Control-Mode Density/Area Protection of Storage of Class I through Class IV Commodities in NFPA 13

Fourth in a series

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The first three installments of this series looked at the requirements for storage from a general perspective, covering Chapters 12 and 13. The next four articles will cover Chapters 14 through 17 and will be specific to the type of sprinkler that is used – Control-Mode Density/Area, Control-Mode Specific-Application, and ESFR. This article will address Control-Mode Density/Area (CMDA) Protection which utilizes standard spray type sprinklers, having K-factors of 5.6 or greater for Class 1 through Class IV commodities (Chapters 14 and 16). Control-mode sprinklers are designed to control or contain a fire until such time as the fire department arrives. Generally, systems are designed with sufficient safety factors that can raise the performance to suppression quality such that extinguishment can occur prior to fire department arrival, though this is not the design aim for these types of sprinklers. In order to determine the design criteria for control mode protection, the designer will use the Density/Area curves provided in Chapters 14 and 16. These curves are similar to those found in Chapter 11 for occupancy/hazard based protection criteria.

However, before determining the sprinkler density and operating area, one needs to answer the three essential questions: 1) What will be stored? 2) How will it be stored? And, 3) How high will it be stored? How this question is answered also requires the designer to know ceiling heights and clearances above the storage. After answering these questions, the designer is able to determine which chapter to use. As a refresher, Chapter 14 deals with the protection of palletized, solid-piled, bin box, shelf, or back-to-back shelf storage of Class I through Class IV commodities, and Chapter 16 deals with the protection of rack storage of Class I through Class IV commodities.

For storage heights that are 12 ft or less, Chapters 14 and 16 specify that the design criteria used for miscellaneous storage in Chapter 13 is to be utilized. The density/area curves in Chapters 14 and 16 are based on storage that is 20 ft. in height and on a sprinkler temperature rating of ordinary or high-temperature. These curves are based on full scale fire testing of K-5.6 and K-8.0 sprinklers that was performed from the late 1970's through the 1990's. The data from these tests showed that sprinkler temperature plays a factor for K-5.6 and K-8.0 sprinklers in that fewer high temperature sprinklers operated as compared to ordinary temperature heads. The design curves were developed to reflect this decreased number of operating sprinklers providing a more favorable discharge density when using high temperature heads. With the increased use of K-11.2 and larger sprinklers, specifically for densities of .34 gpm/sq. ft. or greater, it has been found that the high temperature curves can be used with the same effectiveness, regardless of the temperature rating of the sprinkler.

Since the curves are based on a storage height of 20 ft, the densities must be adjusted for storage heights other than 20 ft. using Figures 14.2.4.3 (solid-pile, palletized, bin box, or shelf storage) or Figure 16.2.1.3.4.1 (rack storage). The designer is cautioned that the adjustment figure does not always apply (see Tables 16.2.1.3.2 and 16.2.1.3.3.1 for storage over 20 ft. up to 25 ft.), and cannot be used at all for storage greater than 25 ft. in height. For storage less than 20 ft., a reduction in density is allowed and storage over 20 ft., requires an increase in the design density. This adjustment in density does not affect the sprinkler operating area. As an example, where a system is protecting class IV commodities stored 25 ft high and are solid piled, the design criteria is found in Chapter 14. If high-temperature CMDA sprinklers are used the designer refers to Figure 14.2.4.2. which shows a required density of .295 gpm/sq. ft. over an area of 2000 sq. ft. However, this is for 20 ft of storage so Figure 14.2.43 must be applied which shows that the density must be increased 135% for the storage height of 25 ft. Therefore, the adjusted design density of .398 (or .40) gpm/sq. ft., with the design area remaining at 2000 sq. ft.

However, there are a number of other factors that the designer must keep in mind. For example, section 12.6.3 states that densities greater than .34 gpm/sq. ft. require the use of K-11.2 or larger orifice sprinklers. In addition, back-to-back shelf storage, as well as regular shelf storage of non-encapsulated commodities is limited to 15 ft. in height and reductions to the density are not permitted. Similarly, encapsulated storage of palletized, solid-piled, bin box, or shelf storage is limited to 15 ft. in height due to the increased difficulty in protecting these types of storage arrangements. Some exceptions to the height are allowed for palletized and solid-pile encapsulated storage, but in no case can storage exceed 20 ft. for encapsulated Class I – IV commodities, and only K-11.2 heads or larger can be used.

For non-encapsulated palletized, solid-pile, and bin box storage, the curves shown in Figure 14.2.4.1 and Figure 14.2.4.2 can be used for storage up to 30 ft. in height using the adjustment in Figure 14.2.4.3. Again, care must to be taken to remember that where densities exceed .34 gpm/sq. ft., larger orifice (K-11.2 or larger) sprinklers are required.

Determining the CMDA design criteria for the rack storage of Class I through IV commodities is more complex for the designer. The type of rack (single row, double row, or multiple-row) and the presence of shelving (slatted or solid) all play a role in determining not only the ceiling sprinkler density, but also the need for in-rack protection. Additional consideration is also required where exposed steel columns are present within the rack storage area. In some cases, either horizontal sidewalls must be installed at the columns, higher ceiling densities will be required, or alternate types of sprinklers (CMSA or ESFR) will be required.

When determining the ceiling density for Class I through IV commodities the designer refers to Table 16.2.1.3.2 for single- and double-row racks, or Table 16.2.1.3.3.1 and Table 16.2.1.3.3.2 for multiple-row racks. These tables are used for storage up to and including 25 ft. in height, and depending on the commodity classification, storage height, aisle width, encapsulation (or not), and the provision of in-rack sprinklers and will direct the designer to one of seven sets of design curves, shown in Figures 16.2.1.3.2 (a) through (f). Each of these figures provides curves based on aisle width (4 ft. or 8 ft. aisles), rack type (single- and double-, or multiple-row), the provision of in-rack sprinklers, and sprinkler temperature rating. Care must be taken in ensure that the correct curve is used to determine the required density.

As with the area density curves in Chapter 14, the curves are based on a storage height of 20 ft. Figure 16.2.1.3.4.1 is used to adjust the density based on the height of storage. Tables 16.2.1.3.2, 16.2.1.3.3.1 and 16.2.1.3.3.2 all indicate whether or not the density adjustment curve shown in Figure 16.2.1.3.4.1 can be used. The designer is cautioned that in some cases, the adjustment curve cannot be applied for certain storage arrangements.

In-rack sprinkler requirements for Class I through IV commodities are also provided in Chapter 16. Tables 16.2.1.4.2.1 and 16.2.1.4.2.2 address the maximum spacing requirements within racks. The designer is directed that wherever possible, in-rack sprinklers should be located at the intersection of the longitudinal and transverse flue spaces. The aisle width and encapsulation of the commodity must be known when using the tables to ensure the correct spacing limitations are chosen. In-rack sprinklers are required to discharge at a minimum pressure of 15 psi, regardless of the protected commodity. The number of design sprinklers on a line as well as number of required levels of sprinklers that must be included in the calculations are dependent on the commodity classification. The requirements are outlined in 16.2.1.4.3.1.

When using CMDA design criteria for rack storage over 25 ft. of Class I through Class IV commodities in-rack sprinklers must be installed within the longitudinal flue space for both single- and double-row racks, as well as within multiple-row racks. In addition, face sprinklers may be required depending on the type and height of the rack structure. Similar to storage up to 25 ft., the design criteria is outlined in Table 16.3.1.1 for single- and double-row racks and in Table 16.3.1.2 for multiple-row racks, which provide the required densities depending on whether ordinary or high temperature sprinklers are utilized. In all cases, the design area is 2000 sq. ft. There are also references to specific figures which indicate the placement of sprinklers within the racks for both flue and face sprinklers. The requirements outlined in Table 16.3.1.1 and Table 16.3.1.2 are based on non-encapsulated commodities. If encapsulated commodities are to be protected, the indicated densities must be increased by 25%. When providing face sprinklers, sprinklers need to be located within the rack and not in the aisle. This will ensure both protection from mechanical damage, as well as proper operation of the sprinkler (no delays).

The designer is cautioned to use care when navigating the requirements of Chapters 14 and 16. There are a significant number of tables and figures that are provided which can be misinterpreted if not read correctly. Proper use of the tables and figures, though, will result in a well-designed system that will provide adequate protection for the commodity.

Next: Control-Mode Density/Area (CMDA) Protection Schemes – Plastic and Rubber Commodities