so that you can insure that you don't run out of foam prior to the 10 minute (or lower depending on the design situation) duration required by NFPA 16. There are two ways to perform this "balancing" calculation:

1. Use a computer program that can perform "supply side" calculations. These computer programs work in the opposite direction from standard calculations. For standard calculations, the process starts at the most remote sprinkler in the design area and works in the reverse direction of flow back to the water supply adding flow and pressure demands. In "supply side" calculations, the computer starts at the water supply and works in the direction of the water flow towards the most remote sprinkler dropping off flows at open sprinklers and subtracting pressure traveling deeper into the system due to friction loss. By starting at the supply, the computer can predict how much actual foam will be discharged at the higher pressure coming from the water supply and the foam concentrate tank can be sized to accommodate this additional foam demand.

2. Perform the calculation by hand using the following steps:

    a. Calculate the system using the customary process of starting at the most remote sprinkler and working backwards towards the water supply to determine your flow and pressure demand.

    b. Compare your flow and pressure demand to the reasonable worse-case water supply and make sure that you are on or below that water supply curve.

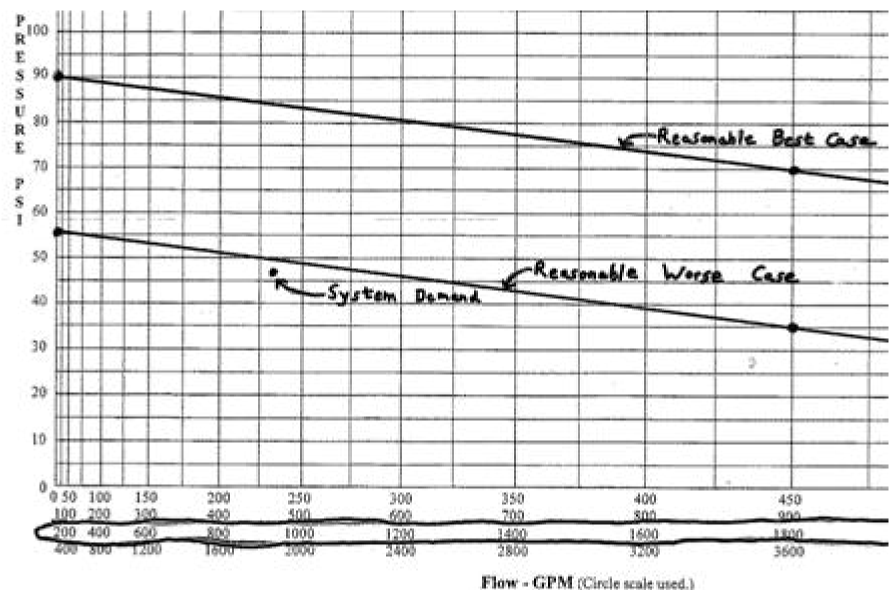
    c. Use the flow and pressure demand to calculate a k-factor for the fire protection system: $k = Q/\sqrt{P}$

    d. Consider the reasonable best-case water supply using a graph or a mathematical description of the water supply as a formula taken from the static pressure and the residual flow and pressure data.

    e. Determine the pressure at the water supply for the calculated demand flow

f. Apply the k-factor from step (c) to the pressure obtained in step (e) to determine a new probable flow from the available water supply. Note that this procedure is conservative in that the actual flow from the water supply will be between the demand flow calculated in step (a) and the flow calculated in step (e), but this is the best that can be done by hand and will oversize the foam concentrate tank creating an extra safety factor.

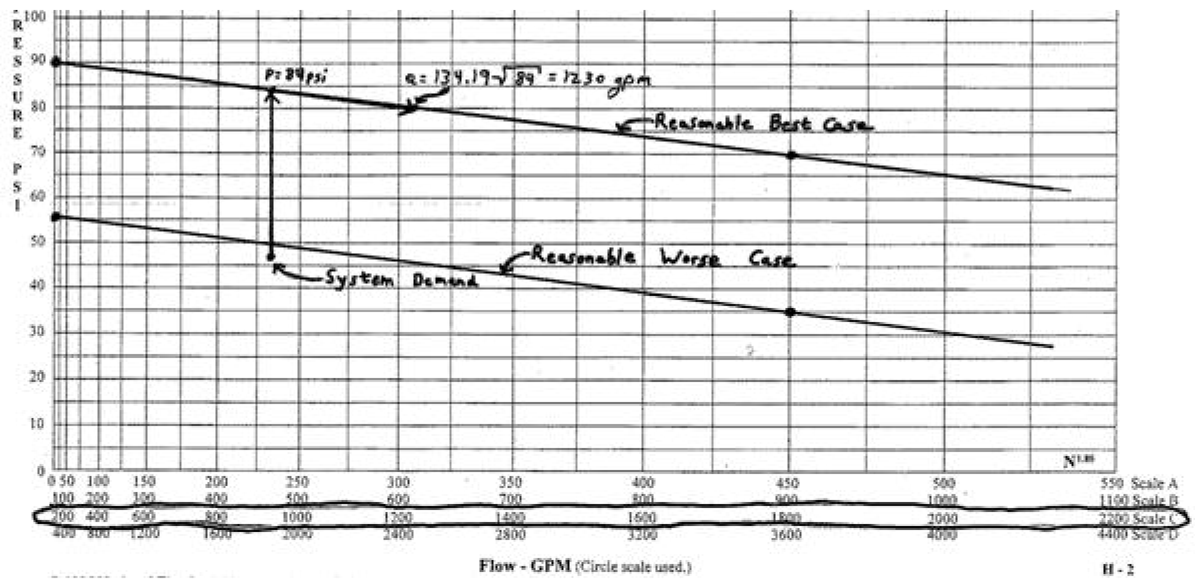
An example of balancing the system to the available water supply would probably be helpful. Consider a wet pipe foam/water sprinkler system that is hydraulically calculated with a demand of 920 gpm at 47 psi. The reasonable worse-case water supply is provided as 55 psi static pressure and 35 psi residual pressure at 1800 gpm. The reasonable best-case water supply is provided as 90 psi static pressure and 70 psi residual pressure at 1800 gpm. These pieces of data are plotted on the graph below.



The system demand is just below the reasonable worse-case water supply, so the fire protection system will work regardless of the fluctuations in the water supply. If the fire were to occur during this reasonable worse-case water supply condition, then the flow would be close to 920 gpm and the foam concentrate would not run out too quickly.

But if the fire was to occur during a time when the best case water supply would be happening, a greater flow would occur. It is extremely difficult to determine exactly what that flow would be, but it can be over-estimated by following the procedure discussed above:

a) Done and shown on graph above.
b) Done and shown on graph above.
c) k = 134.19, calculated as follows: $k = Q/\sqrt{P} = 920/\sqrt{47} = 134.19$
d) Done and shown on the graph above.
e) At 920 gpm, the reasonable best-case water supply is at 84 psi (see graph below)
f) A system with a k-factor of 134.19 will produce a flow of 1230 gpm at 84 psi, calculated as follows: $Q = k\sqrt{P} = 134.19\sqrt{84} = 1230$



In actuality, the real flow from this system would be somewhere between 920 gpm and 1230 gpm, but it does not pay to try and refine the calculation beyond this point. The foam concentrate tank can be sized using a flow of 1230 gpm. Assuming a 3% foam and a foam duration demand of 10 minutes, the tank would need to hold at least 369 gallons of foam (1230 x 0.03 x 10 = 369). If the tank had been sized on the 920 gpm flow demand, it would have only been sized for 276 gallons of foam (920 x 0.03 x 10 = 276) and would have run out of foam in less than 10 minutes if the water supply had been stronger at the time of the fire.

Although it was not stated in the question, it should also be pointed out that NFPA 16 requires this calculation to be done twice: once for the most remote design area and once for the demand area closest to the water supply. This way, the foam concentrate will last for the foam duration even if the fire occurs close to the water supply where the actual pressure will be higher, creating more flow from each sprinkler. The same procedure as outlined in this response will work for both calculations.

Question 8 – Sprinklers in Shower Stalls

Are sprinklers required in shower stalls under NFPA 13 or NFPA 13R?

Answer: If the shower stall is a compartment on its own (see the definition of a compartment in NFPA 13 and NFPA 13R) then sprinklers can be omitted if the compartment is less than 55 sq ft and if the shower stall is in a dwelling unit since the shower stall can be considered its own bathroom. If the shower stall is a part of a bathroom, the sprinkler can be omitted if the entire bathroom (including the area of the shower stall) is less than 55 sq ft and the bathroom is in a dwelling unit. If none of these conditions apply, then the bathroom needs to be sprinklered and the sprinklers need to protect the floor area of the bathroom including the area of the shower stall. However, the sprinkler does not need to be physically in the shower stall to protect that floor area.

The extent to which you worry about obstructions to the spray pattern and reaching every corner of the space occupied by the shower stall is subject to some judgment. NFPA 13 does not expect water to fall into every corner of every piece of floor area within the coverage area of a sprinkler. Section 8.6.5 outlines many situations where obstructions are permitted to create spaces where water will not fall directly within an area covered by a sprinkler. But the fact that the sprinkler includes the floor area in question means that the discharge from the sprinkler includes the water that would fall in this space, which is still put out to the room and is capable of absorbing the heat from the fire and preventing the fire from spreading beyond the space.

Many shower stall arrangements might have lintels or other obstructions to the sprinkler's spray pattern and these are not directly addressed in the obstruction rules of NFPA 13. But a reasonable application of the rules would be to see if the space obstructed by the lintel or other obstruction is similar to other apparent dry spaces allowed by section 8.6.5, which would be permitted by the equivalency rules of section 1.5 and section 1.6 of NFPA 13.

NFPA 13R is more forgiving of obstructions than NFPA 13 and has some specific dimensions of acceptable areas that will not get direct sprinkler spray. Use of these rules can help, but it should also be pointed out that a situation permitted by NFPA 13 should also be permitted by NFPA 13R, so any of the equivalencies discussed above for NFPA 13 could also be used in a system complying with NFPA 13R.

Question 9 – Butterfly Valves and Fire Pumps

NFPA 20 recognizes that a water utility might use a butterfly valve to control the connection of a private main to their underground main (section 4.14.5.2 in the 2010 edition, similar sections in other editions) in addition to the OS&Y valve that we install on the suction side of the pump, but why is this valve required to be at least 50 ft from the pump?

Answer: Butterfly valves cause turbulence (an uneven distribution of the water flowing through a cross-section of the pipe) in the flow of water through the piping. If turbulent water is brought into the suction flange of the fire pump, it has the potential to cause uneven loading of the impeller with more water on one part of the impeller than on another. At the speeds which fire pumps turn, this uneven loading can cause the pump to rip itself apart. A distance of 50 feet has been considered a sufficient distance to allow for the turbulence created by the butterfly valve to dissipate prior to the turbulent flow getting to the fire pump.

Question 10 – Back-to-Back Sidewall Sprinklers and Dwelling Unit Separations

We are protecting hotel guest rooms (each room is a different dwelling unit) with branch line piping in the wall between two guest rooms and back-to-back sidewall sprinklers protecting each of the rooms on the other side of the wallboard. The International Building Code is being used in this jurisdiction and the dwelling units are required to have a minimum 1-hr fire resistance separation. The AHJ says that we need to provide additional protection for the penetration of the wallboard beyond the metal sprinkler escutcheon. Is the AHJ correct?

Answer: Yes. This type of penetration is called a "through penetration" because it goes all the way from one side of the separating wall all the way through the wall to the other side. A fire starting in one guest room could travel along the penetration and end up in the next dwelling unit. A "through penetration" of a wall having a 1-hr fire resistance rating needs to be sealed with a material also rated for 1-hr fire resistance. There are many materials that will accomplish this, but a metal escutcheon is not one of them.

If you wanted to avoid the requirement for the extra penetration protection, you could slightly re-design the sprinkler system. The International Building Code defines a "membrane penetration" as one where only one layer of the wall is penetrated. If you were to have the pipe in the wall and only penetrate the wallboard on one side with a sidewall sprinkler, this would only be a membrane penetration. The International Building Code allows a membrane penetration to be covered by a metal escutcheon with no additional protection needed for the 1-hr rated wall. A penetration can be made for the guest room on the other side of the wall offset from the first wall in a different stud cavity, which would also be a membrane penetration on that side, which would also just need to be covered with a metal escutcheon. By offsetting the penetrations to different stud cavities, you change a "through penetration" to a "membrane penetration" and make the building code easier to comply with.

Question 11 – Suction Pressure for Pumps Supplied by Tanks

Can you explain why NFPA 20 allows a suction pressure of -3 psi for pumps fed by tanks and how to perform this calculation? Should we be concerned with the pressure of the water at the centerline of the pump?

Answer: Note that the section numbers in this answer are from the 2010 edition, similar sections appear in previous editions. Section 4.14.3.2 of NFPA 20 was written to allow fire pumps to be at the same elevation as the bottom of the tank. Prior to this section being in the standard, you would have to elevate the bottom of the tank higher than the pump so that at the end of the water supply duration (when the water level was low in the tank) the water would still be delivered to the suction flange of the pump at a positive gage pressure (4.14.3.1). That was never the intent of the committee, but it was a consequence of how the language was written at that time.

In order to use section 4.14.3.2, the base of the tank has to be at the same elevation as the base of the pump (or higher). This means that the anti-vortex plate should be pretty close to the same elevation as the centerline of the suction flange of the pump. Section 4.14.3.2 also says that you have to take into account the water level as the last water in the tank is leaving the tank that satisfies the duration demand of the fire protection system. Therefore, if you were using all of the water in the tank all the way down to the anti-vortex plate, you would have to take the elevation change between anti-vortex plate and the suction flange of the pump into account when calculating whether or not you are going to end up at -3 psi or not. The adjustment should be minimal since the distance should not be very big.

But if you can satisfy the duration demand of the fire protection system with water still in the tank above the anti-vortex plate, then the elevation difference from this point to the centerline of the pump suction flange becomes the adjustment that needs to be made in accordance with 4.14.3.2. With the water level higher, this will add to the pressure at the suction flange of the pump rather than subtract from it.

Water loses energy when it flows through pipe and makes turns (friction loss). Water loses energy when it goes uphill and gains energy when it goes downhill. You have to account for all of these losses when calculating whether or not the water will arrive at the suction flange of the pump at a specific pressure. Technically, the standard says that the measurement is made at the suction flange of the pump, not the centerline of the impeller. The value of -3 psi is acceptable to the pump manufacturers' when measured at the centerline of the suction flange, not the centerline of the impeller. The slight additional elevation loss from the suction flange to the impeller has already been accounted for in the determination of -3 psi as an acceptable value.

If you look at Figure A.6.3.1(a) in NFPA 20, you will see a typical arrangement that the committee was explicitly allowing by section 4.14.3.2. The difference between the elevation of the anti-vortex plate and the centerline of the suction flange would depend on the size of the suction pipe, but it would be half the diameter of the suction pipe plus a few inches for the extra distance of the elbow. For a pump using an 8 inch or 10 inch suction pipe, this would be between 5 and 10 inches, which would only be responsible for 0.36 psi difference in the suction pressure calculation, but technically, it would need to be done if you were counting on the water in the tank being used all the way down to the level of the anti-vortex plate. If you could satisfy the demand of the fire protection system with water at a higher level in the tank, then the difference in elevation would be calculated as the difference from when that last water left the tank to the centerline of the suction flange.

Question 12 – Rack Storage of Class IV Commodity 12 ft in Height in a 49 ft High Building

We have rack storage of Class IV commodity only up to 12 ft in height planned for a building that is 49 ft high. What criteria can we use for this protection? Table 13.2.1 should apply, but does not have protection criteria for this combination. Chapter 16 could be used with the high clearance sections of Chapter 12, but section 16.2.1.2.1 sends the user back to Chapter 13. What should we do?

Answer: It does not matter which set of criteria you look at, you cannot protect 12 ft high rack storage of Class IV commodity under a 49 ft high ceiling with spray sprinklers. You have five potential options:

1) Install a drop ceiling at the 32 ft height and follow the criteria in Table 13.2.1.

2) Protect the rack storage as if it was 29 ft high storage under a 49 ft high ceiling in accordance with section 16.3.

3) Some combination of options 1 and 2 where you install a drop ceiling at some level and increase the rack protection. For example, you could install a drop ceiling 42 ft above the floor and protect the rack storage as if it was 22 ft high. Table 16.2.1.3.2 would allow this height of class IV commodity to be protected without in-rack sprinklers as long as the ceiling sprinkler density was calculated correctly.

4) Find a special sprinkler that is listed for protection of ceilings up to 49 ft. There might be an ESFR sprinkler that can protect Class IV commodities with ceiling heights up to 50 ft. Although this is not directly in NFPA 13, it is permitted to be used in accordance with the "special sprinkler" clauses of the standard.

5) Hire a Professional Engineer to develop custom criteria that would work in this situation that could be used under the equivalency clauses of sections 1.5 and 1.6 of NFPA 13. Note that this would require special AHJ approval.

Question 13 – Separate Control Valves for Townhomes using NFPA 13R

We are putting sprinklers into a cluster of townhomes in accordance with NFPA 13R. Are we required to provide a separate system for each townhome with its own control valve, or are we allowed to have one system protect the cluster?

Answer: Section 4.6 of NFPA 13R provides the designer with three options as follows:

1. Put a separate control valve in for each unit.

2. Use a single system with a single control valve for all of the units and keep the control valve outside of any of the dwelling units.

3. Use a single system with a single control valve for all of the units and keep the control valve in a common area accessible by any of the units.

Since all of these rules are considered equal, you are allowed to select either option 2 or option 3 and provide a single system to protect the whole cluster as long as the control valve is outside of the dwelling units in an area accessible by the occupants of any unit.

Upcoming NFSA "Technical Tuesday" Seminar – May 8

Topic: Dry Standpipe Systems
Instructors: Kevin J. Kelly P.E.
Date: Tuesday, May 8, 2012- 10:30 am EST

There are three different types of dry standpipe systems: automatic-dry systems, semi-automatic-dry systems, and manual-dry systems. This seminar will define each of these systems, discuss how they work, when they should be selected, and cover the special design and hydraulic calculation requirements for each of the dry systems.

To register or for more information, click HERE or contact Michael Repko at (845) 878-4207 or e-mail to seminars@nfsa.org.

Layout Technician Training Course (2-week course)

Fishkill, NY – October 8-19, 2012

For more information, contact Nicole Sprague using Sprague@nfsa.org or by calling 845-878-4200 ext. 149 or click HERE.

Upcoming In-Class Training Seminars

The NFSA training department also offers in-class training on a variety of subjects at locations across the country, and in recognition of the current recession has adopted a new reduced fee structure. Here are some upcoming seminars:

May 2	Colorado Springs, CO	Plan Review Procedures & Policies
May 3	Colorado Springs, CO	Sprinkler Protection of Special Storage
May 14	Champaign, IL	Designing with Fire Sprinklers
May 15	Oklahoma City, OK	Inspection, Testing & Maintenance for the AHJ
May 16	McFarland, WI	Designing with Fire Sprinklers
May 17	Mashantucket, CT	NFPA 13, 13R & 13D Update 2010
May 18	Apple Valley, MN	Designing with Fire Sprinklers

These seminars qualify for continuing education as required by NICET, and meet mandatory Continuing Education Requirements for Businesses and Authorities Having Jurisdiction.

To register for these in-class seminars, click HERE. Or contact Michael Repko at (845) 878-4207 or e-mail to seminars@nfsa.org for more information.