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METC 279

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**Fire Protection**

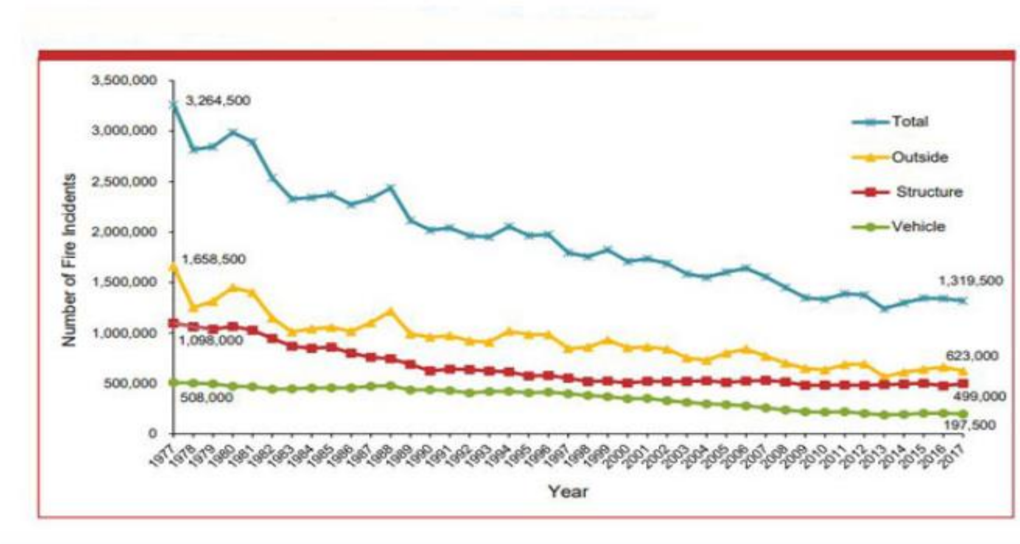
**https://bcfdmo.com/wp-content/uploads/2018/08/fire_sprinkler_shutterstock-1526667017-1479-300x225.jpg**

**Abstract:**

Each and every day, all across the world, many people travel to their places of employment or places where they must enter some sort of building structure. Often times, people don't enter a building thinking about a fire occurring. Most of the times people don't walk in a building and think about the building burning or something catching fire, what kind of Fire Protection System the building has, or what does a fire protection system look like. According to *https://www.nfpa.org/public-education/campaigns/fire-prevention-week/fire-facts,* fire departments responded to 1,319,500 fires in 2017. It is said that a structure fire occurs every 63 seconds. While that 1.3 million number is not all structural fires, data shows that 499,000 of them were. Fire Protection is such a critical factor when it comes to the construction and design of a building. As Shambaugh & Son puts it, "Fire Sprinklers Save

Lives". This statement is simple, yet so relevant in today's society. Safety is one of the world's most important issues and when it comes to fires, lives are on the line. This is why I have chosen to write about Fire Protection.

**Fires in the U.S. during 2017 by type**




***https://www.nfpa.org/public-education/campaigns/fire-prevention-week/fire-facts*l**

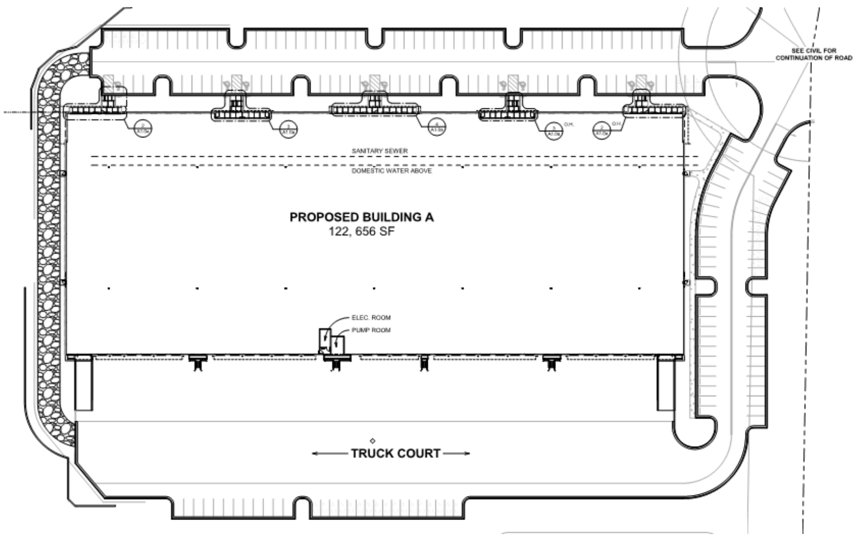
**Introduction:**

The purpose of this technical report is to inform you on How To Design A ESFR Fire Protection System Layout for an estimator to bid the project. This design can commonly be found in warehouses and manufacturing facilities with areas that require protection for high-piled storage occupancies. The acronym ESFR stands for Early Suppression Fast-Response. According to *https://www.vikingsprinkler.com/esfr.php*, this system is designed to suppress a fire by emitting a substantial amount of water straight to the fire to lessen the heat release rate. Unlike other sprinkler heads, after ESFR sprinkler heads detect a fire, the valve releases and large droplets of water come flowing out with a larger momentum than standard heads. Due to the momentum and the size, these water droplets pierce the fire and penetrate all the way down to the bottom and have the full capability of suppressing the fire.

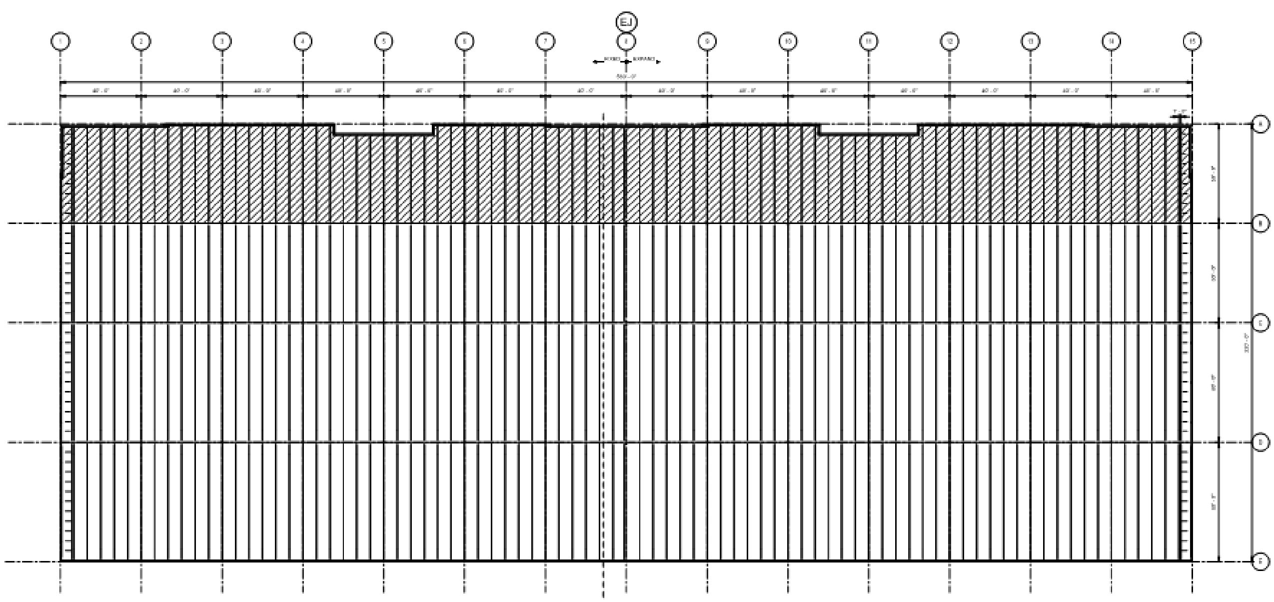
**Design Requirements:**

Per the Scope of work and the requirements, I was asked to design an ESFR, wet-pipe system, for a 560'x220' building that would contain high-piled storage all throughout the building. Due to there being jogs in the building, the actual building size will be 122,716 sqft. The maximum ceiling height shall not exceed 40 ft. Therefore I will use an ESFR pendent sprinkler head with a K-Factor of 16.8 throughout the building for proper and adequate coverage. This building structure requires four separate systems, and four sprinkler riser assemblies.

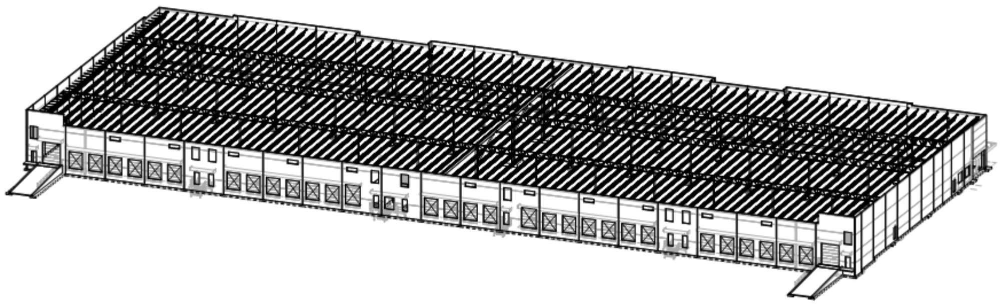
Per the NFPA-13, ESFR sprinklers have a maximum coverage area of 100 sqft per sprinkler head. Each sprinkler head has a maximum spacing of no more than ten feet apart, and a minimum spacing of no less than eight feet apart. In reference to obstructions that will affect the spray pattern, ESFR sprinklers can be no more than half of the maximum allowable distance away from the obstruction, and no closer than four inches away from the obstruction. An example of this would be a wall. The sprinkler head can be no further away than five feet from the wall because as stated earlier, the sprinkler head has a maximum spacing of no more than ten feet apart. Steel obstructions have different rules.




This site plan shows the basic, outer shell of the building, as well as the property layout.
This is useful because it shows me where my pump room is. The pump room is where my four riser sprinkler assembly lead-ins are for the building.




The image above shows my building size of 560’x220’. It shows my A-frame joist pattern that’s running vertical from column line one through fifteen, as well as my expansion joint at column eight. Running horizontally are the girders. These are represented by column lines A through E.



Based on location and size of the building, expansion joints can often hint towards a building being at risk for a seismic catastrophe. This building has an expansion joint, therefore I must perform a seismic risk assessment calculation. Below is the seismic data I will use to determine if this will require a seismic design.

DESIGN SEISMIC INFORMATION:

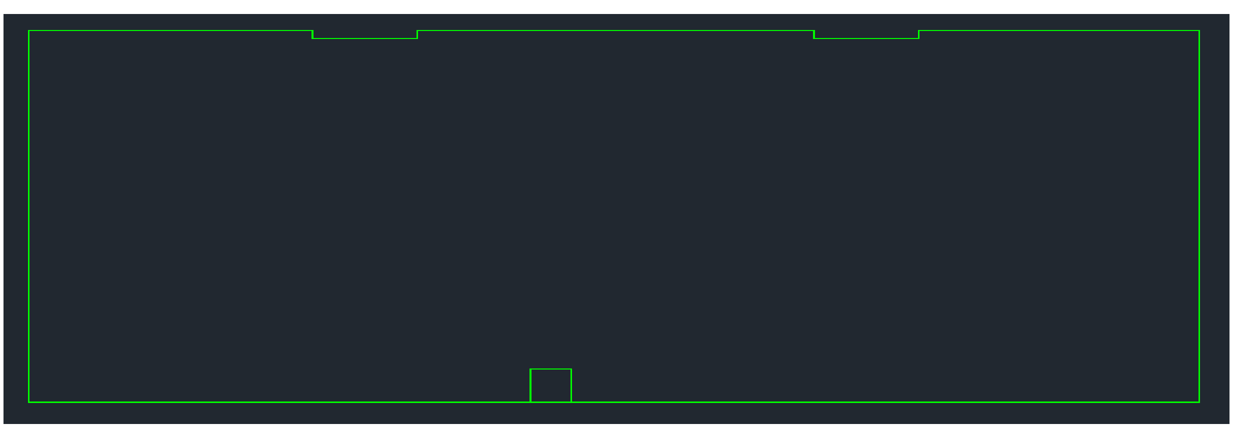
1. RISK CATEGORY: II
2. MAPPED SPECTRAL RESPONSE COEFFICIENT, Ss = 0.216g
3. MAPPED SPECTRAL RESPONSE COEFFICIENT, S1 = 0.096g
4. SPECTRAL RESPONSE COEFFICIENT, Sds = 0.230g
5. SPECTRAL RESPONSE COEFFICIENT, Sd1 = 0.153g
6. SITE CLASS: D
7. BASE SEISMIC-FORCE RESISTING SYSTEM: ORDINARY PRECAST CONCRETE SHEAR WALLS AND ORDINARY STEM WALLS AND STEEL BRACED FRAMES NOT SPECIFICALLY DETAILED FOR SEISMIC RESISTANCE
8. DESIGN BASE SHEAR: 292 K
9. ANALYSIS PROCEDURE: EQUIVALENT LATERAL FORCE (ASCE 7, SECTION 12.8)
10. RESPONSE MODIFICATION FACTOR, R: 3
11. SEISMIC DESIGN CATEGORY: C
12. SEISMIC IMPORTANCE FACTOR, Ie = 1
13. SEISMIC RESPONSE COEFFICIENT, Cs = 0.077

| | |
|---|---|
| **Component Importance Factor (Ip)**<br>The importance factor is always 1.5 for a life safety system | 1.5 |
| **Risk Category (I thru IV)**<br>Table 1604.5 - Nature of Occupancy | II |
| **Mapped Spectral Acceleration for Short Periods (Ss)**<br>Maps 1613.3.1 | 0.216 |
| **Mapped Spectral Acceleration for a 1 second Period (S1)**<br>Maps 1613.3.8 | 0.096 |
| **Site Class (A thru F)**<br>ASCE Chapter 20 - Need Soil Information | D |
| **Site Coefficient (Fa)**<br>Table 1613.3.3(1) - Need Ss & Site Class | |
| **Site Coefficient (Fv)**<br>Table 1613.3.3(2) - Need S1 & Site Class | |
| **Max Considered Earthquake Spectral Response Acceleration-Short Periods (Sms)** | |
| **Max Considered Earthquake Spectral Response Acceleration- 1 sec Period (Sm1)** | |
| **Design Spectral Response Acceleration for Short Periods (Sds)**<br>Calculation: Sds = 2/3 x Sms | 0.230 |
| **Design Spectral Response Acceleration for 1 sec Period (Sd1)**<br>Calculation: Sd1 = 2/3 x Sm1 | 0.153 |
| **Seismic Design Category based on short period response accelerations (A thru F)** | B |
| **Seismic Design Category based on 1 second period response access (A thru F)** | C |
| **Worst Case Above:**<br>A or B = NO; C, D, E, or F = YES | C |
| | |
| **Seismic Design Required:** | **YES** |

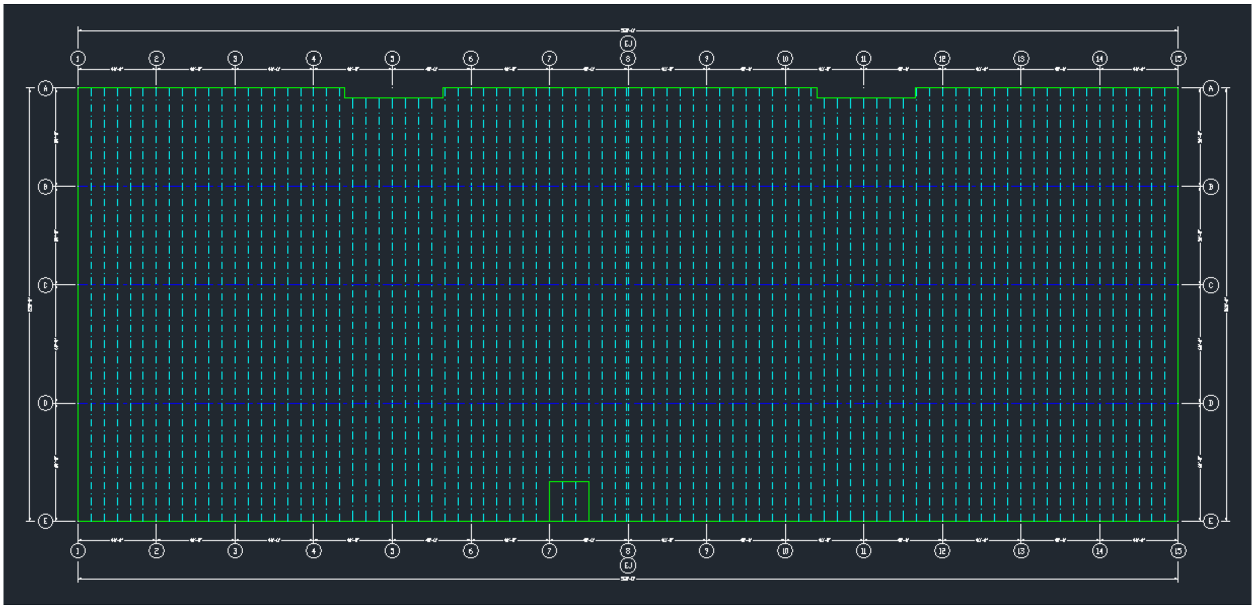
**Detailed Design Documentation:**

Now that I know my building requires a seismic design, I can start designing it.

The first step is to draw the walls of the building.

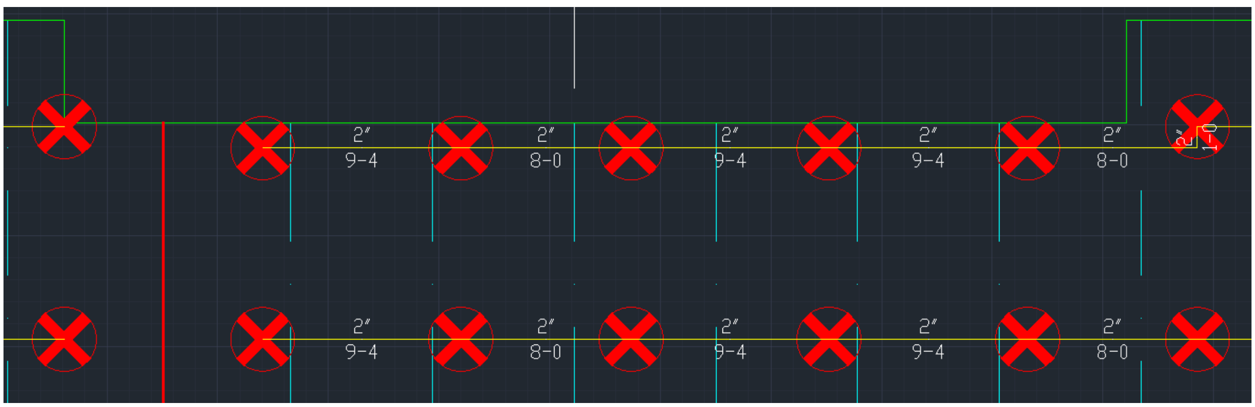


If you reference the bottom steel drawing on page three, this is what the shell of the building looks like. The next step I must take is to insert my steel, and the columns and dimensions.

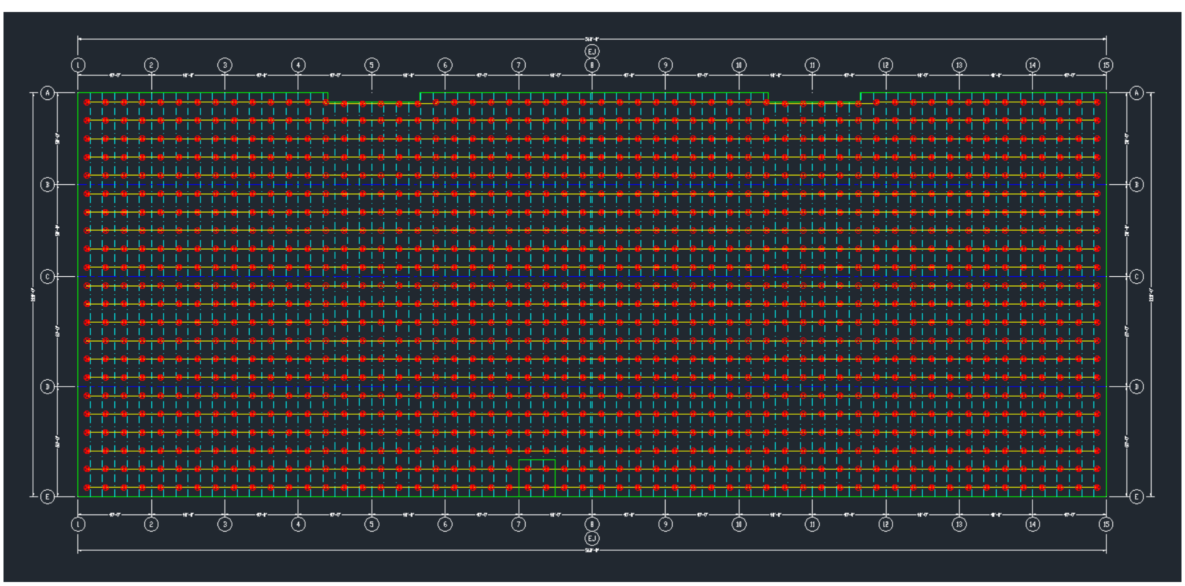


Per the steel drawing above, my bay's going horizontally are 40'-0" from column to column line. Between each column line there are six spaces. This means each joist must be 6'-8" apart. The bay's running vertically have a total distance of 220'-0". If you look at the drawing closely, you will notice that the first two bays towards the top are slightly smaller than the bottom two bay's. This is because the top two bays from column line A to column line C are 50'-0" apart. The bottom two bays from column C to column E are spaced at 60'-0" apart which gives me a total distance of 220'-0". The light blue steel lines represent my joists, and the dark blue steel lines represent my girders. Joists and girders are considered obstructions. As I stated earlier, there are different code requirements for steel obstructions. Per the NFPA, an ESFR sprinkler head can be no closer to a joist than 1'-0". For estimating purposes, I design ESFR systems with sprinkler heads no closer than 1'-3" to my joists. For ESFR sprinkler heads, the NFPA requires that these heads can be no closer than 2'-0" to the girders. These code requirements will cause me to alter my design which will ultimately hinder my ability to use the allowable maximum area of 100 sqft.

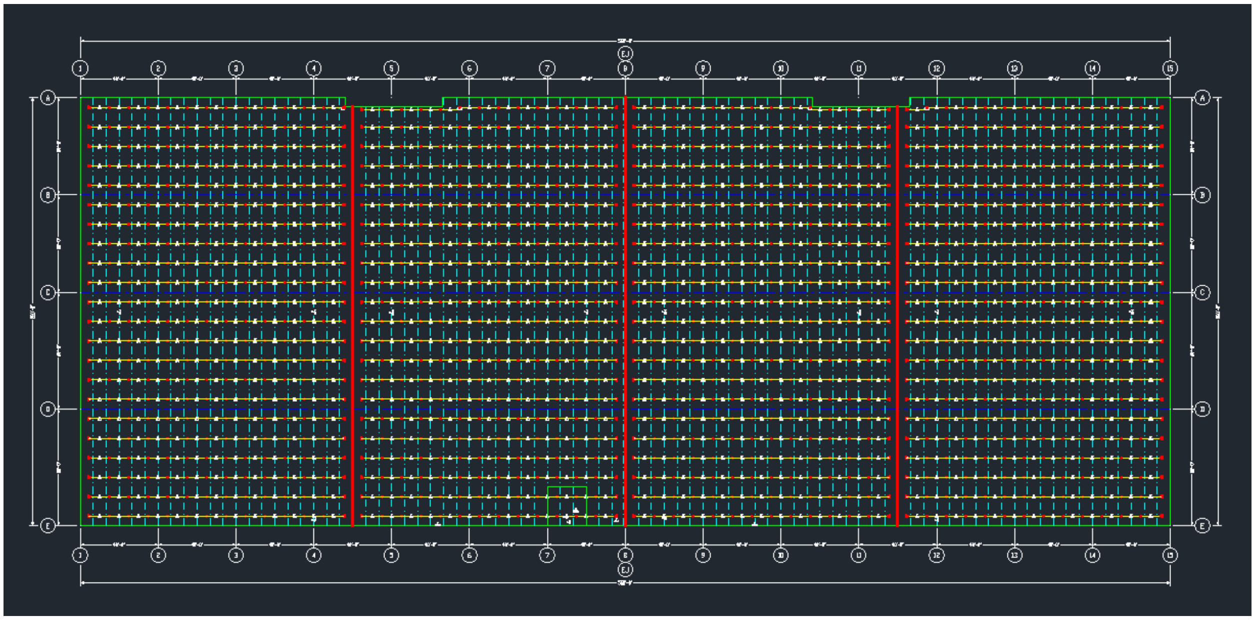
As I stated earlier, the maximum sqft of an ESFR sprinkler head is 100 sqft, with a maximum sqft of 10'x10' in each direction. Also, the sprinkler head can be no more than half of the maximum distance away from a wall. Since the depth of my building is 220'-0", and I have bays that are each divisible by ten, I can take 220'-0", and divide that by ten to know how many sprinkler lines I will need in this building. 220/10 = 22 sprinkler lines. Because of bays A through E being divisible ten, I can maximize every line and space each line 10'-0" apart. The image above shows four main things. The first one being that my first sprinkler line is exactly 5'-0" away from the wall. This is the absolute maximum that I'm allowed to go because per the NFPA, an ESFR sprinkler head can be no further away from a wall than half of the maximum distance. The next thing being that the picture above shows that my lines are spaced at the maximum distance of 10'-0" apart. The third thing the image shows is the heads that are spaced 9'-4" in between each other are positioned 1'-4" off of the joist. This means that I have a legal positioning of the head because it is no closer than 1'-3" to the joist. The heads that are 8'-0" apart are positioned to where they aren't touching the joist, so I do not have worry about the spacing. The last thing the image explains is the spacing pattern that I've used. My heads are spaced in a repeatable pattern of 9'-4", 9'-4", 8'-0". This is an odd pattern, but it is due to the fact that the building has two jogs in it. This means that the building has cut-outs in it. The image below shows one of the jogs.



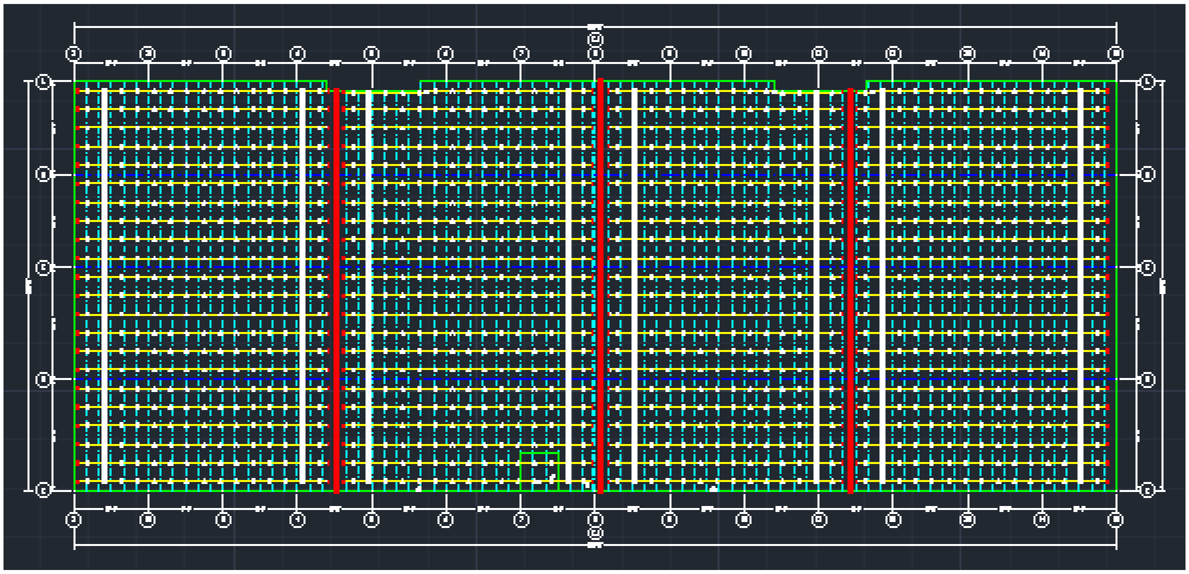

As you can see in the image above, the top lines of heads is lower around the jog but the heads are spaced using the same pattern. After I continued the pattern and placed each head, I also put in my pipe for each head.



The image above shows what the overhead of the building looks like once all of the heads and pipes (commonly known as branch lines) for the heads are placed. The next step is to zone split the building. In order for this fire protection system to be effective and work hydraulically, there can't just be one source of water trying to feed all 122,716 sqft of this building. We use zones to split the building up and each zone will be supplied by a riser bank. According to the NFPA requirements, zones must not exceed 40,000 sqft per system. If I take my 122,716 sqft, and divide that by 40,000, that number results in 3.0679. I can't have a partial zone, therefore I must have four zones. Due to this building being seismic, typically a rule of thumb is to never cross a zone with the direct head piping. This means that I must zone split at my expansion joint.

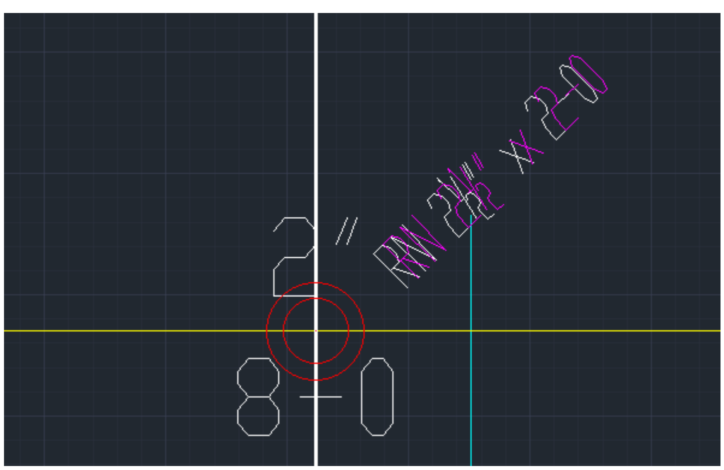


My expansion joint is at column line 8. So my first zone split needs to occur at this point. The expansion joint lies in the center of this building which benefits the placement of the next three zones, they can all be relatively close in size. To place my other three zones, I had to find the midpoint from column line 1 through column line 8. When I found the midpoint, I adjusted the zone split to be exactly between two heads.This split occurs directly between column lines 4 and 5. The next split occurs on the right side of the expansion joint from column line 8 to halfway in between column lines 11 and 12. The last zone split occurs from the end of the third zone split all the way to the column line 15. The zone split from column line 1 to half way in between column lines 4 and 5, measures at 30,924 sqft. From the end of that zone split to the zone split at the expansion joint, it measures at 31,167 sqft. The expansion joint to halfway in between column lines 11 and 12, this zone split measures at 29,136 sqft. From the end of this zone split to column line 15, this measures at 31,488 sqft. These zones are all legal because they are under the 40,000 sqft maximum. The next step would be to delete any pipe cross my zone splits. If you look at the location of each zone split, you will notice that no branch lines (the pipe connecting each head) is crossing the zones. After I complete this step, I now can place the mains. The mains are what feed the branch lines that are connected to the sprinkler heads.

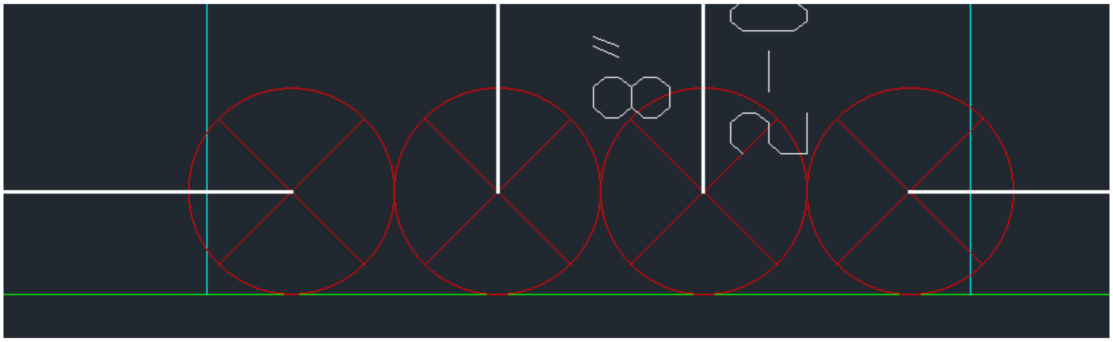


The mains are the thick, white lines running in a vertical just like the zones. This type of layout is commonly referred to as a “grid system”. There is also such a thing called a “tree” system. A grid system, such as this one, requires that the two mains be only 2 sprinkler heads in on each side.

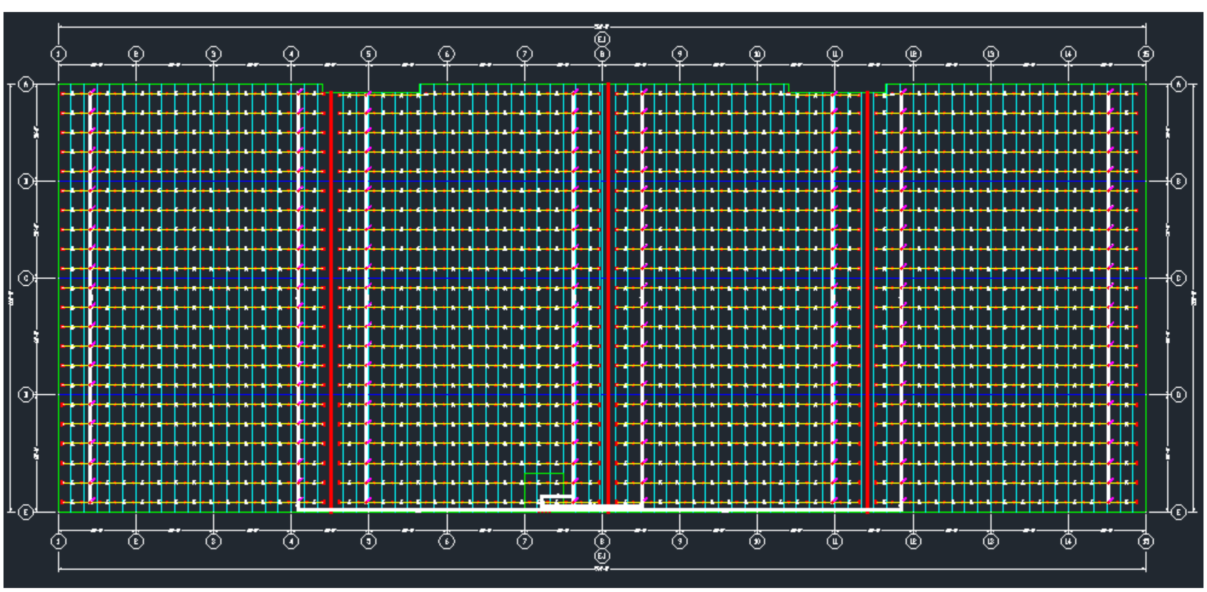
This means that for each zone split, the mains have to be placed after two heads on each side of the zone. The image above displays it. The next step is to go through the layout and place the riser nipples.



According to the NFPA-13 in 3.5.9 a riser nipple is “A vertical pipe between the cross main and branch line.” These are used to supply water to our branch lines. Our mains are hung lower than the sprinkler branch lines, thus we need something that joins the main and the branch lines together. The two-and-a half inch number represents the diameter of the pipe, and the two-foot number represents the length of the pipe. The next step is to place in the water source to feed the systems.



According to the NFPA-13 in 3.5.13 a system riser is “The aboveground horizontal or vertical pipe between the water supply and the mains (cross or feed) that contains a control valve (either directly or within its supply pipe), a pressure gauge, a main drain, and a waterflow alarm device.” In simpler terms that make it more understandable, a system riser is a pipe that feeds water to our systems. Each system has its own riser. Therefore this building must have four risers. The pipe running out from each riser is referred to as bulk piping or bulk feed. This bulk piping then runs to one of the mains in each zone. The main that the bulk piping runs to, is referred to as the feed main. The definition is in the name. The feed main feeds water to our fire protection system. The main that is not connected to our bulk main is referred to as our floater main. The floater main is just there for the water in the system to run to. This is where some of the water will be stored. This is a wet-system, meaning that there will always be water in the piping. This also means that this system will never get cold enough for the water to freeze and burst a pipe. After I place the risers and connect the bulk feed to a main in each system, the estimator can now do a take-off of this project and bid this. The finished design of this ESFR fire protection layout should look like this.



To recap this design report, after obtaining the design requirements, I completed the following: drew the walls, inserted the joists, girders, and expansion joint, placed the dimensions, found the most efficient head spacing pattern, put in the branch line piping connecting the sprinkler heads, zone (system) split at the expansion joint and placed all other zones based off the expansion joint, deleted any branch line crossing a zone split, placed two mains in each system, placed riser nipples at each main intersecting a branch line, placed risers and ran bulk feed to each system.

**Conclusion:**

The purpose of this report is to inform the reader of the proper steps to design an ESFR fire protection system for an estimator to bid. Fire Protection is not a common industry for someone to consider going in to. This industry is a specialized industry whom not everyone can take part in. The education in which I've obtained at Ivy Tech, has thoroughly enhanced the skills and abilities required to work in the fire protection industry. All of the classes I've taken in some way or another have been both directly and indirectly related to this industry. Technical subjects such as Fluids, Statics, Chemistry and Physics have all been directly related to this industry. Fluid relates because fluids help put out fires. Static relates because each and every project I do contains forces in equilibrium. This is important when it deals with the support system to hang the fire protection system. Chemistry relates because certain systems require a foam chemical rather than H2O. This is common in rooms and facilities where data is stored. Physics relates to this field because fire protection systems constantly need something pushing fluid into a system. The CAD classes have been very critical and beneficial to my career as well. I design on a version of CAD every day, it is what I perform most of my work in. The math classes I've taken have enhanced how my brain thinks and how I pick up on concepts. Without the education provided to me through Ivy Tech, I would not be equipped nearly enough to understand the concepts in which I use every day.

**Works Cited:**

Sprinkler image from Boone County Fire Protection Division: ***https://bcfdmo.com/wp-content/uploads/2018/08/fire_sprinkler_shutterstock-1526667017-1479-300x225.jpg***

Graph from: **https://www.nfpa.org/public-education/campaigns/fire-prevention-week/fire-factsI**

General Fire Protection information from: ***https://www.vikingsprinkler.com/esfr.php***

General Fire Protection information from: ***https://www.shambaugh.com/services/fire-protection***