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Non-Uniform Hydraulic Calculation Areas: Part 2

Hydraulic calculations offer many challenges since actual buildings are rarely comprised of simple rectangular shapes. In many cases, there are obstructions to protect around, building configurations to handle and small rooms to contend with. Spacing the sprinklers is the first stage, but determining which ones should be calculated under the density/area calculation method can also lead to a headache. This article will cover omitting small rooms from hydraulic calculations, two or more sprinkler systems in the same compartment and handling mixed occupancies. There is an assumption in this article that the reader has an understanding of the density/area method for calculating sprinkler system hydraulics. A short review can be found in SQ No. 151 (Nov/Dec 2008) in Part 1 of this series. Also, note the scenarios presented here are only a selection of the variations found in the field.

Omitting Small Rooms

When a small room is within the hydraulically remote area, NFPA 13 (2007 Edition) Section 22.4.4.6.2 states, "The requirements of 22.4.4.6.1 to include every sprinkler in the design area to be included in the system discharge shall not apply where the area of application is equal to or greater than the minimum allowable area of Figure 11.2.3.1.1 for the appropriate hazard classification (including 30 percent increase for dry pipe systems). Sprinkler discharge in closets, washrooms, and similar small compartments requiring only one sprinkler shall be permitted to be omitted from hydraulic calculations within the area of application. Sprinklers in these small compartments shall, however, be capable of discharging minimum densities in accordance with Figure 11.2.3.1.1."

For example, an ordinary hazard group 2 occupancy that is protected with a dry pipe system would need to calculate 1950 ft^2 (181.2 m^2); this being the 30 percent increase over a starting value of 0.2 gpm/ft^2 over 1500 ft^2 (8.1 mm/min over 139.4 m^2). The area has been laid out in Figure 1. Sprinklers are located at 10 ft by 12.5 ft (3.0 m by 3.8 m) in the 30,000 ft2 (2787.1 m^2) building. The ceiling is 10 ft (3.0 m) high. Rooms "A" and "B" are separate rooms, each protected by one sprinkler. With the area laid out for the hydraulic calculations, it is apparent that the remote area includes two small rooms. According to the quoted Section 22.4.4.6.2 above, both small rooms can be omitted from the remote area calculation. Under this provision additional area to make up the omitted space within the small rooms is not required. In addition, the section notes that the area laid out must equal or exceed that called for in Figure 11.2.3.1.1, the density/area graph. This means that the area adjustments, such as the quick response sprinkler reduction in Section 11.2.3.2.3, could not be applied to the remote area and then omit the space of the small rooms on top of that.

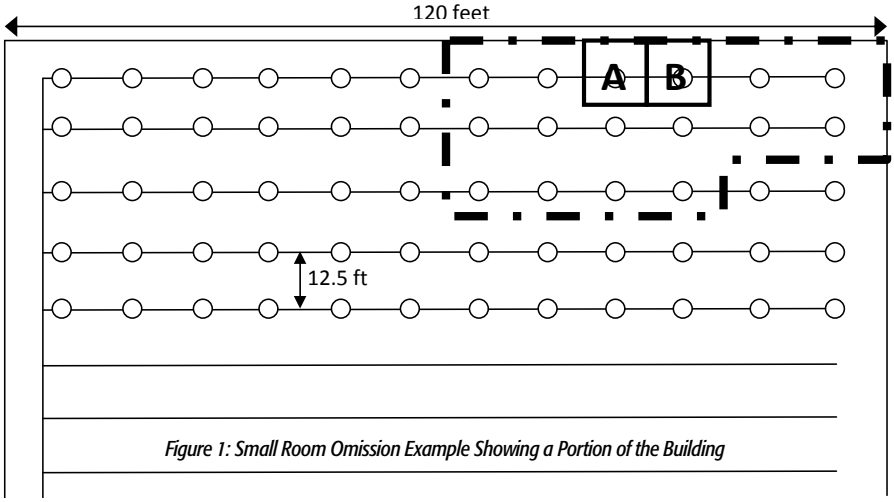

Figure 1: Small Room Omission Example Showing a Portion of the Building

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The omission of multiple small rooms is not prohibited. However, caution should be taken when there are many small rooms in the hydraulically most remote area. Thought should be given to where a fire could grow and spread and if sufficient area is truly included for the hazard that is being protected. Additional hydraulically remote areas may need to be selected. There is an opportunity that the hydraulically most demanding area may be closer to the riser if there are no small rooms to omit in that area. In other words, multiple calculations may be needed in order to determine which is the most demanding situation.

On a final note, the sprinklers in the small rooms need to be verified for the appropriate densities available to the sprinklers. In many cases, the pressures available at the connections to the small room(s) are more than adequate to supply the flow. If the small room(s) are located at the end of the branch line, then the available pressure for the sprinkler in the small room might be the driving value of the calculation.

Multiple Systems

A compartment that is very large would be protected with two or more fire sprinkler systems based on the area limitations in Section 8.2. Another scenario would be the addition of a second system due to expansion of the space or other building alterations. This may involve small systems sharing space in a single compartment. Each of these scenarios is handled differently.

When there are multiple systems that are large protecting their own sections of a single compartment, each system's remote area needs to be calculated back to the water supply. NFPA 13 assumes a single fire scenario. Therefore, each system's demand for flow and pressure would be found and compared with the available water to the systems in order to ensure adequate water.

In small spaces that may have sprinklers supplied from two different systems, it is important to remember that NFPA 13 crosses walls and partitions with the design area under the density/area method. This would mean that the design area would be laid out for each system and calculated as noted in the previous paragraph. The worst case scenario, looking at the hydraulics of the system, would still be the entire design area required applied to the piping network of a single system.

If there are multiple systems to protect a building, but one or more of those systems is smaller than the required design area, then it would be necessary, under the density/area method, to pick up the remainder of the design area on an adjacent system. In other words, the fire does not know how the sprinklers are being fed. The anticipated area of operation would still need to be calculated. For example, an addition has been put on the building and the area of the new section was given its own sprinkler system that covered 1200 ft^2 (111.5 m^2). It was decided that the density/area method was the best option for hydraulic calculations, but 1500 ft^2 (139.4 m^2) needs to be in the design area. Then, the additional 300 ft^2 (27.9 m^2) would have to be added from an adjacent system, still trying to maintain the fire rectangle to the best the system arrangements will allow.

Mixed Occupancies

It is common to have mixed occupancies in buildings. For example, storage areas may have designated areas for different commodity classes or an open area of a building may be divided into light and ordinary hazard applications without a physical barrier between them. These are a couple of ways to handle the scenario.

The first and simplest method is to protect the space for the higher hazard. This offers the owner the most flexibility in their space in that they can move the arrangement around and still have proper protection. This would mean that if part of a space was ordinary hazard and the other part was light hazard that the entire space would be protected for ordinary hazard. This makes the hydraulic calculation easier as there is only one density/area point that needs to be considered from Figure 11.2.3.1.1.

The next option would be to divide the area in such a fashion that each hazard is designated to a specific portion of the space. If there is a physical barrier between the two hazards then the systems protecting the hazard are each designed for their individual hazard. If there is no physical separation between the two hazards then the higher hazard protection scheme must be carried an additional 15 ft (4.6 m) into the lower hazard area in accordance with Section 11.1.2(1). It is also important to make sure that the last row of sprinklers between the two hazards is not over spaced for the hazard it is protecting consistent with the "S x L Rule", Section 8.5.2.1, for the area of protection of each sprinkler.

For the purposes of calculating the system demand when mixed occupancies are present, multiple hydraulic calculations may be necessary in order to determine which area is actually more demanding. It is possible for the lower hazard to be more demanding if sprinkler spacings are maximized and minimal pipe sizes are used.

Depending on the specific arrangement and the amount of floor area designated for each hazard , it may also be possible to have a hydraulically remote area that contains more than one hazard classification. The calculation would be done then so that each hazard receives its appropriate density required by Figure 11.2.3.1.1. Often the higher hazard is the driving force as it requires more pressure in the pipeline and the higher pressure will increase the amount of flow from the sprinklers in the lower hazard as well. For further information on these remote areas that contain multiple hazards see the May/June 2009 Sprinkler TechNotes.

Summary

In general, NFPA 13 lays out the concepts that need to be applied for the amount of area that should be calculated. However, there are often arrangements in the field that need to be given thought as they do not fit perfectly into the rules. When dealing with small rooms within larger areas, multiple systems to protect the space, or mixed occupancies, the hydraulic calculations may require multiple iterations and additional consideration to find what truly is the reasonable worst-case hydraulically most demanding area.