Introduction

Hydraulic calculations are very important when designing fire protection systems, since they ensure that the piping delivers enough water to extinguish any fire. The hydraulic calculation procedure deals with three very important aspects of a fire suppression system:

- If a fire occurs, how much water is required to extinguish it?
- Is the available water supply enough?
- What is the optimal layout of the piping system, and what friction losses are produced?

Occupancies Classifications

We define is the hazard type (product and building which are being protected). The degree of fire danger can be categorized into three main types:

- Light Hazard – Degree of fire danger is light
- Ordinary Hazard – Degree of fire danger is medium
- Extra Hazard – Degree of fire danger is high

Occupancies Classifications

Light Hazard Occupancies – NFPA 13

A.5.2 Light hazard occupancies include occupancies having uses and conditions similar to the following:

- Animal shelters
- Churches
- Clubs
- Eaves and overhangs, if of combustible construction with no combustibles beneath
- Educational
- Hospitals, including animal hospitals and veterinary facilities
- Institutional
- Kennels
- Libraries, except large stack rooms
    - It is not the committee's intent to automatically equate library bookshelves with ordinary hazard occupancies or with library stacks. Typical library bookshelves of approximately 8 ft in height, containing books stored vertically on end, held in place in close association with each other, with aisles wider than 30 in. can be considered to be light hazard occupancies. Similarly, library stack areas, which are more akin to shelf storage or record storage, as defined in NFPA 232, Standard for the Protection of Records, should be considered to be ordinary hazard occupancies.
- Museums
- Nursing or convalescent homes
- Offices, including data processing
- Residential
- Restaurant seating areas
- Theaters and auditoriums, excluding stages and prosceniums
- Unused attics

Occupancies Classifications

Ordinary Hazard Occupancy (Group 1)

A.5.3.1 Ordinary hazard occupancies (Group 1) include occupancies having uses and conditions similar to the following:

- Automobile parking and showrooms
- Bakeries
- Beverage manufacturing
- Canneries
- Dairy products manufacturing and processing
- Electronic plants
- Glass and glass products manufacturing
- Laundries
- Restaurant service areas

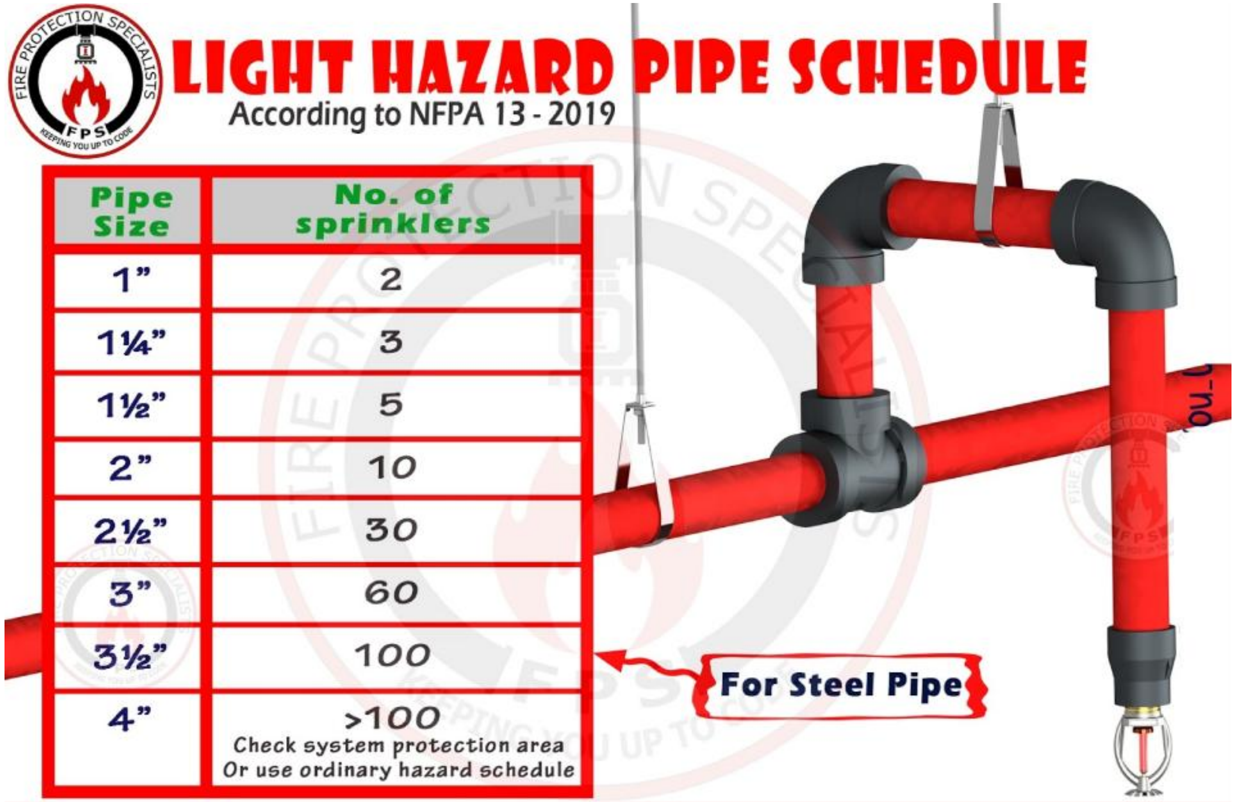
Pipe Size Calculations

Table 22.5.2.2.1 Light Hazard Pipe Schedules

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	3 sprinklers	1¼ in.	3 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	10 sprinklers	2 in.	12 sprinklers
2½ in.	30 sprinklers	2½ in.	40 sprinklers
3 in.	60 sprinklers	3 in.	65 sprinklers
3½ in.	100 sprinklers	3½ in.	115 sprinklers
4 in.	See Section 8.2	4 in.	See Section 8.2

For SI units, 1 in. = 25.4 mm.

Pipe Size Calculations



Pipe Size	No. of sprinklers
1"	2
1¼"	3
1½"	5
2"	10
2½"	30
3"	60
3½"	100
4"	>100 Check system protection area Or use ordinary hazard schedule

Pipe Size Calculations

PIPE SCHEDULES

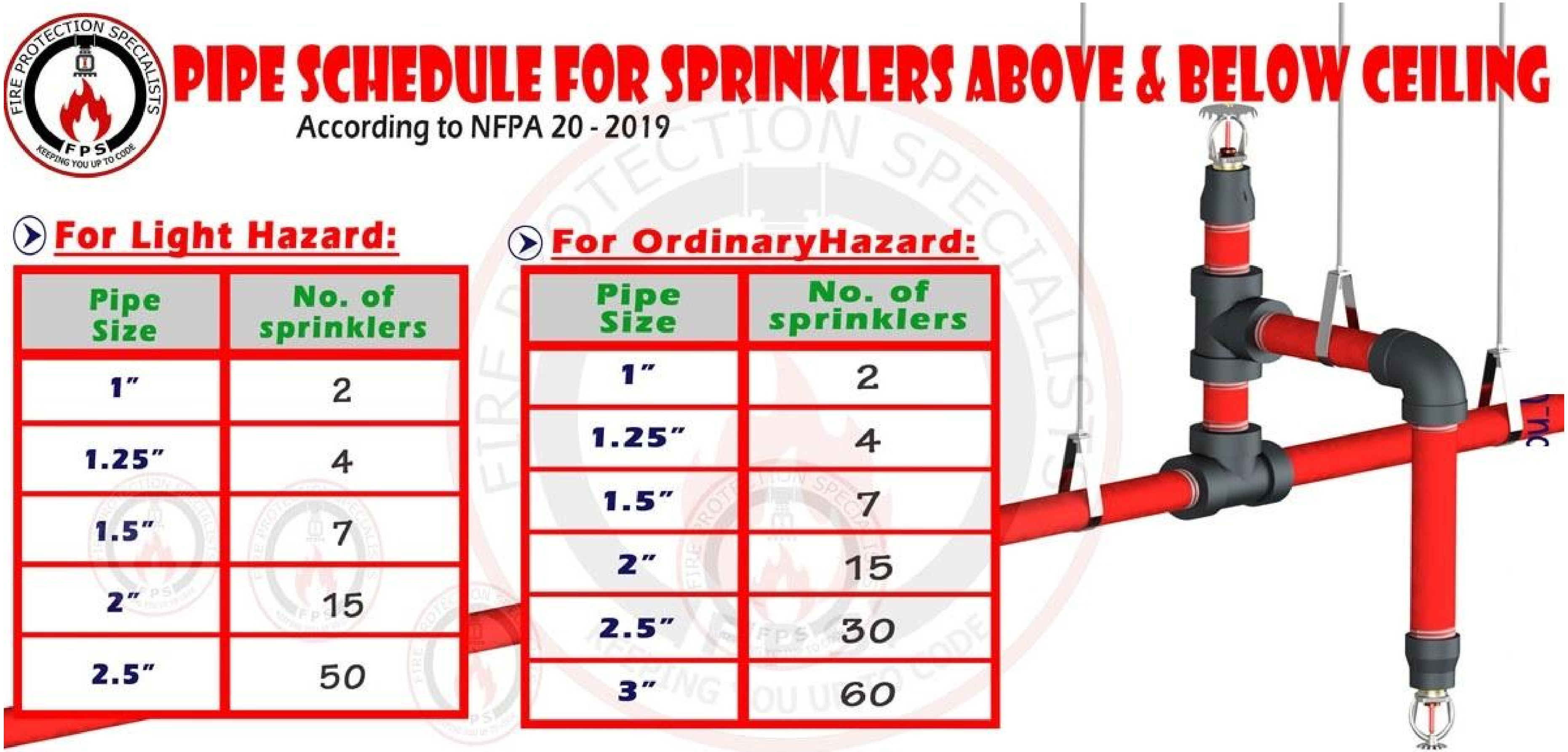
According to NFPA 13 - 2019

Pipe Size	No. of sprinklers: Ligh Hazard	No. of sprinklers: Ordinary Hazard, Separation ≤ 3.7m	No. of sprinklers: Ordinary Hazard, Separation > 3.7m	No. of sprinklers: Extra Hazard
1"	2	2	2	1
1¼"	3	3	3	2
1½"	5	5	5	5
2"	10	10	10	8
2½"	30	20	15	15
3"	60	40	30	27
3½"	100	65	60	40
4"	>100 Check system protection area & Use ordinary hazard pipe schedule	100	100	55
5"	>100 Check system protection area & Use ordinary hazard pipe schedule	160	160	90
6"	>100 Check system protection area & Use ordinary hazard pipe schedule	275	275	150
8"	>100 Check system protection area & Use ordinary hazard pipe schedule	>275 & Check system protection area	>275 & Check system protection area	-

Note that:

- The piping schedule for extra hazard is just used as a guide for only existing systems, New systems should be hydraulically calculated.
- System protection area limitation:
  - For Light & ordinary, 4830 m^2
  - For Extra hazard, 3720 m^2

<u>Pipe Size Calculations</u>



PIPE SCHEDULE FOR SPRINKLERS ABOVE & BELOW CEILING

According to NFPA 20 - 2019

For Light Hazard:

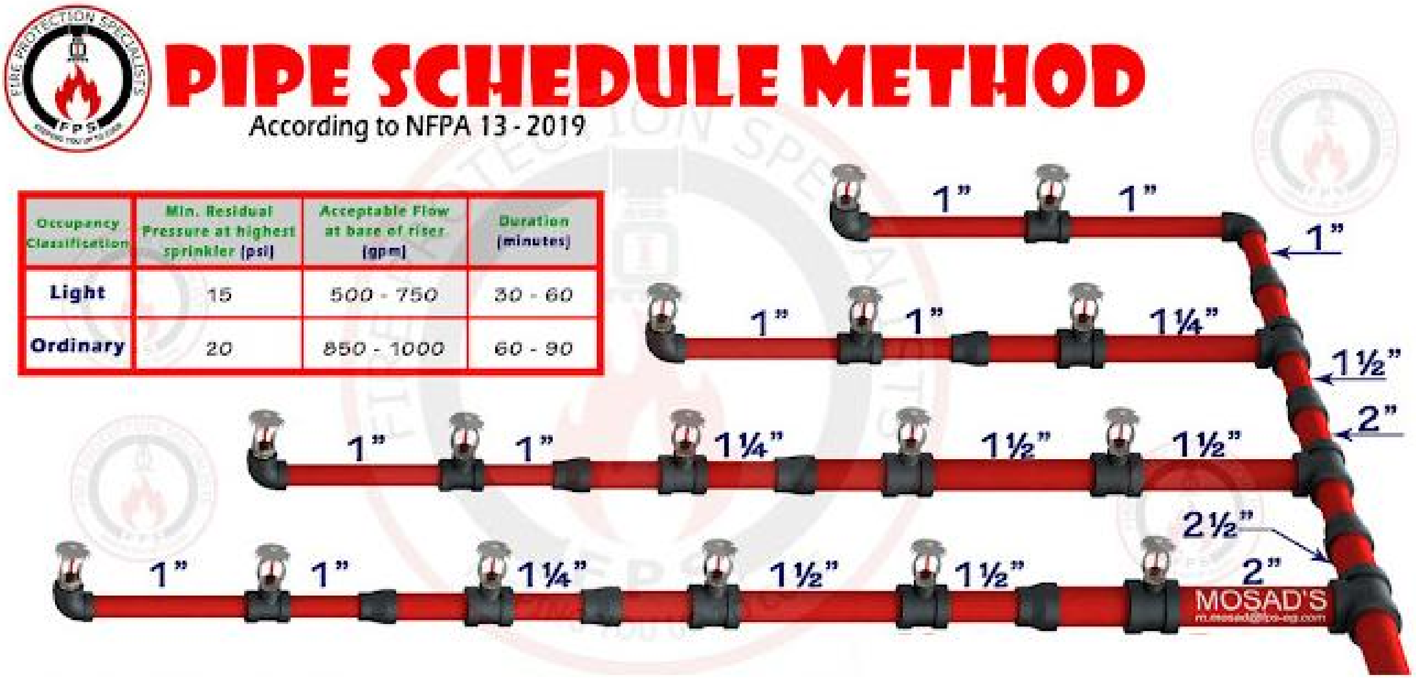
Pipe Size	No. of sprinklers
1"	2
1.25"	4
1.5"	7
2"	15
2.5"	50

For OrdinaryHazard:

Pipe Size	No. of sprinklers
1"	2
1.25"	4
1.5"	7
2"	15
2.5"	30
3"	60

Pipe Size Calculations

PIPE SCHEDULE METHOD FOR FIREFIGHTING SPRINKLER SYSTEM



Occupancy Classification	Min. Residual Pressure at highest sprinkler (psi)	Acceptable Flow at base of riser (gpm)	Duration (minutes)
Light	15	500 - 750	30 - 60
Ordinary	20	850 - 1000	60 - 90

What are Hydraulic Calculations?

Hydraulic calculations are used to determine the pressure and output of water (flow) for a given sprinkler system. It all starts with a fundamental equation found in NFPA 13, which is used throughout the calculation process:

$K = Q \div \sqrt{P}$

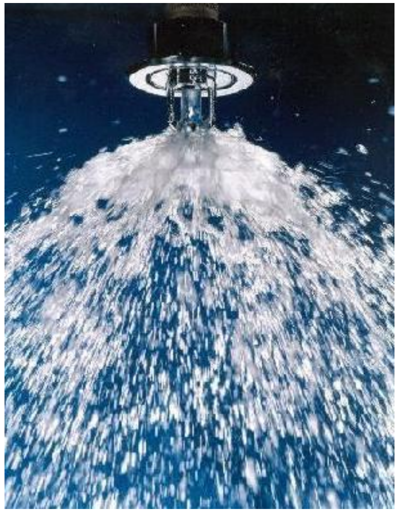
This equation shows the relationship between

- sprinkler flow rate,
- pressure, and
- the orifice (sprinkler opening).

What are Hydraulic Calculations?

- **Q = Flow Rate (gpm).** The flow rate is the amount of water that flows through the sprinkler head and is measured in gallons per minute (gpm).
- **P = Pressure at the sprinkler head (psi).** This one is simple; it is basically the pressure at which the water flows from the sprinkler, measured in pounds per square inch (psi). A sprinkler with a lower pressure will yield a slower stream of water, where a sprinkler with a higher pressure will produce a much faster stream.
- **K = K-Factor of the sprinkler head.** The K-Factor depends on the orifice diameter of the sprinkler. A sprinkler with a low K-Factor will restrict the flow of water, whereas a sprinkler with a higher K-factor will allow more water to pass through the sprinkler head. Large k-factors yield larger flows and small k-factors yield smaller flows.

If pressure is held constant and k increases, it results in a larger flow rate.



What are Hydraulic Calculations?

K-factor Calculation Example

- What is the K-factor for an outlet that is flowing 65 gpm at 30 psi?
- $$k = \frac{Q}{\sqrt{P}}$$

$$k = \frac{65\,\text{gpm}}{\sqrt{30\,\text{psi}}}$$

$$k = \frac{65}{5.48} = 11.86$$

What are Hydraulic Calculations?

Now that we have the definitions out of the way, lets look closer at the basic hydraulic formula itself.

The basic hydraulic formula can be re-arranged in three different ways as follows:

Solving for K-Factor	$K = Q \div \sqrt{P}$
Solving for pressure (psi)	$Q = K \times \sqrt{P}$
Solving for flow rate (gpm)	$P = (Q \div K)2$

Now that we have all the pieces, lets put this puzzle together with a practice problem!

What is the K-Factor of a sprinkler head that is flowing at 18 psi at a flow rate of 28 gpm?

What are Hydraulic Calculations?

22.4.2.1 Friction Loss Formula.

22.4.2.1.1 Pipe friction losses shall be determined on the basis of the Hazen–Williams formula, as follows:

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}}$$

where:

p = frictional resistance in psi per foot of pipe
Q = flow in gpm
C = friction loss coefficient
d = actual internal diameter of pipe in inches

What are Hydraulic Calculations?

Table 22.4.4.7 Hazen–Williams *C* Values

Pipe or Tube	*C* Value*
Unlined cast or ductile iron	100
Black steel (dry systems including preaction)	100
Black steel (wet systems including deluge)	120
Galvanized (all)	120
Plastic (listed) all	150
Cement-lined cast or ductile iron	140
Copper tube or stainless steel	150
Asbestos cement	140
Concrete	140

What are Hydraulic Calculations?

Hazen-Williams Example

If a pressure gage is reading 40 psi at one end of a 32-foot section of 2-inch schedule 40 pipe (C = 120) flowing at 110 gpm, what will a gage at the other end read?

$$P_L = \frac{4.52Q^{1.85}}{C^{1.85}d_i^{4.87}} = \frac{4.52(110\text{gpm})^{1.85}}{(120)^{1.85}(2.067\text{in})^{4.87}}$$

$$P_L = 0.112 \text{ psi/ft}$$

Pressure lost in 1 foot of pipe = 0.112 psi

Pressure lost in 32 feet of pipe = 32 x 0.112 = 3.584 psi

Other end gauge will read = 40 – 3.584 psi = 36.416 psi

Density / Area Curve (NFPA 13)

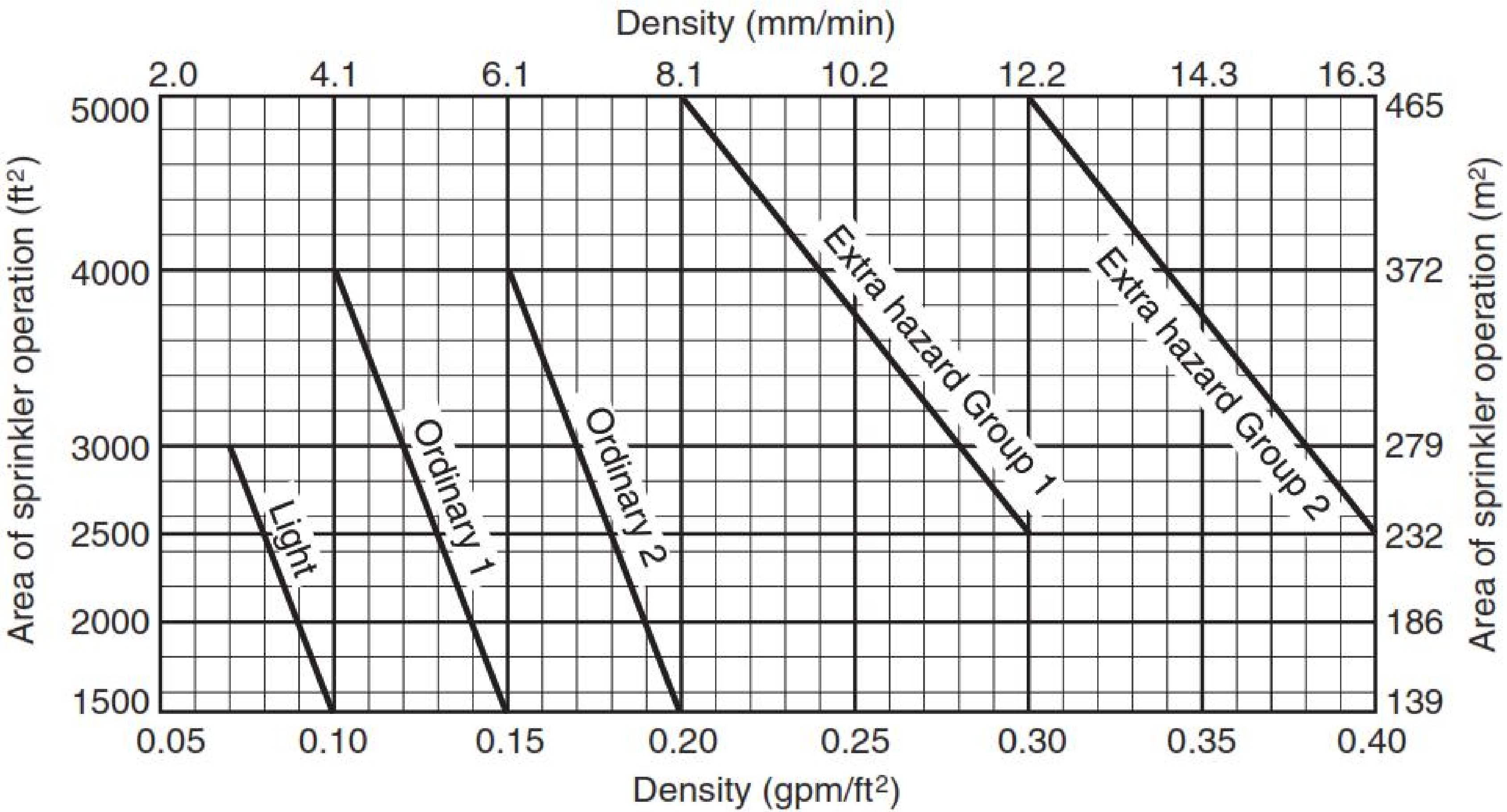


FIGURE 11.2.3.1.1 **Density/Area Curves.**

Densities and Remote Area

NFPA-13, (2007) Figure 11.2.3.1.1 displays five density/area curves overlain 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.

Sprinkler Coverage

Table 5-6.2.2(a) Protection Areas and Maximum Spacing (Standard Spray Upright/Standard Spray Pendent) for Light Hazard

Construction Type	System Type	Protection Area ft²	Protection Area m²	Spacing (maximum) ft	Spacing (maximum) m
Noncombustible obstructed and unobstructed and combustible unobstructed	Pipe schedule	200	18.6	15	4.6
	Hydraulically calculated	225	20.9	15	4.6
Combustible obstructed	All	168	15.6	15	4.6
Combustible with members less than 3 ft on center	All	130	12.1	15	4.6

Table 5-6.2.2(b) Protection Areas and Maximum Spacing (Standard Spray Upright/Standard Spray Pendent) for Ordinary Hazard

Construction Type	System Type	Protection Area ft²	Protection Area m²	Spacing (maximum) ft	Spacing (maximum) m
All	All	130	12.1	15	4.6

Number of Sprinklers Remote Area

Total number of sprinklers = Remote Area (Design Area) / Area covered by one sprinkler.

$$\text{Total Number of Sprinkler in Remote Area} = \frac{\text{Remote Area (Design Area)}}{\text{Area covered by one Sprinkler}}$$

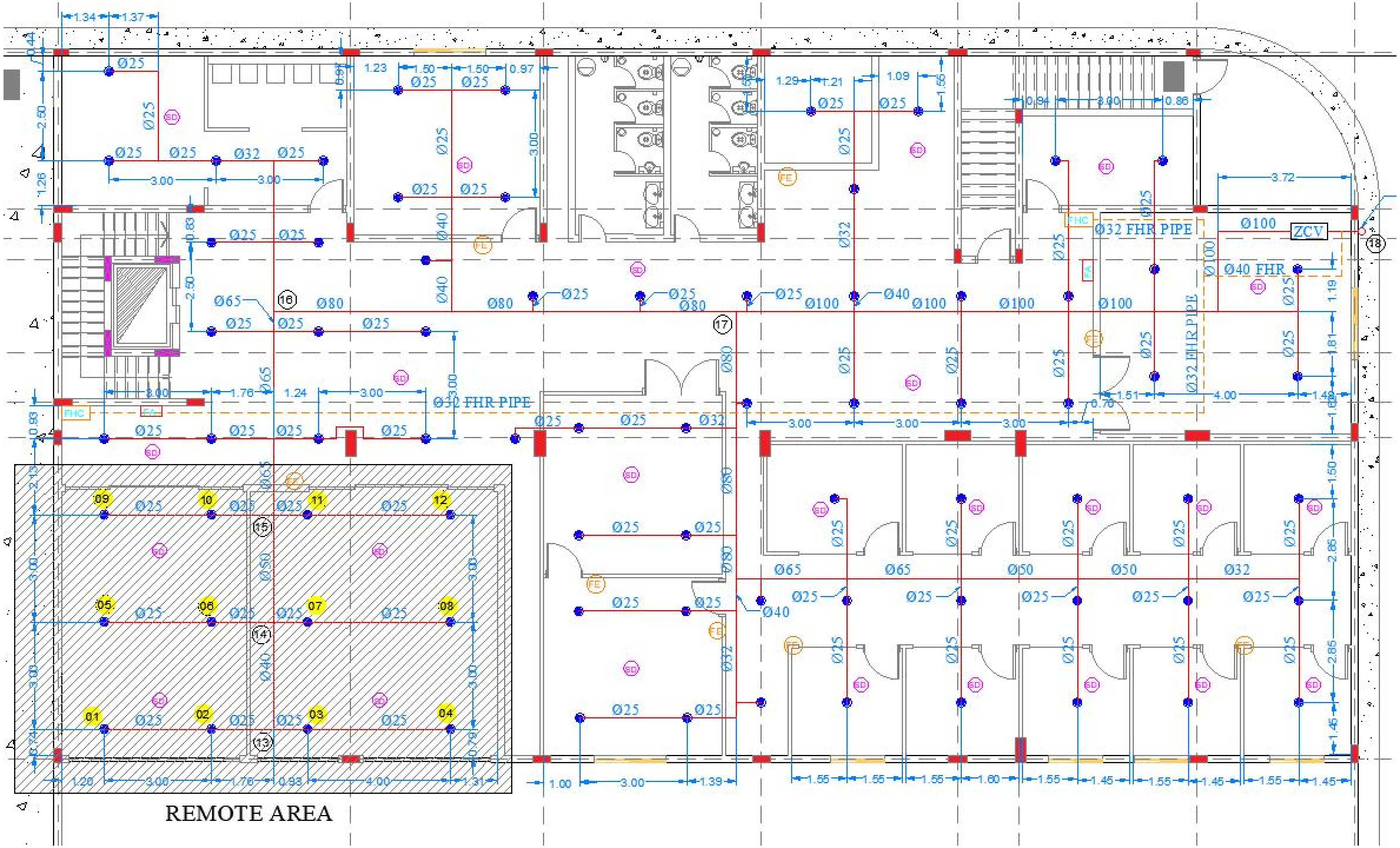
$$\text{Total Number of Sprinkler in Remote Area} = \frac{1500\ ft^2}{130\ ft^2}$$

$$\text{Total Number of Sprinkler in Remote Area} = 11.538$$

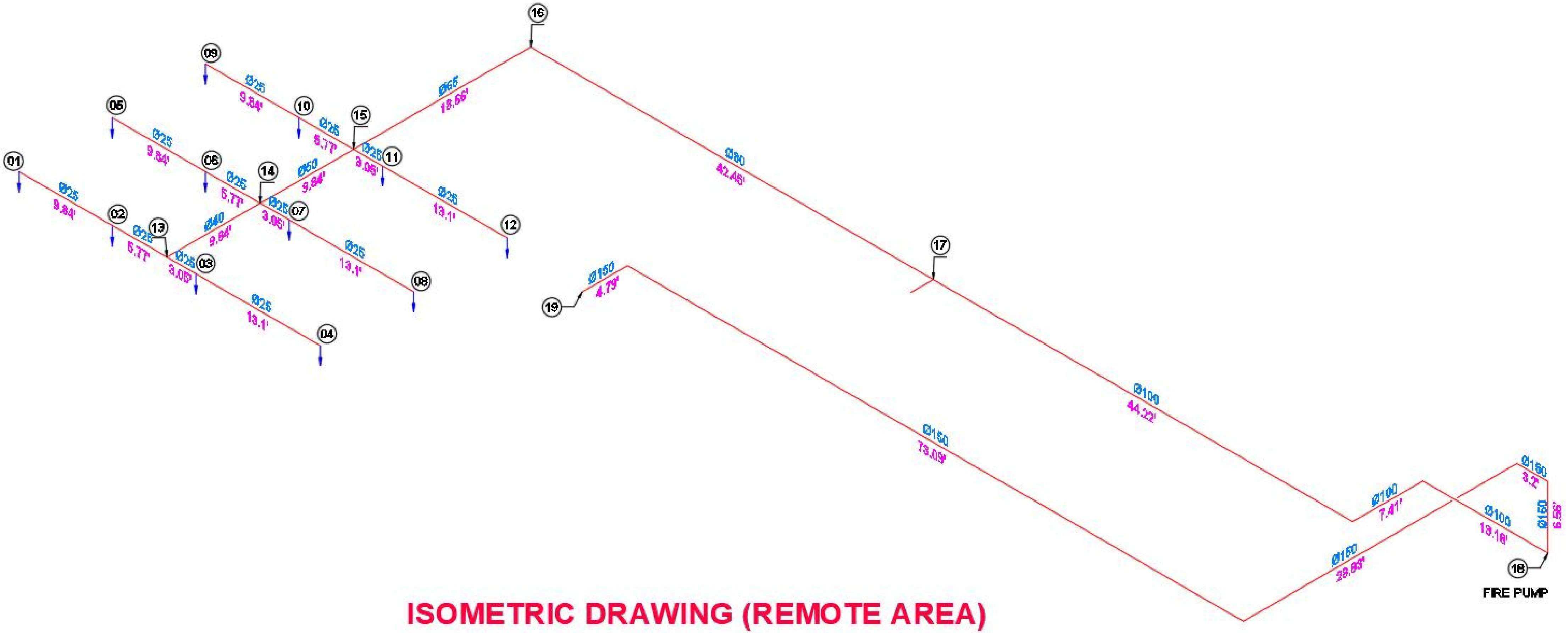
Rounding off 11.538 to nearest whole number we get 12 number of sprinklers.

Therefore, we should consider 12 Nos. of sprinkler heads for design purpose and hydraulic calculations which the water tank at roof should deliver for sprinklers to discharge water in case of fire.

Remote Area Example



Sample Hydraulic Calculation



ISOMETRIC DRAWING (REMOTE AREA)

Sample Hydraulic Calculation

Calculation @ Sprinkler # 1

According to NFPA minimum pressure required at last sprinkler in Light Hazard, P = 15 psi

K – Factor, K = 5.6

Using discharge formula, Q = K x √P

Q = 5.6 √15 = 21.688 gpm

Therefore, Q_1 = 21.688 gpm, P_1 = 15 psi.

Calculation @ PIPE SECTION 1-2

To get pressure and discharge at sprinkler # 2, we need to calculate pressure loss in section 1-2 using Hazen-Williams Formula.

Q = 21.688 gpm, C = 120, d = 1.049”

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}}$$

Putting these values, we get:

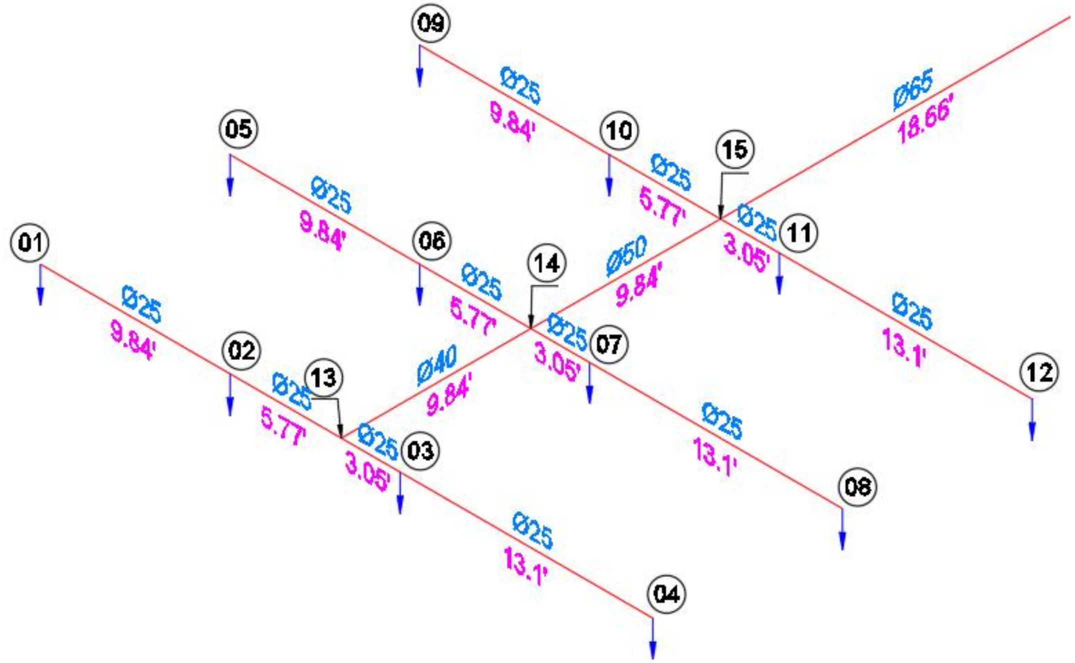
p = 0.1512 psi / feet.

Pressure lost in 1 foot = 0.1512

Pressure loss in 9.84’ = 9.84 x 0.1512 = 1.487 psi.

Pressure required at Sprinkler # 2, P2 = 15+1.487

P_2 = 16.487 psi



Note :

If pipe length in meter, multiply 3.28 to get in feet

1 mtr = 3.28 feet

q stands for individual discharge at given sprinkler

Q stands for total discharge at given sprinkler.

Sample Hydraulic Calculation

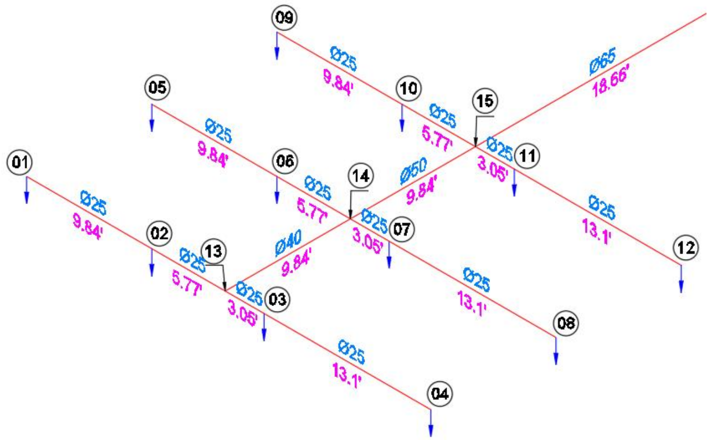
Calculation @ PIPE SECTION 1-2 (Cont…)

But wait, we have fittings also in pipe sections. Pipe section 1-2 has one elbow size 1” x 90° . Using below table 1” elbow is equivalent to 2 feet length. Fitting loss = 0.1512 psi/foot x 2 = 0.302 psi.
Total loss in section 1-2 = Pipe loss + fitting loss = 1.487 + 0.302 = 1.789 psi.
Therefore, pressure required at sprinkler # 2 = 15 + 1.789 = 16.789 psi. Hence, P_2 = 16.789 psi

Table 22.4.3.1.1 Equivalent Schedule 40 Steel Pipe Length Chart

Fittings and Valves	Fittings and Valves Expressed in Equivalent Feet (Meters) of Pipe														
	½ in. (15 mm)	¾ in. (20 mm)	1 in. (25 mm)	1¼ in. (32 mm)	1½ in. (40 mm)	2 in. (50 mm)	2½ in. (65 mm)	3 in. (80 mm)	3½ in. (90 mm)	4 in. (100 mm)	5 in. (125 mm)	6 in. (150 mm)	8 in. (200 mm)	10 in. (250 mm)	12 in. (300 mm)
45° elbow	—	1 (0.3)	1 (0.3)	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	3 (0.9)	3 (0.9)	4 (1.2)	5 (1.5)	7 (2.1)	9 (2.7)	11 (3.4)	13 (4)
90° standard elbow	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	7 (2.1)	8 (2.4)	10 (3)	12 (3.7)	14 (4.3)	18 (5.5)	22 (6.7)	27 (8.2)
90° long-turn elbow	0.5 (0.2)	1 (0.3)	2 (0.6)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	5 (1.5)	6 (1.8)	8 (2.4)	9 (2.7)	13 (4)	16 (4.9)	18 (5.5)
Tee or cross (flow turned 90°)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	8 (2.4)	10 (3)	12 (3.7)	15 (4.6)	17 (5.2)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	50 (15.2)	60 (18.3)
Butterfly valve	—	—	—	—	—	6 (1.8)	7 (2.1)	10 (3)	—	12 (3.7)	9 (2.7)	10 (3)	12 (3.7)	19 (5.8)	21 (6.4)
Gate valve	—	—	—	—	—	1 (0.3)	1 (0.3)	1 (0.3)	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)
Swing check*	—	—	5 (1.5)	7 (2.1)	9 (2.7)	11 (3.4)	14 (4.3)	16 (4.9)	19 (5.8)	22 (6.7)	27 (8.2)	32 (9.3)	45 (13.7)	55 (16.8)	65 (20)

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.



Sample Hydraulic Calculation

Fittings can be excluded as per below NFPA section:

22.4.4.7 Friction Loss. Pipe friction loss shall be calculated in accordance with the Hazen–Williams formula with *C* values from Table 22.4.4.7, as follows:

(1) Include pipe, fittings, and devices such as valves, meters, flow switches in pipes 2 in. or less in size, and strainers, and calculate elevation changes that affect the sprinkler discharge.

(2) Tie-in drain piping shall not be included in the hydraulic calculations.

(3) Calculate the loss for a tee or a cross where flow direction change occurs based on the equivalent pipe length of the piping segment in which the fitting is included.

(4) The tee at the top of a riser nipple shall be included in the branch line, the tee at the base of a riser nipple shall be included in the riser nipple, and the tee or cross at a cross main-feed main junction shall be included in the cross main.

(5) Do not include fitting loss for straight-through flow in a tee or cross.

(6) Calculate the loss of reducing elbows based on the equivalent feet value of the smallest outlet.

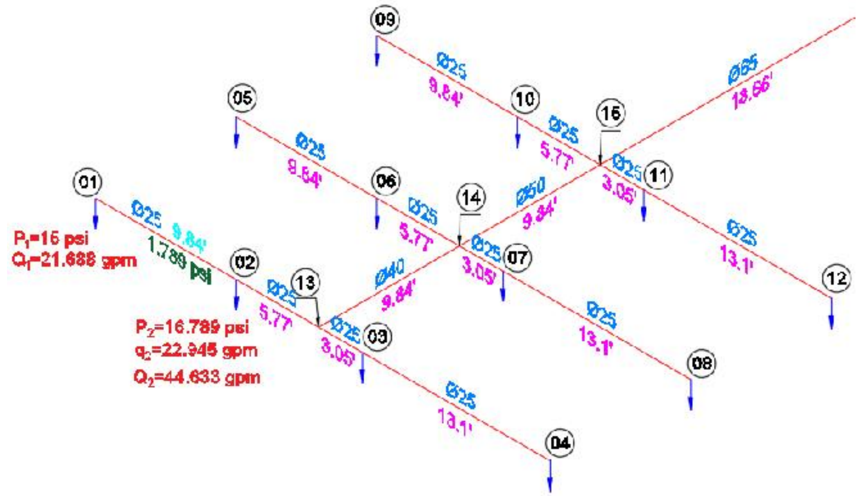
(7) Use the equivalent feet value for the standard elbow on any abrupt 90 degree turn, such as the screw-type pattern.

(8) Use the equivalent feet value for the long-turn elbow on any sweeping 90 degree turn, such as a flanged, welded, or mechanical joint-elbow type. *(See Table 22.4.3.1.1.)*

(9) Friction loss shall be excluded for the fitting directly connected to a sprinkler.

(10) Losses through a pressure-reducing valve shall be included based on the normal inlet pressure condition. Pressure loss data from the manufacturer's literature shall be used.

Sample Hydraulic Calculation



Calculation @ Sprinkler # 2

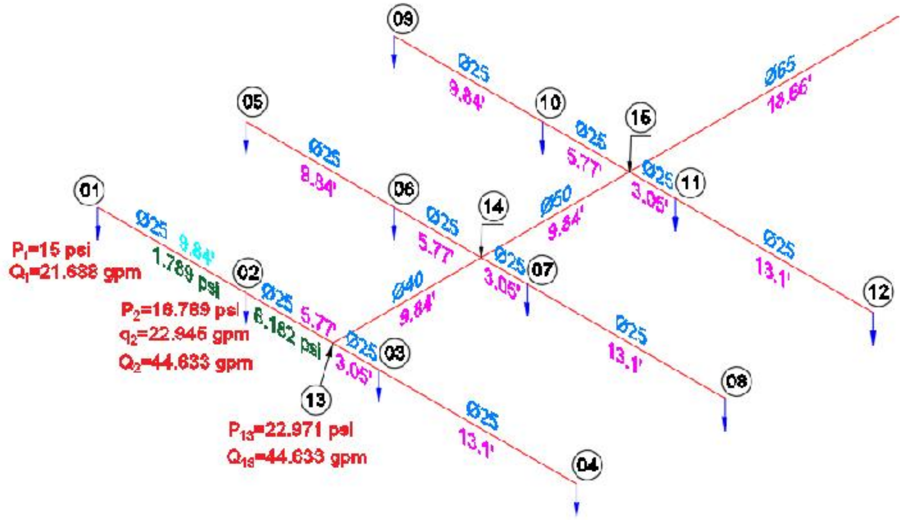
Pressure at Sprinkler # 2 , P2 = 16.789 psi.

K – Factor, K = 5.6

Using discharge formula, $q_2 = K \times \sqrt{P_2}$

$q_2 = 5.6 \sqrt{16.789} = 22.945$ gpm

Therefore, $q_2 = 22.945$ gpm, $P_2 = 16.789$ psi.



Calculation @ PIPE SECTION 2-13

using Hazen-Williams Formula.

Total discharge at Sprinkler # 2, $Q_2 = Q_1 + q_2$

$= 21.688 + 22.945$

$= 44.633$ gpm

Q = 44.633 gpm, C = 120, d = 1.049”, we get:

p=0.574 psi/feet (1 foot = 0.574 psi of loss)

In this section we have 1 Tee equal 5 feet.

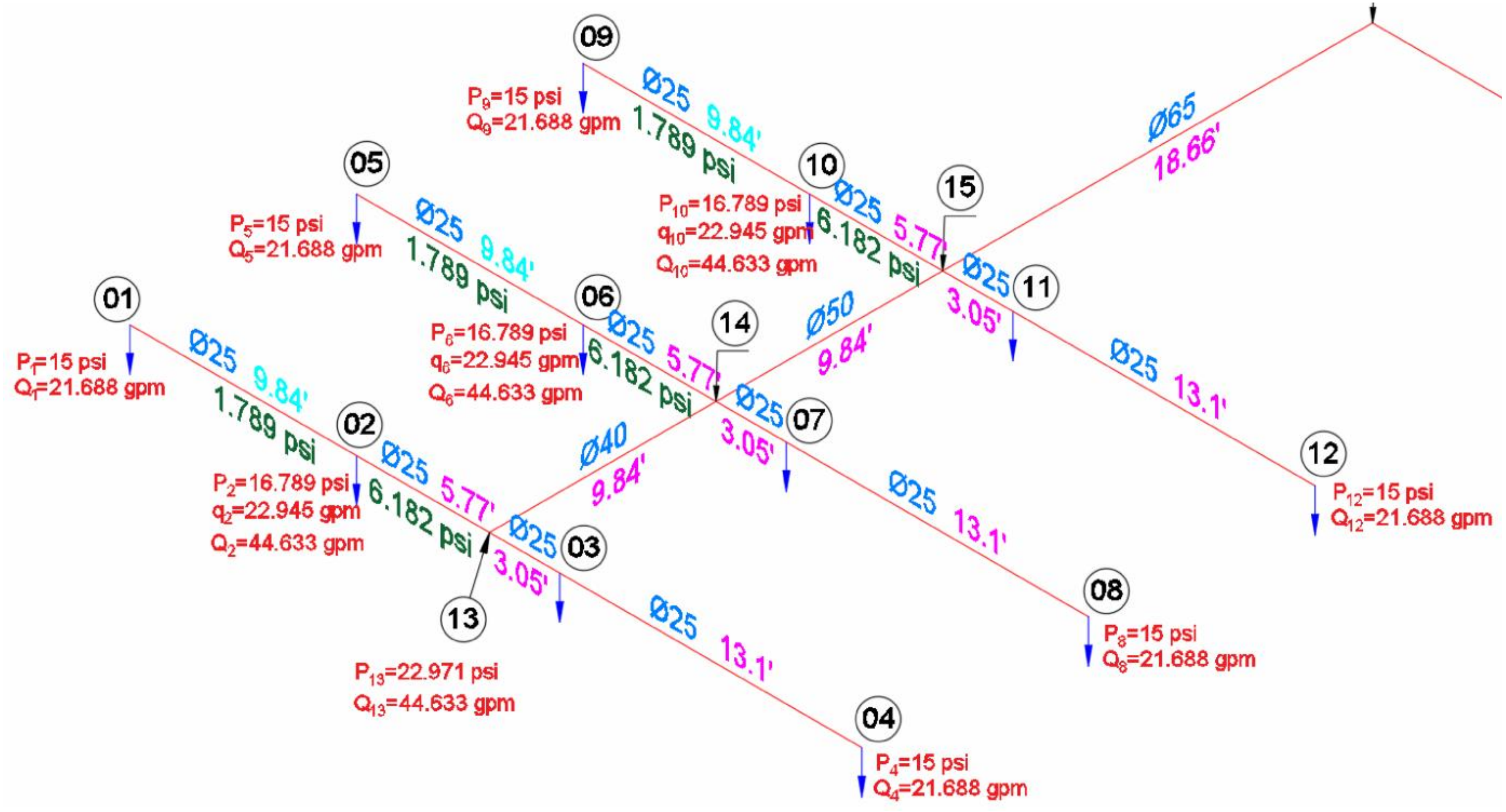
Total Pipe + Fitting length = 5.77+5 = 10.77 feet

Total loss in section 2-13 = 10.77x0.574 = 6.182 psi

Pressure required at Point # 13 = 16.789 + 6.182

$P_{13} = 22.971$ psi

Sample Hydraulic Calculation



Since pipe sections 1-2-13, 5-6-14 & 9-10-15 are identical. Calculations will be same. Similarly, Sprinkler No. 1, 5, 9, 4, 8 & 12 are called end sprinklers and will have same minimum pressure P = 15 psi and Discharge Q = 21.688 gpm

Sample Hydraulic Calculation

Calculation @ Sections 4-3, 8-7 & 12-11

Using Hazen-Williams Formula.

Q = 21.688 gpm, C = 120, d = 1.049”

Putting these values, we get:

p = 0.1512 psi / feet.

Pressure lost in 1 foot = 0.1512

We have one 1” Elbow equals 2’ length.

Total Pipe + Fitting Length = 13.1+2 = 15.1’

Pressure loss in 15.1’ = 15.1 x 0.1512

= 2.283 psi.

Pressure required at Sprinkler # 3

= 15+2.283

$P_3 = P_7 = P_{11} = 17.283$ psi

Discharge at sprinklers 3, 7 & 11:

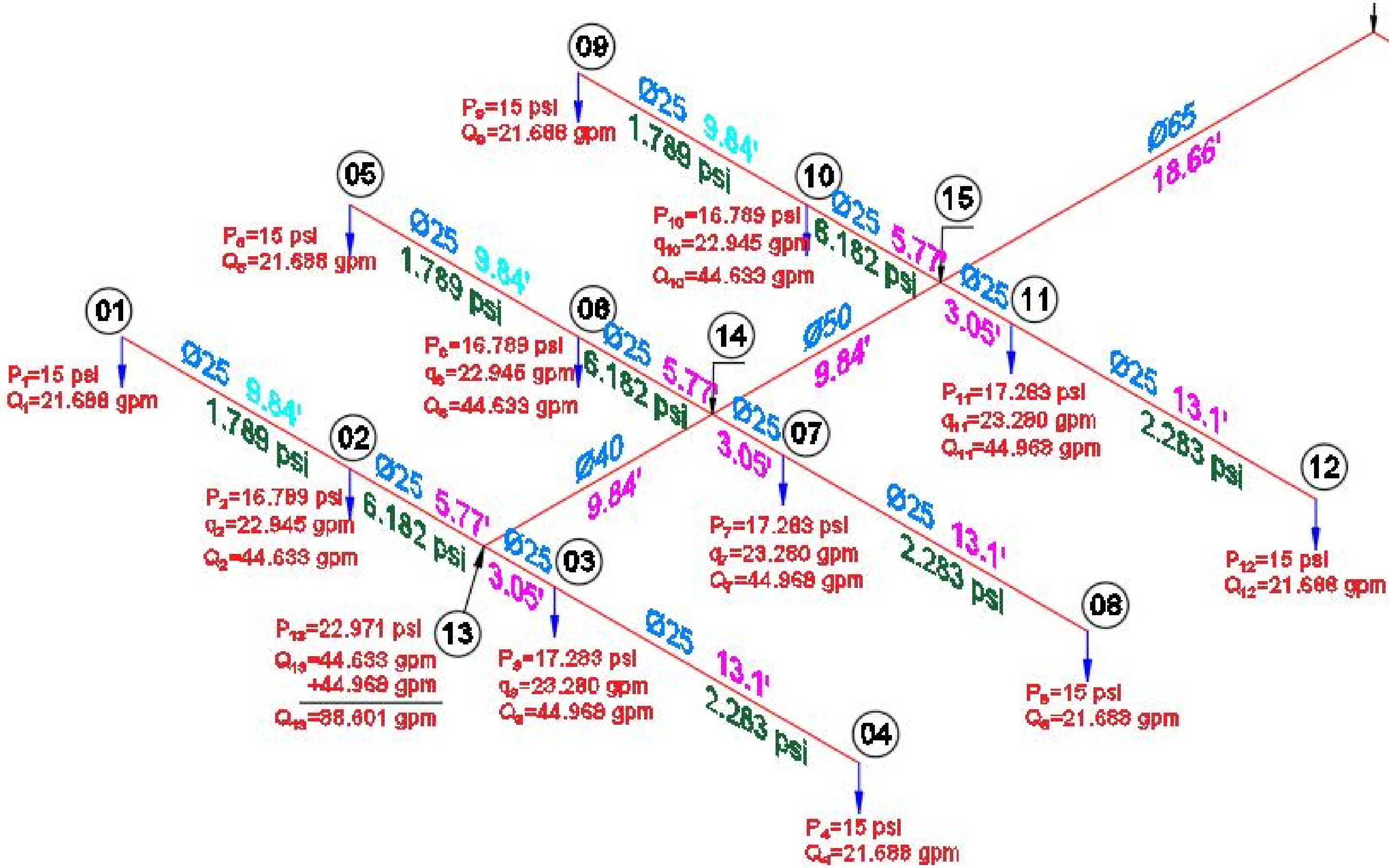
Q = K x √P = 5.6 x √17.283 = 23.280 gpm

$q_3 = q_7 = q_{11}$ = 23.280 gpm

Total discharge at 3, 7, 11:

Q = 21.688 + 23.280 = 44.968 gpm

$Q_3 = Q_7 = Q_{11}$ = 44.968 gpm



Sample Hydraulic Calculation

Calculation @ Sections 3-13, 7-14 & 11-15

Using Hazen-Williams Formula.

Q = 44.969 gpm, C = 120, d = 1.049”

Putting these values, we get:

p = 0.582 psi / feet.

We have one 1” Tee in this section

Total Pipe + Fitting Length = 3.05+5 = 8.05’

Pressure loss in 8.05’ = 8.05 x 0.582

= 4.685 psi.

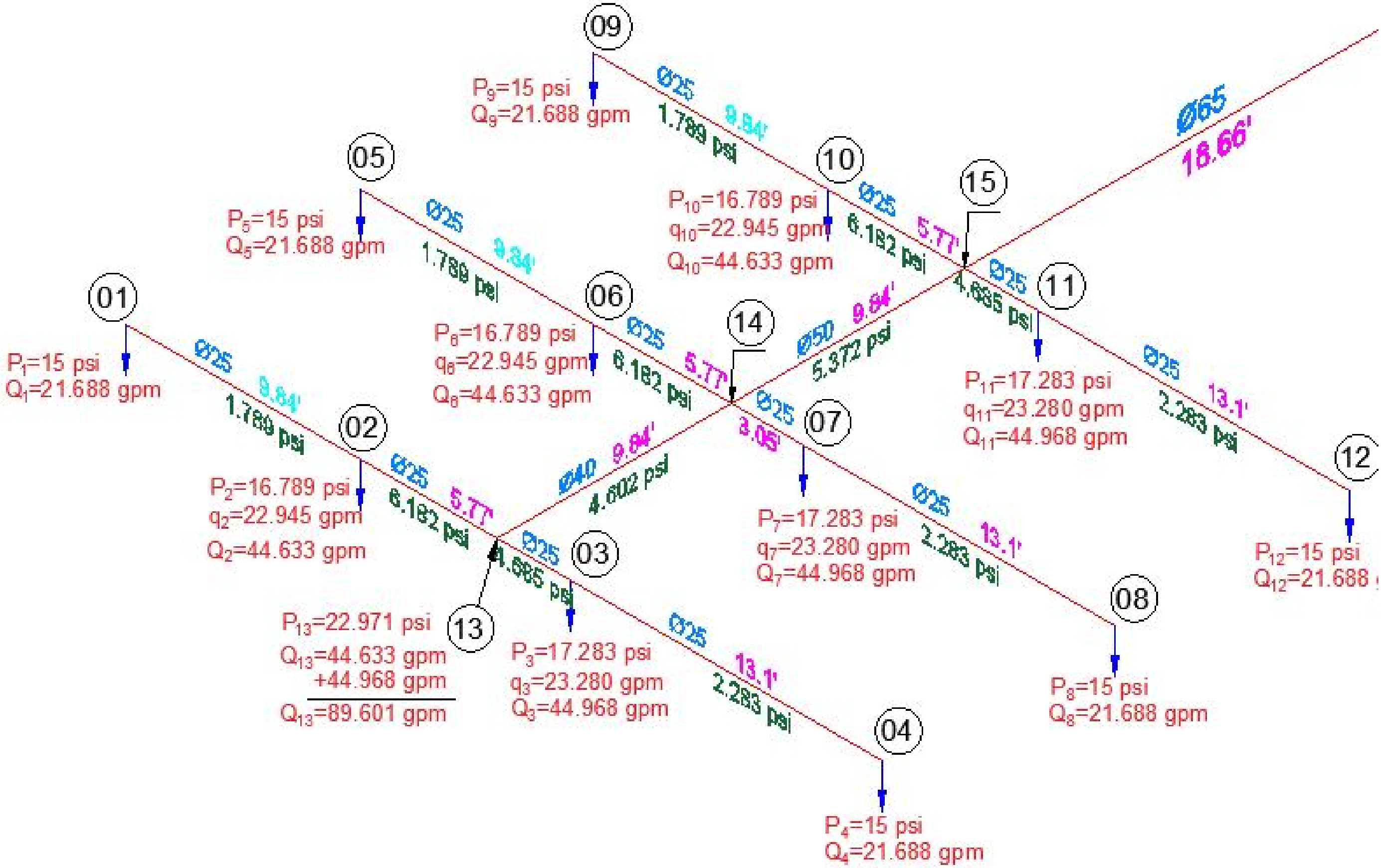
Pressure required at Sprinkler # 13

= 17.288+4.685

P_{13} = 21.973 psi

Please note at point 13 we have two pressures. 22.971 psi required for sprinkler #2 and # 1 and 21.973 psi required for sprinkler # 4 and # 3.

We use higher pressure (22.971 psi) to calculate pressure loss in next pipe section 13-14.



Sample Hydraulic Calculation

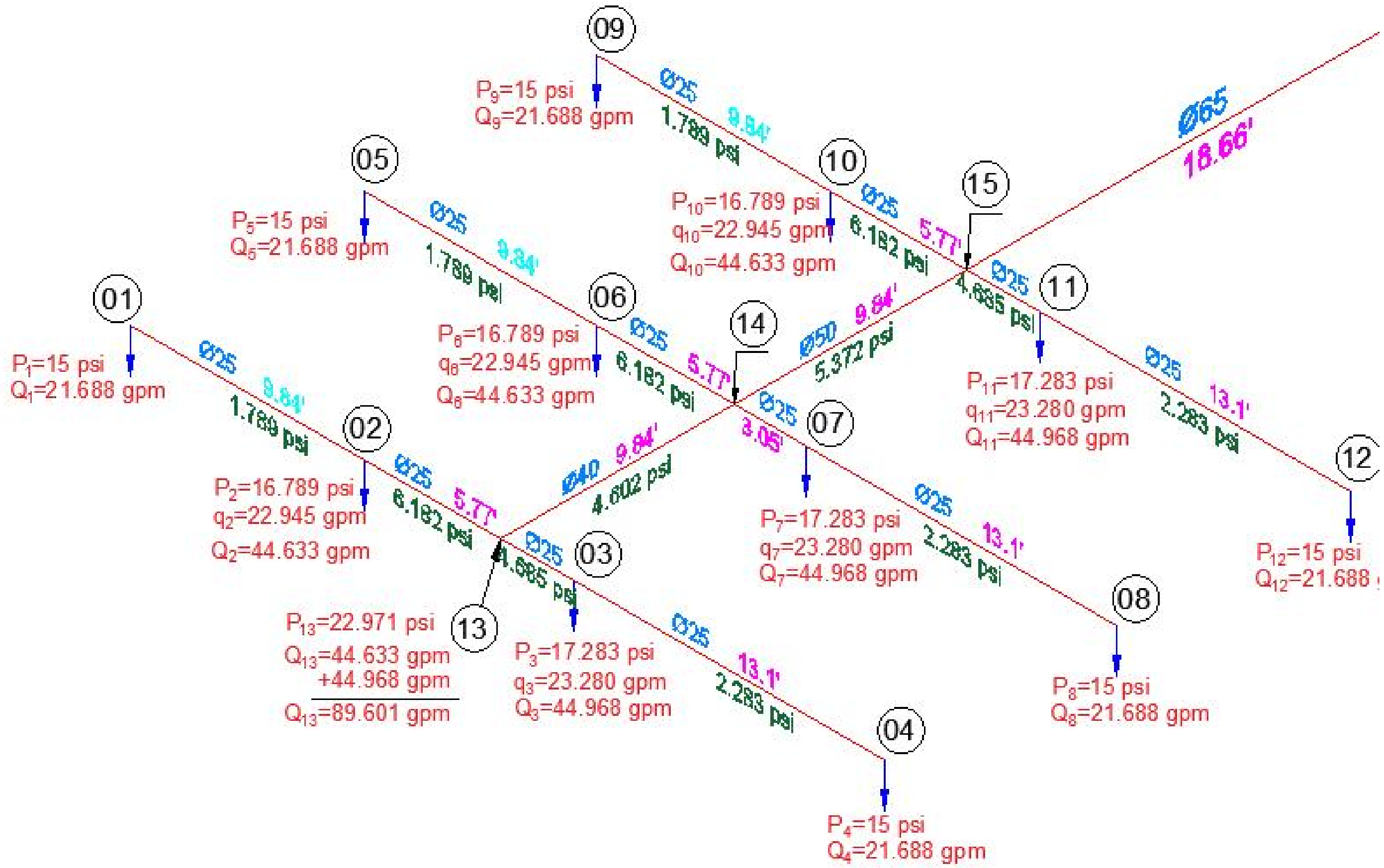
Calculation @ Sections 13-14

At point 13, P = 22.971, Q (total) = 88.601
(Flow for all 04 Nos. sprinklers)

Using Hazen-Williams Formula.
Q = 89.601 gpm, C = 120, d =1.61” (1-1/2”)
Putting these values, we get:
p = 0.258 psi / feet.
We have one 1” Tee in this section
Total Pipe + Fitting Length=9.84+8 =17.84’
Pressure loss in 17.84’ = 17.84 x 0.258
Loss in section 13-14 = 4.602 psi.

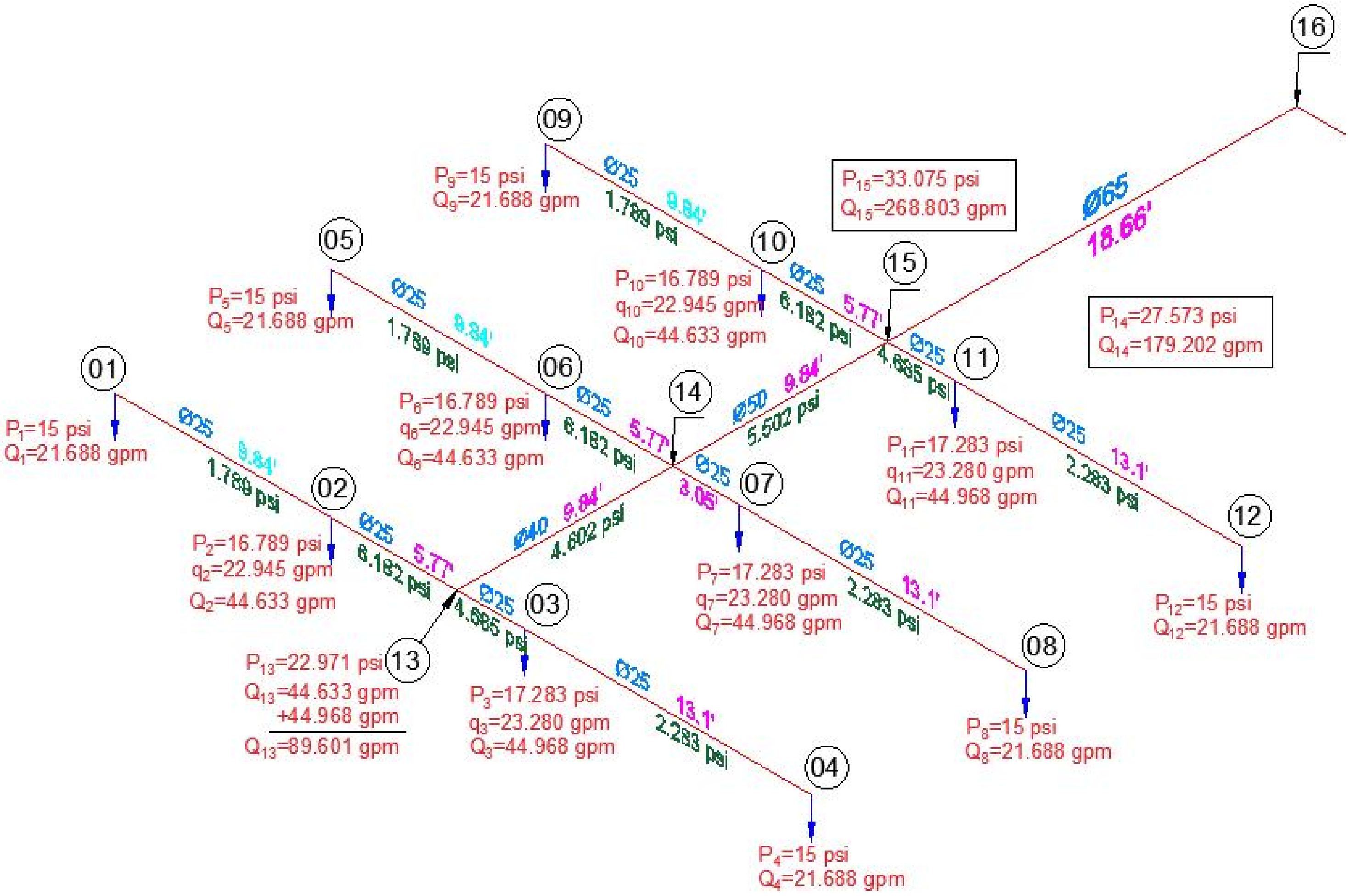
Pressure required at point 14:
= 22.971 + 4.602
P_{14} = 27.573 psi

Total discharge at point 14:
= Discharge of 08 nos. sprinklers
(01, 02, 03, 04, 05, 06, 07 & 08)
Q_{14} = 177.202 gpm



Sample Hydraulic Calculation

We repeat the same procedure up to point 15 and get the following:



Sample Hydraulic Calculation

Calculation @ Sections 15-16

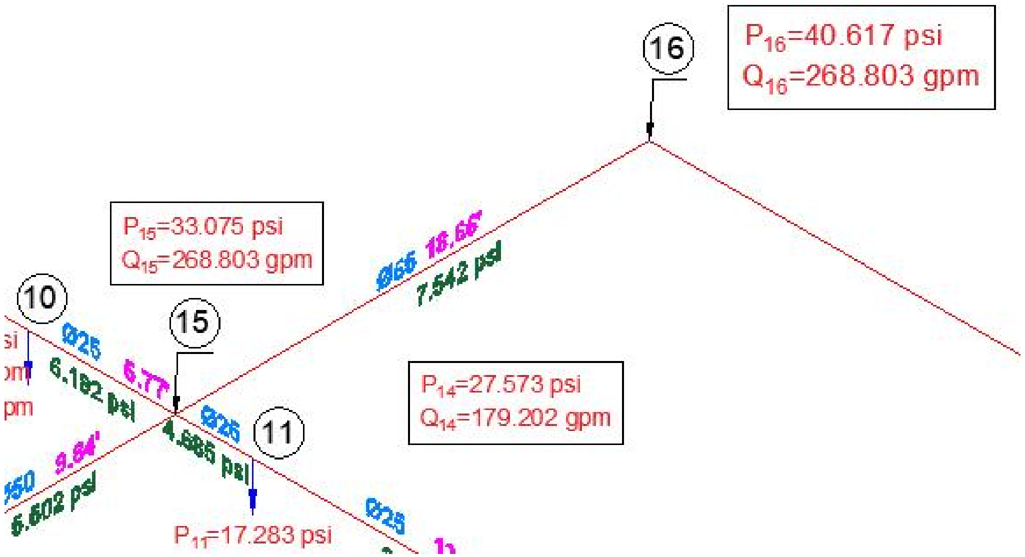
At point 15, Q = 268.803 and P = 33.075 psi

Using Hazen-Williams Formula.
Q = 268.803, C=120, d = 2.469” (2-1/2”)
Putting these values, we get:
p = 0.246 psi / feet.
We have 1 tee equal 12 feet.
Total Length = 18.66+12 = 30.66’
Total loss in section 15-16 = 30.66x0.246
= 7.542 psi

Pressure required at point 16:
= 33.075 +7.542
P_{16} = 40.617 psi.

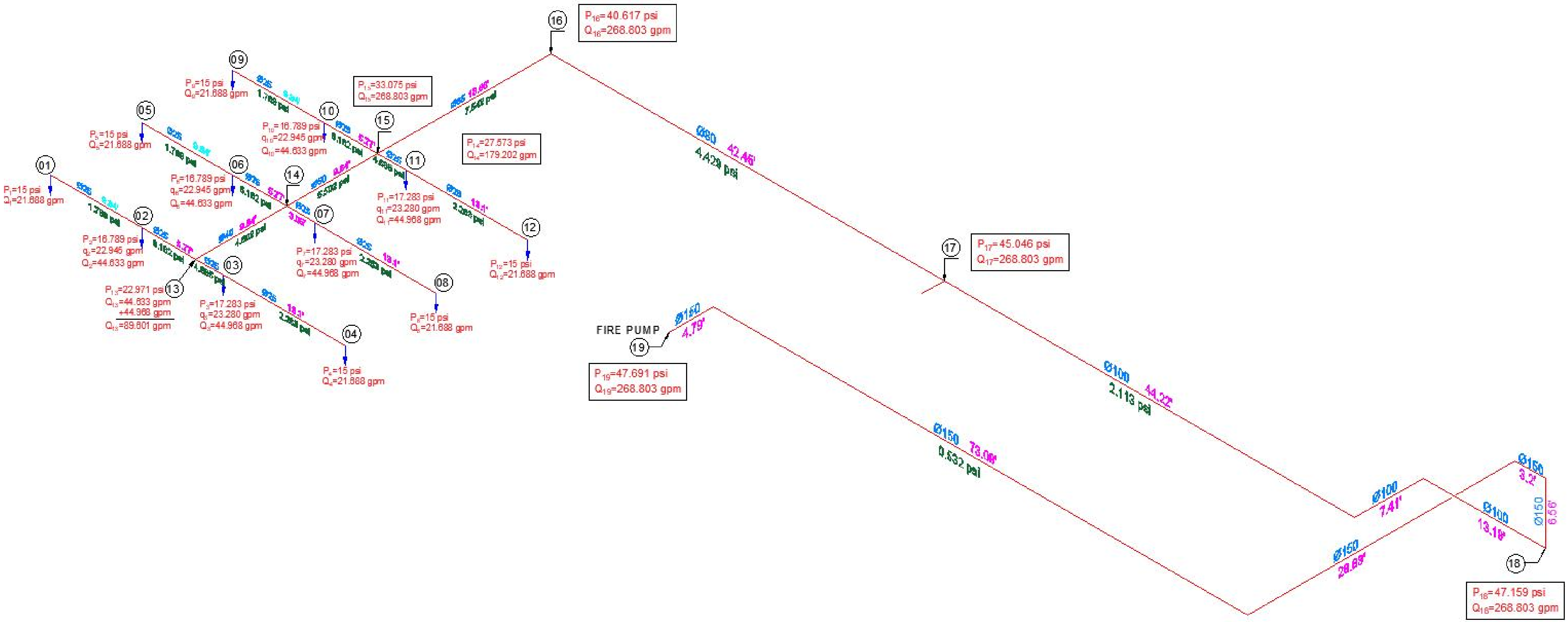
Total discharge remains same since no sprinklers are added.

Q_{16} = 268.803 gpm



Sample Hydraulic Calculation

We repeat the same procedure up to point 19 (Fire Pump) and get the following:



Pressure due to Elevation (height)

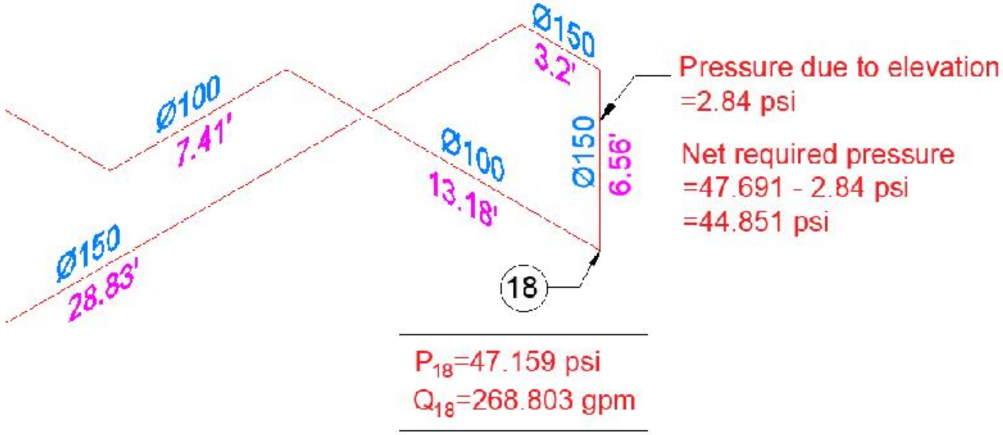
1 Bar Pressure = 14.5 psi Pressure.
1 Bar = 10 mtr of pressure head.

(In BS units, 1 foot of elevation = 0.433 psi/ft pf pressure).

10 mtr = 14.5 psi
1 mtr = 14.5 / 10 = 1.45 psi

Pipe going up from GF high level to roof = 6.56 feet.
(Since we have converted length to feet we will use BS units)

Therefore, 6.56 feet = 6.56 x 0.433 psi
= 2.84 psi
If fire pump is on GF and lifting water upwards,
we need 2.84 psi of pressure to lift water up to a height of 6.65 feet.
But in this case fire pump is on roof and it is pumping water downwards.
Therefore, we have to subtract 2.84 from total required pressure.
Net required pressure, P = 47.691 – 2.84
= 44.851 psi



Fire Hose Reel Calculations

Hose stream allowance

NFPA 13, section 11.1.4.2 states that "**The minimum water supply requirements for a sprinkler system shall be determined by adding the hose stream allowance to the water supply of sprinklers**"

Hose stream allowance or demand is the amount of additional water that is added to the sprinkler hydraulic calculation design, when hose connections are added to sprinkler systems.

For Light Hazard system, Hose stream allowance = 100 gpm.

Therefore, total water required for fire fighting system:

= 268.803 + 100 gpm

= 368.803 gpm (gallons per minute)

Notice there is no additional pressure required for the hose allowance. It is simply added as flow since the fire department will use the pump on the pumper truck to produce the pressure needed.

Table 11.2.3.1.2 Hose Stream Allowance and Water Supply Duration Requirements for Hydraulically Calculated Systems

	Inside Hose		Total Combined Inside and Outside Hose		
Occupancy	gpm	L/m	gpm	L/m	Duration (minutes)
Light hazard	0, 50, or 100	0, 189, 379	100	379	30
Ordinary hazard	0, 50, or 100	0, 189, 379	250	946	60–90
Extra hazard	0, 50, or 100	0, 189, 379	500	1893	90–120

Fire Pump Capacity and Pressure

Flow Rate (gpm)
Minimum flow rate required for Fire Pump shall be 368.803 gpm. Rounding off,
Minimum flow rate for fire pump = 370 gpm (gallons per minute)

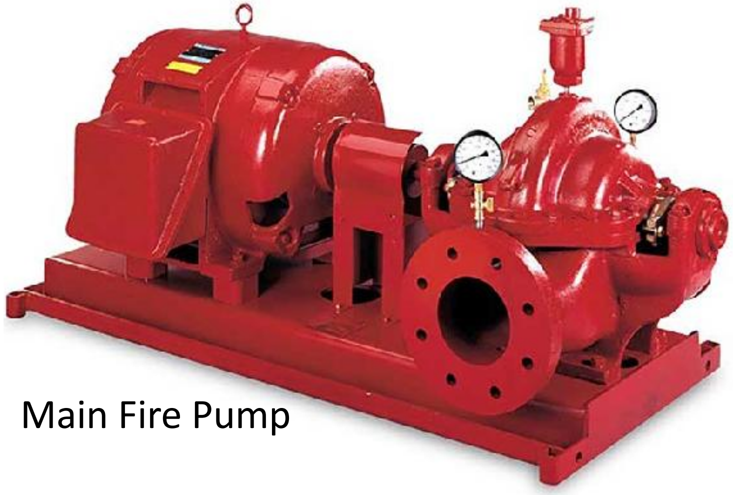
Minimum Pressure
Pressure required for sprinkler system = 44.851 psi = 45 psi
Pressure required for FHR system = 65 psi

Hence the minimum pressure for system will be 65 psi
Total pressure required for Fire Fighting system = 65psi (4.5 bar)

Therefore, main fire pump shall be 370 gpm @ 65 psi.
Or 370 gpm @ 4.5 bar (1 bar = 14.5 psi)

Jockey Pump Capacity and Pressure
Jockey Pump capacity shall be 5% of main fire pump capacity.
Therefore, Jockey pump capacity = 0.05* 370 = 18.5 gpm = 20 gpm

Jockey pump pressure shall be 0.5 bar more than main pump pressure. Therefore, Jockey pump pressure = 4.5 + 0.5 = 5 bar.
Therefore, Jockey pump shall be 20 gpm @ 5 bar



Main Fire Pump

Jockey Fire Pump

Fire Tank Capacity

From above calculation we get total required water flow rate is 370 gpm.

According to Fire Brigade and NFPA regulations, water tank shall have designed for 30 minutes' operations in Light Hazard occupancies in case of emergency fire. This means there should enough water in tank to run fire pump for at least 30 minutes duration till fire trucks arrives.

Therefore, total tank capacity = 370 gpm x 30 minutes
= 11,100 Gallons
= 11,100/264
= 42 m^3 (1 m^3 = 264 Gallons)

Tank dimensions = 7 x 3 x 2 = 42 m^3
Therefore, L = 7 m, B = 3 m and H = 2 m

Weight of the Tank:

Mass = Volume x Density
= 42 x 1000 kg (Density of water = 1000 kg/m^3)
= 42,000 kg
= 42 Tons (1 Ton = 1000 Kg)

THANK YOU