# Saving The Demand of Fire Sprinkler Systems

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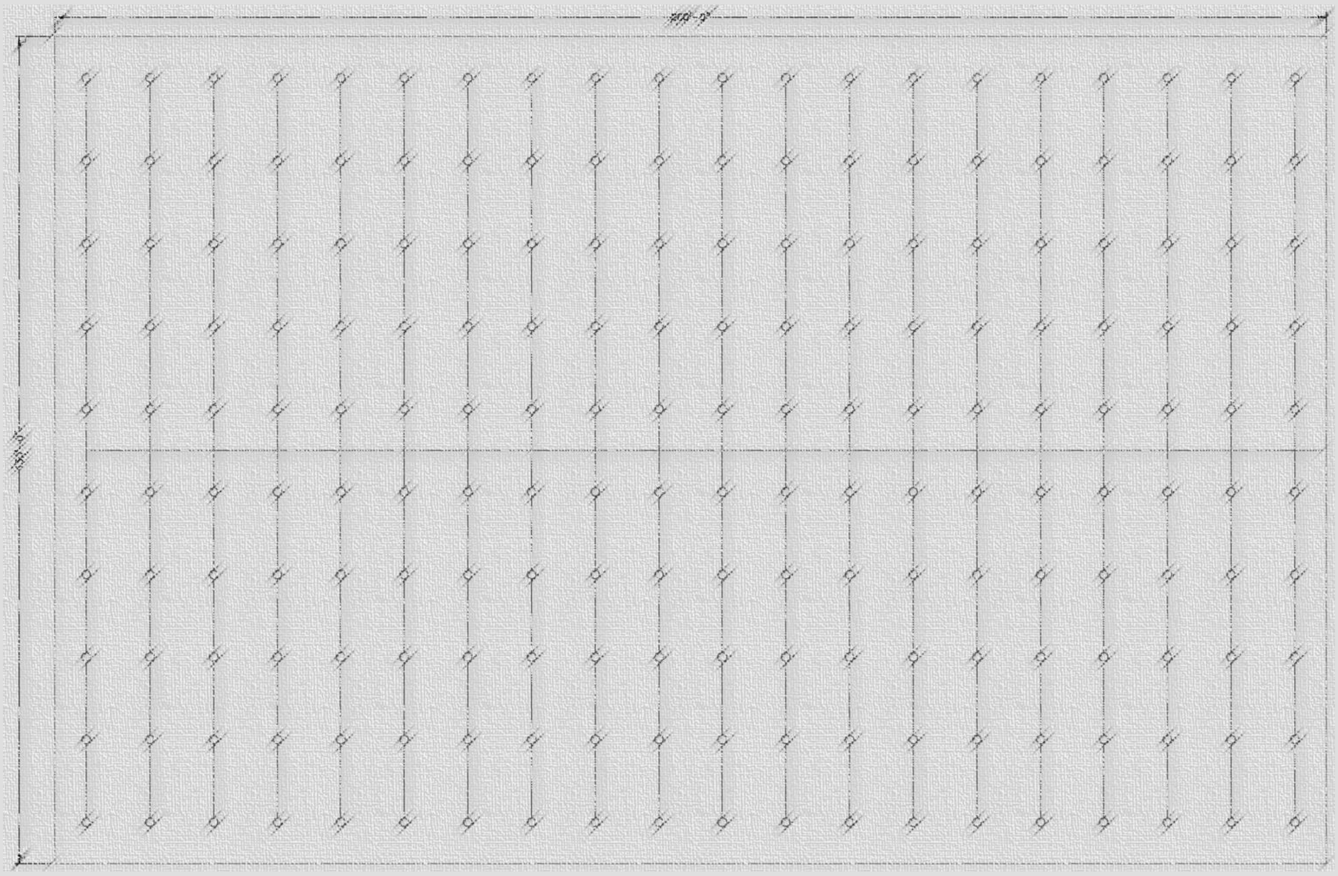

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In this paper, we study the methods of saving sprinkler system demand.

Consider the following example:

- **Occupancy hazard classification:** OH2
- **Area:** 200’ x 130’
- **System type:** Wet pipe
- **Sprinklers:** Upright spray sprinklers, standard response, K5.6
- **Pipe Type:** Black steel, Sch 40
- **Sprinkler coverage:** 13’ x 10’
- **Brach line and sprinklers elevation:** 10’
- **Cross Main elevation:** 9’
- **Branch line size:** 1 in for one sprinkler, 1 1/4in for two sprinklers, 1 ½ in for five sprinklers
- **Riser Nipple size:** 1 1/2 in
- **Cross Main & Riser:** 3 in
- **Ceiling height:** 10 ft
- **Hose stream allowance:** 250 gpm

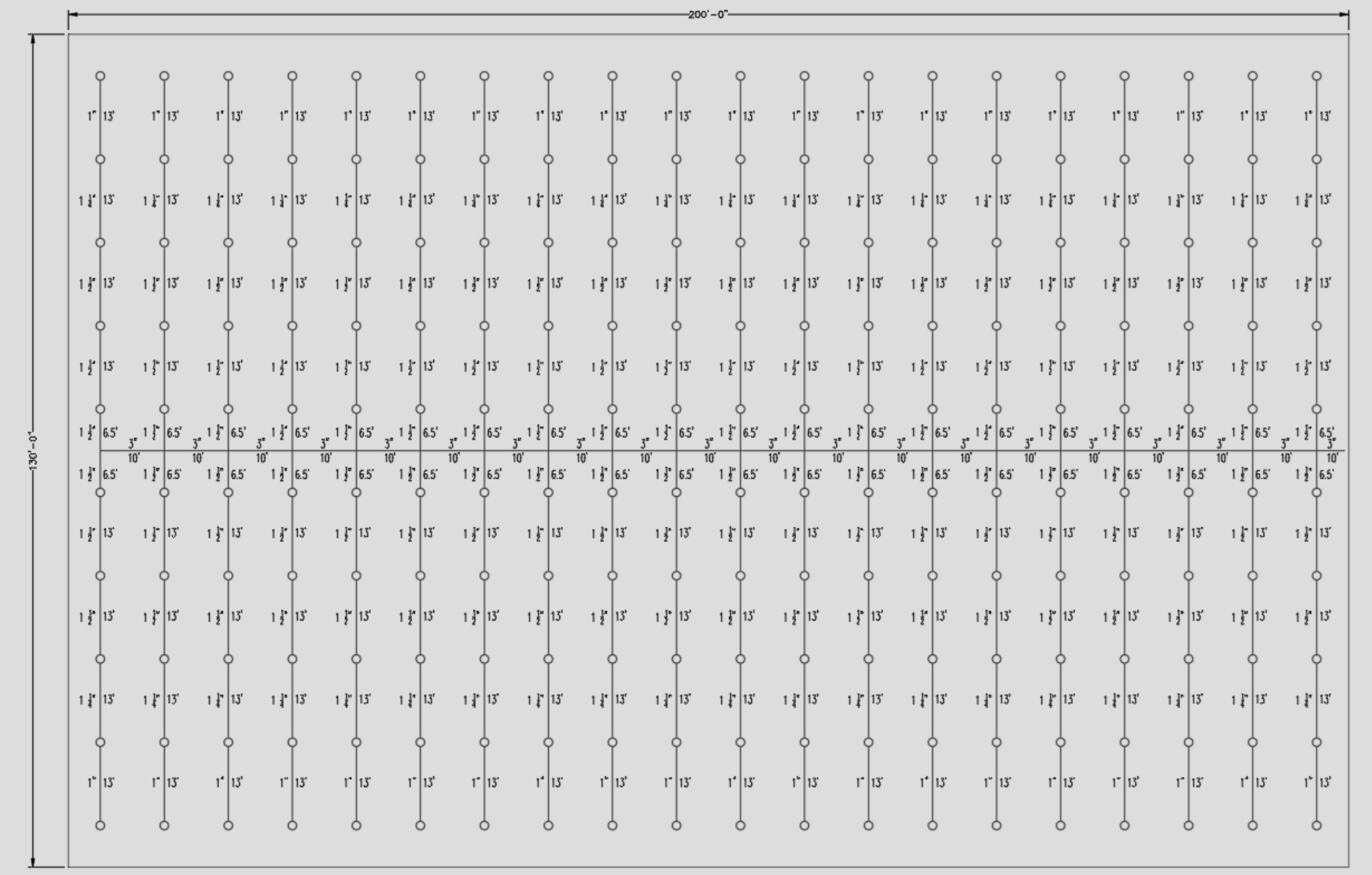


**Figure 1- Project Layout**

We will examine different situations that could affect system demand. The flowrate and pressure will be calculated at the base of riser, and we ignore the pressure loss between the city main and the BOR in this paper. Assuming the example above is an existing system, so in accordance with the section 19.2.3.1.1(2) of NFPA 13 (2022 Edition), we are permitted to apply Density/Area curves.

**1) Selecting the lowest point of the OH2 curve:**

According to Figure 19.2.3.1.1, when the lowest point of the OH2 curve is selected, the density is 0.2 gpm/ft² and the area of sprinkler operation is 1500 ft². The design area contains 12 sprinklers as shown in Figure 2.

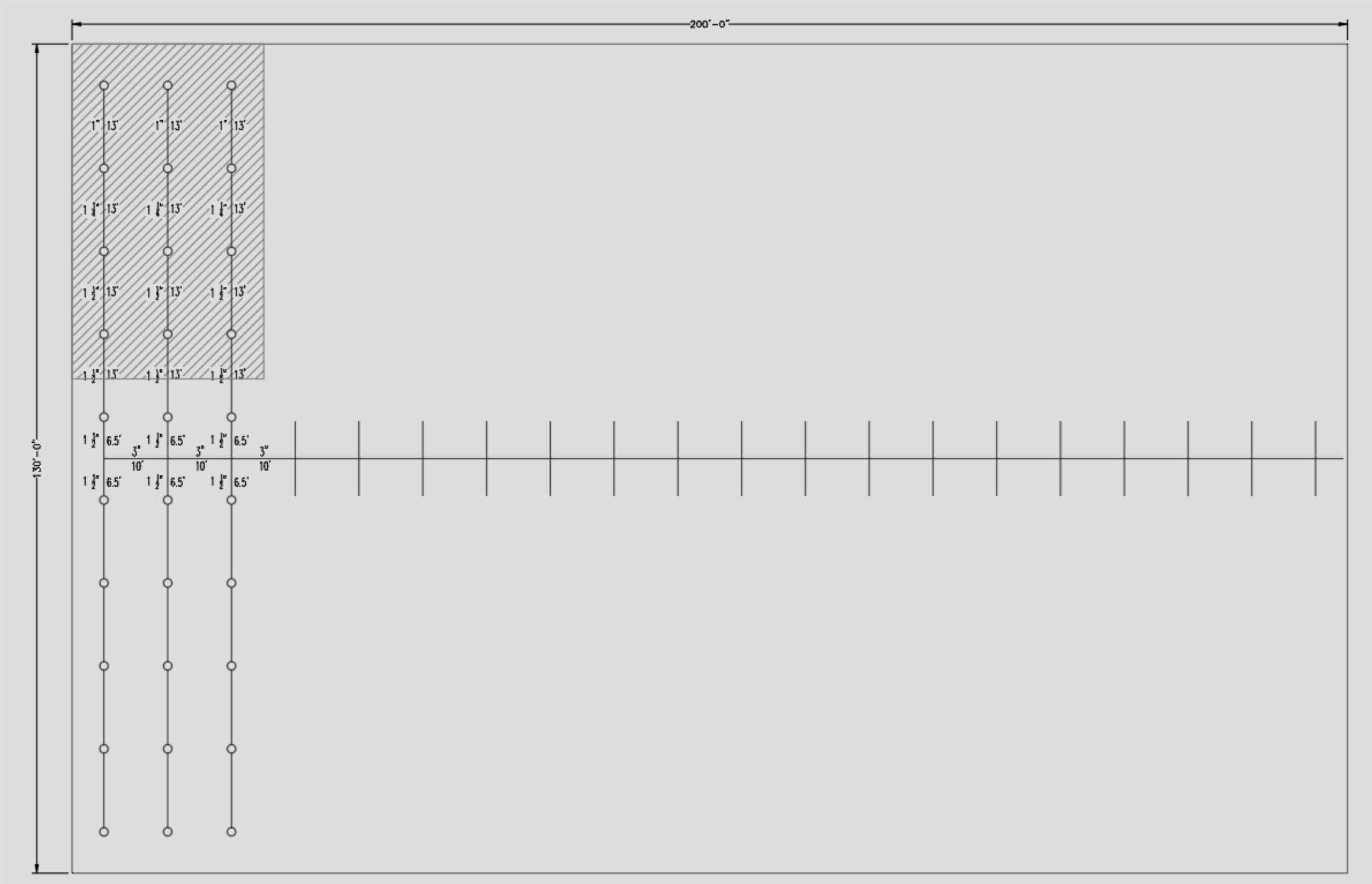


**Figure 2- Design area based on the lowest point of OH2**

The system demand is 592 gpm @ 77.4 psi.

We will use these values as a benchmark for comparing the results of other methods we will study later.

**2) Upsizing the pipes:**

Increasing the size of the pipes is one of the solutions to decrease the pressure demand. Even though water velocity isn't a concern for sprinkler system design, it causes more pressure loss. To reduce the pressure demand, designers should increase the size of pipes with a higher velocity. According to the Hazen-Williams equation, the power of internal diameter is 4.87, so increasing the pipe diameter has a great impact on pressure loss.

In our example, if we upsize the 1 ½ in pipes into 2 in, the system demand will be 589 gpm @ 65 psi.

**3) Wall thickness of pipes:**

A greater pipe schedule means a thicker wall thickness and a smaller internal diameter, so a smaller pipe schedule increases internal diameter and reduces system demand.

Applying Sch 10 in our example cause the system demand will be decreased to 591 gpm @ 71.3 psi.

**4) Quick Response sprinklers:**

We can save significantly on system demand when we use Quick Response sprinklers as permitted by 19.2.3.2.3 (based on ceiling height).

In our example, the 10 ft ceiling height allows us to reduce the design area by 40%. The new design area is shown in Figure 3.

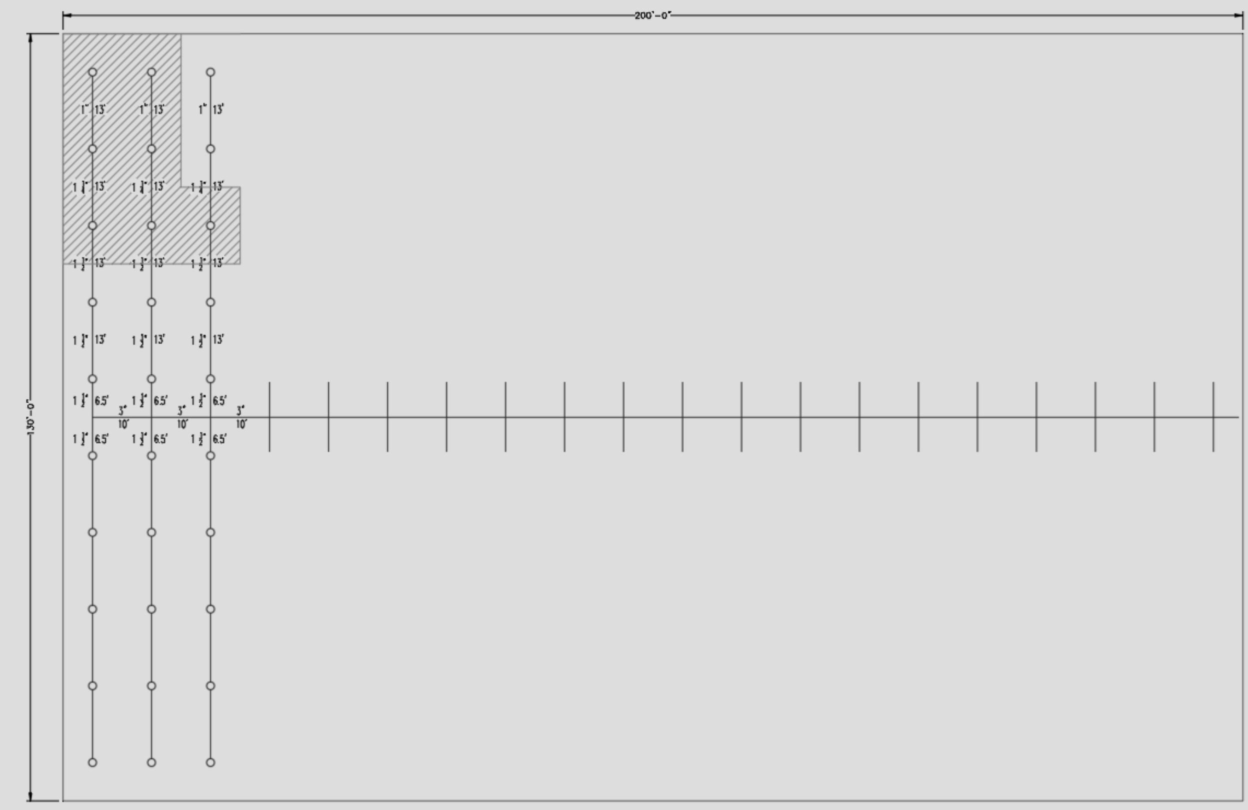


**Figure 3- Impact of QR sprinklers on design area**

In this situation, system demand is 449 gpm @ 52.8 psi.

5) **K-Factor of Sprinklers:**

Generally, sprinklers with a bigger K factor require less pressure to discharge a specific amount of water. For example, when a sprinkler needs to discharge 30 gpm, K5.6 requires 28.7 psi, whereas K8.0 requires only 14.1 psi.

It should be noted although we can achieve any flow rate by increasing the pressure, the higher pressure results in smaller water droplets (mass). Thus, in certain cases, such as storage occupancies, where water droplets' momentum plays a vital role in controlling fires, NFPA13 specifies the minimum K factor of CMDA sprinklers. (21.1.2, 21.1.3 and 21.1.4).

The system demand with K8.0, will be 620gpm @73.7psi.

In our example, if the hazard classification was OH1, and we used K8.0, the demand increased compared to when K5.6 was used. Although K8.0 only requires 5.94 psi to discharge 19.5 gpm (=130 ft2 x 0.15 gpm/ft²) for OH1, the NFPA13 specifies a minimum operating pressure of 7 psi for sprinklers (to dismount the cap of sprinkler after the bulb is broken). The minimum pressure required causes higher flowrate per sprinkler (more than we actually need) and higher pressure loss. It is crucial to select the appropriate K factor when designing sprinkler systems.

6) **Velocity pressure:**

Due to small values of velocity pressure in the piping of sprinkler systems, this pressure is generally ignored in hydraulic calculations. When the internal diameter of the pipes is small, applying velocity pressure has a greater effect on reducing demand. Due to the use of the "Trial-Error method", velocity pressure calculations are more challenging.

If we consider velocity pressure in our calculations, the demand will be 584 gpm @ 76.3 psi.

7) **Upper point of the curve:**

By selecting the upper design point of OH2 curve (0.15 gpm & 4000 ft²), the required pressure per sprinkler decreases. For our example, if we use the upper point of the curve, we only need 19.5 gpm and 12.1 psi for most remote sprinkler (instead of 26 gpm and 21.5 psi, when we select the lower point). Selecting the upper point usually results in a smaller branch line and a larger cross and feed main. In our example, if we select the upper point of the OH2 curve and upsize the cross and riser from 3 into 4 in, the demand will be 732 gpm @ 69.5 psi.

By selecting the lowest curve, we will be able to control fire in a smaller area, reduce fire damage, and system flow demand. Due to these reasons, the 2022 edition of NFPA 13 required the lowest point of the curves (appeared in Table 19.2.3.1.1) for designing the new sprinkler systems.

8) **Smooth Pipes:**

We can save system demand if we use Copper-Type M pipes, which has a C factor of 150 and a larger internal diameter than Cooper pipe Types K and L.

The system demand with copper piping will be 585 gpm@ 65.9 psi.

9) **Darcy-Weisbach equation for smooth pipes:**

For smooth pipes (C factor 140 or more), applying the Darcy-Weisbach equation led to saving the system demand. This equation is more challenging in comparison to Hazen- Williams. Finding absolute roughness (ε) of used pipes, also determining the friction factor (f) by "Moody diagram", "Colebrook-White" or "Swamee-Jain" correlations is not easy and straightforward.

Anyway, if we apply the Darcy-Weisbach formula with cooper pipes, the system demands will be 584 gpm@ 65 psi.

10) **Gridded piping configuration:**

One of the best ways to decrease system demand is using a Gridded piping configuration. Hardy-Cross method should be applied for the gridded piping. Calculation of gridded systems without the computers is so hard and time-consuming. The application of gridded piping is subject to some limitations depending on the type of sprinkler system (8.2.3.10 and 8.3.2.7).

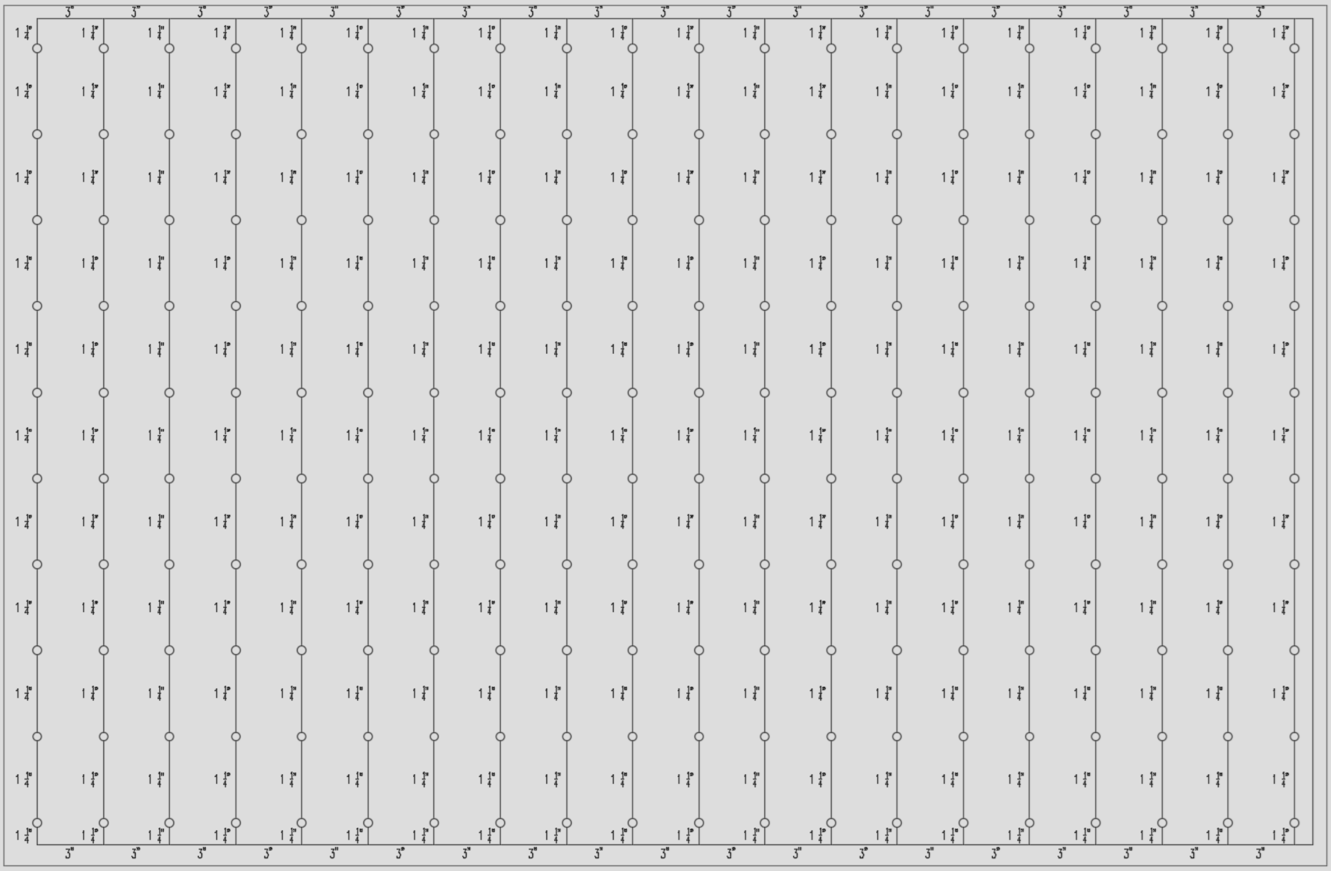

**Figure 4- Gridded System**

The system demand with gridded piping (1 1/4 in Branch lines and 3 in Cross mains) will be 565 gpm @ 48.3 psi.

**Summary Table:**

| No. | Item | Q (gpm) | P (Psi) | Q (%) | P (%) |
|---|---|---|---|---|---|
| 1 | SR Spray Sprinkler, K5.6, Lowest point of Curve, Sch 40 | 592 | 77.4 | - | - |
| 2 | Upsizing the pipes | 589 | 65 | -0.5 | -16.0 |
| 3 | Sch 10 pipes | 591 | 71.3 | -0.2 | -7.9 |
| 4 | Quick Response sprinklers | 449 | 52.8 | -24.2 | -31.8 |
| 5 | K Factor 8.0 | 620 | 73.7 | 4.7 | -4.8 |
| 6 | Velocity pressure | 584 | 76.3 | -1.4 | -1.4 |
| 7 | Upper point of the curve, Cross amin and Riser 4 inch | 732 | 69.5 | 23.6 | -10.2 |
| 8 | Type M- Copper pipe, C 150 | 585 | 65.9 | -1.2 | -14.9 |
| 9 | Darcy-Weisbach Method and copper pipes | 584 | 65 | -1.4 | -16 |
| 10 | Gridded piping configuration | 565 | 48.3 | -4.6 | -37.6 |

**Conclusion:**

In this paper, we examined the effects of some parameters on the demand of sprinkler systems based on the specific project.  Some of the above-mentioned methods may not be valid if project conditions change. It is interesting to know that sometimes upsizing the pipes will also result in an increase in demand. To design a cost-effective system, the designer should consider all the project conditions. This is the beauty of sprinkler system design!