

Hydraulic Design of Fire Water Sprinkler Systems Containing Typical Branch Lines

An Online Continuing Education Course for Engineers

Course Number: M-2059

Credit: 2 Hours / 2 PDH / 2 CPD

Hydraulics for Sprinkler Systems with Typical Branch Lines

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Occupancy classification

Any hydraulic design of sprinkler systems must begin with an analysis of the commodity being protected. The National Fire Protection Association, Standard No. 13 “*Installation of Sprinkler Systems*” (NFPA-13) defines three basic commodity classifications: Light Hazard, Ordinary Hazard, and Extra Hazard. These classifications are defined in NFPA-13, and examples are given in that document.

Ordinary Hazard occupancies are divided into two categories: Ordinary Hazard Group 1 and Ordinary Hazard Group 2. Extra Hazard occupancies are also divided into two categories: Extra Hazard Group 1 and Extra Hazard Group 2.

Once a hazard classification is chosen for a known occupancy, the water requirements may be established from NFPA-13, (2007) Figure 11.2.3.1.1

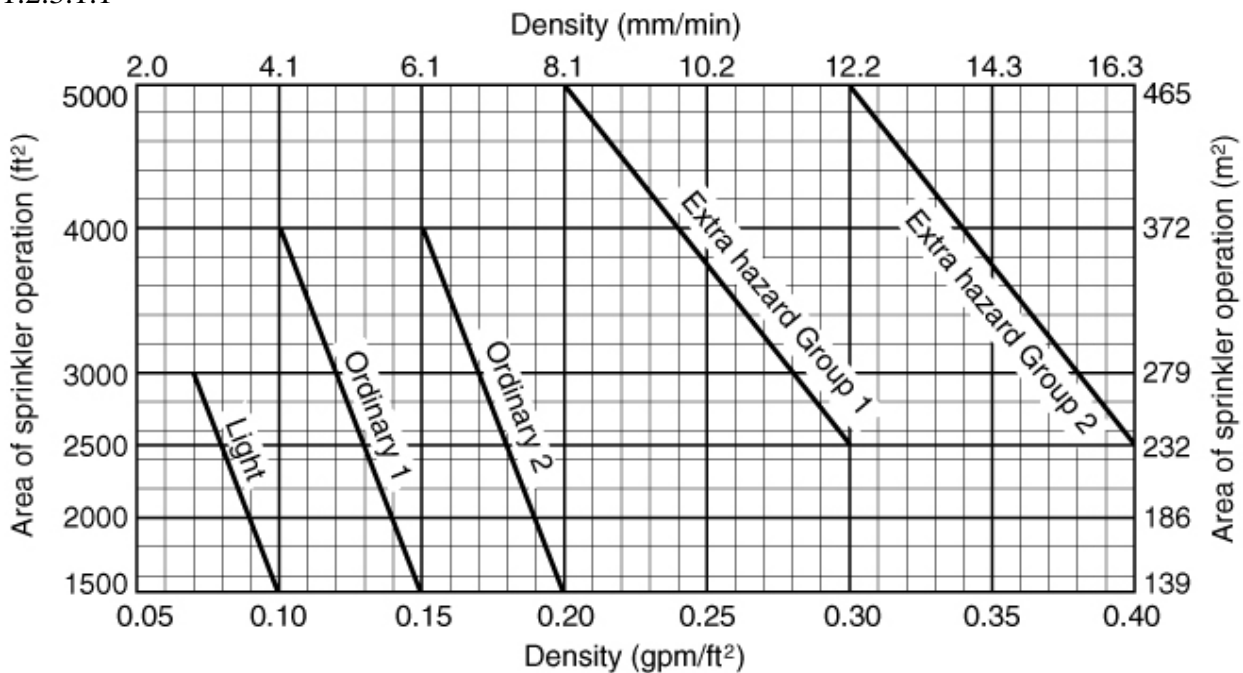


FIGURE 11.2.3.1.1
Density/Area Curves.

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Densities and Remote Areas

NFPA-13, (2007) Figure 11.2.3.1.1 displays five density/area curves overlaid on a graph. These five curves correspond to the previously discussed hazard classifications: Light Hazard, Ordinary Group 1 Hazard, Ordinary Group 2 Hazard, Extra Hazard Group 1, and Extra Hazard Group 2.

These curves stipulate the required minimum densities and remote areas that establish minimum water requirements for sprinkler systems.

Definition:

Density – the amount of water that must be delivered every minute for every square foot of floor space. The English units for density is (gallons per minute per square foot (gpm/sq.ft.)) For example, a Light Hazard occupancy could be designed for a density of 0.1-gpm/sq.ft. This means that 0.1-gallons must discharge every minute for every square foot of floor space over a specified area.

Definition:

Remote Area – the minimum area of floor space over which the density must discharge.

As an example, Figure 11.2.3.1.1 indicates that an acceptable design for an Ordinary Hazard Group 1 occupancy is 0.15-gpm/sq.ft. over 1500-sq.ft.

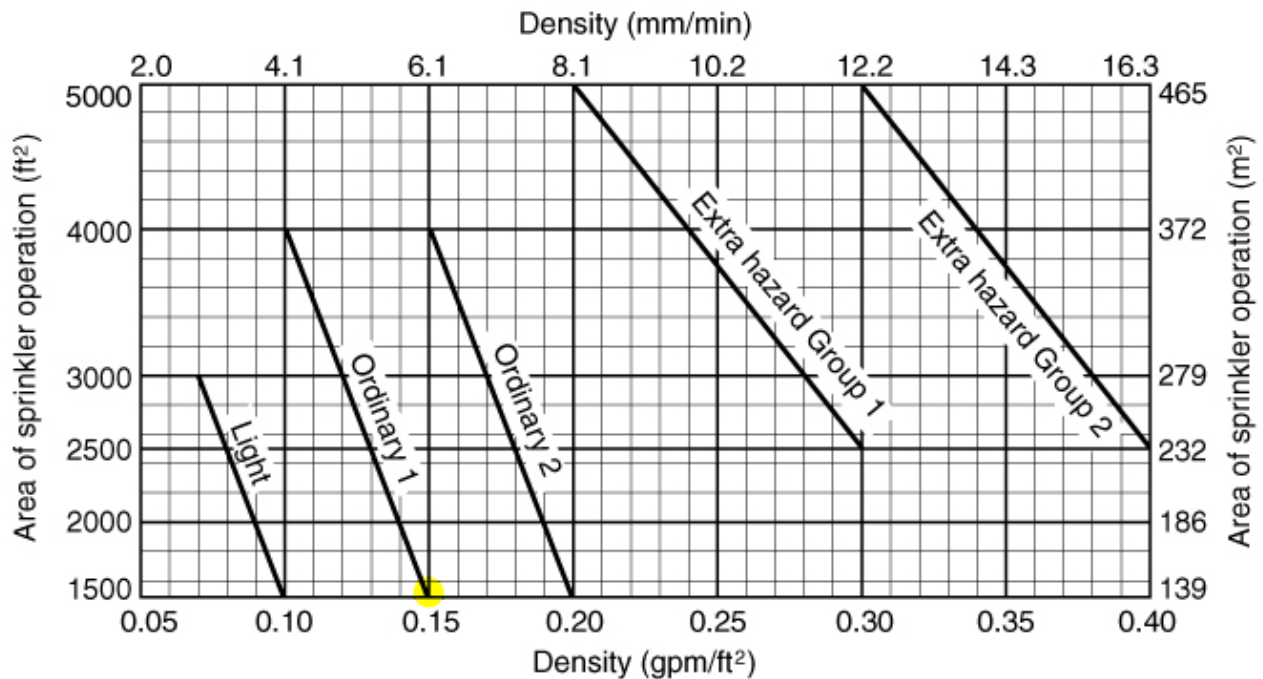


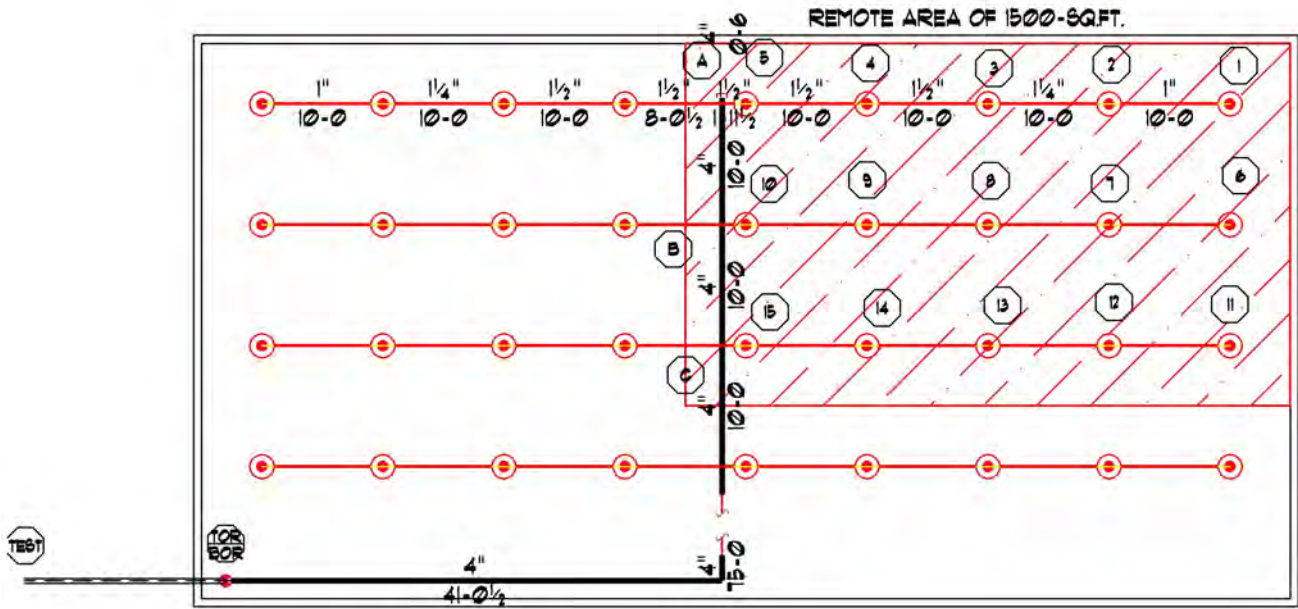
FIGURE 11.2.3.1.1
Density/Area Curves.

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This means the sprinkler system designer will choose the most hydraulically demanding 1500-sq.ft. of the sprinkler system layout and perform a calculation of all sprinklers within that 1500-sq.ft. area. Therefore, only a portion of sprinklers on a sprinkler system is expected to operate during a typical fire, not all. If all sprinklers on a sprinkler system operate, the water supply most likely will not be adequate to control the fire.

Below is an example remote area for an Ordinary Group 1 occupancy, which in this example is a 1500-sq.ft. remote area. Note the remote area contains fifteen sprinklers, which are numbered 1 – 15. The most hydraulically remote sprinkler is sprinkler #1 since it is physically the most remote. There are cases when the physically remote sprinkler will not be the hydraulically remote. If the hydraulically remote sprinkler is not evident, additional calculations can be performed to verify.

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Remote Area #1

End sprinkler start conditions

Once the hydraulic requirements are selected for the occupancy, the hydraulic calculation of the sprinkler system may begin. In modern times sprinkler system hydraulics are performed by computer programs. However, in the early days of sprinkler system hydraulic design, all systems were calculated with a calculator as we will do here. A thorough understanding of these principles is not required to perform calculations on a hydraulic calculation program, but these are the principles on which the program operates. A better understanding of these principles will allow the designer to better understand how the sprinkler system will function hydraulically.

The density/area curves will tell the designer the starting point of the design. Our example is an Ordinary Hazard Group 1 occupancy, and we will choose the point on the density/area curve of 0.15-gpm/sq.ft. over 1500-sq.ft.

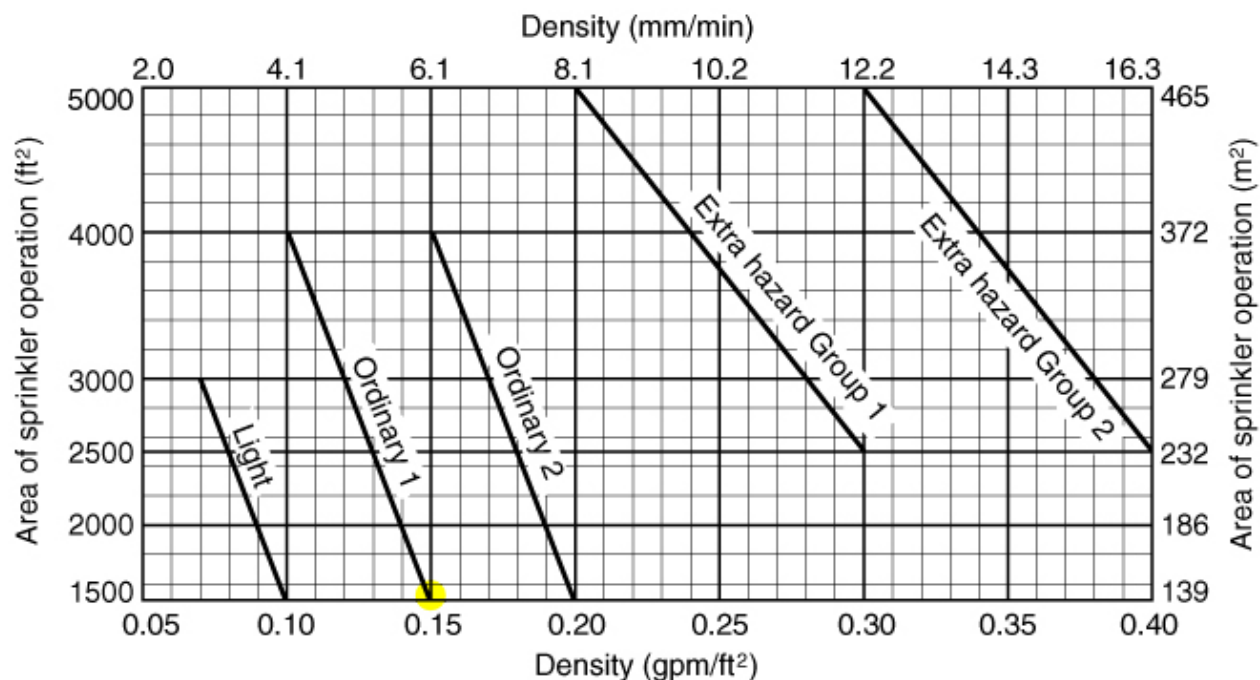


FIGURE 11.2.3.1.1
Density/Area Curves.

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This means that every square foot of the 1500-sq.ft. remote area must be covered with at least 0.15-gpm. By extension, this means that the floor area under each sprinkler, called the Protection Area of Coverage, must be provided with 0.15-gpm/sq.ft. In other words, each sprinkler must discharge enough water to provide a minimum of 0.15-gallons per minute for every square foot it protects.

Definition:

Protection Area of Coverage – *the floor area protected by an individual sprinkler.*

$$A_c \times D = Q_s$$

If the beginning sprinkler in our example protects 100-sq.ft. of floor area, then the amount of water that must exit the sprinkler is

Where:

Q_s = Flow from individual sprinkler

A_c = Protection Area of Coverage for individual sprinkler

D = Density

Therefore, 100-sq.ft. x $\frac{0.15 - \text{gpm}}{\text{sq.ft.}}$ = 15.0-gpm.

The end sprinkler must discharge 15.0 gpm to meet the minimum density requirement at this point; however, there is a possibility that no sprinkler may satisfy this condition for determining the minimum

100-sq.ft. it protects in order to complete the calculation process at this point. NFPA (2007) section 22.4.4.10.1 states that you must verify that our end sprinkler has a k-factor of 8.0. The formula for determining the minimum flow rate is:

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Where,

Q = Flow from individual sprinkler

k = Sprinkler k-factor (see NFPA 13)

p = Pressure from an individual sprinkler

Therefore, $Q = 8.0\sqrt{7} = 21.2$

Since the sprinkler in our example has a k-factor of 8.0 and a pressure requirement of 7.0 psi, the minimum flow rate is 21.2-gpm. Since the beginning sprinkler only discharges 15.0-gpm, the end sprinkler must discharge 21.2-gpm to meet the density requirement at this point.