Fire Protection Analysis – DCI Data Center Building

California Polytechnic State University
FPE 596 – Culminating Experience in Fire Protection Engineering

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Keywords: Fire Protection Analysis, Performance Based Design, Fire Dynamics Simulator (FDS), Pathfinder, Atrium

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ABSTRACT

A fire protection analysis utilizing prescriptive and performance based design was performed for the existing [redacted] (DCIB) located in [redacted], MN. A new tenant is investigating converting the DCIB from a building used for data center, to an office building which will utilize an open office concept.

A prescriptive analysis of the building was performed to determine the life safety, fire suppression, fire alarm and structural requirements to ensure compliance with current applicable codes and standards. The prescriptive requirements are outlined and reviewed in Section 1 through Section 5 of this analysis. Modifications to the DCIB are required to achieve the prescriptive requirements. Some of the modifications include additional doors for rooms throughout the building, and additional egress width for both doors and stairs for the second- through the fifth-floor. The modification to add additional stairway and doorway width will come at a substantial cost.

A performance-based analysis was performed and described in Section 6 for this building utilizing computer-based modeling software. A single fire scenario was modeled with two separate fire plume exhaust rates in the atrium to determine if the building occupants have adequate time to safely egress the building prior to untenable conditions. The performance based analysis showed tenability limits can be maintained throughout the atrium for a minimum duration of twenty (20) minutes. Additional design fires should be modeled to indicate the exhaust system can maintain the tenability limits of other potential fires in the atrium. Additionally, the model should be ran for one and a half (1.5) times the required safe egress time, or forty-seven (47) minutes to ensure all occupants can evacuate safely from the building.

As will be discussed in this analysis, the occupant load in the building will be roughly tripled with the proposed tenant modifications. The new occupant load causes issues for the existing egress components causing this building to fall out of compliance with the prescriptive codes. Additional door and stairway width is recommended for the buildings new tenant modifications.

1.0 INTRODUCTION

1.1 Objective

This fire protection analysis will provide a fire protection review of the [redacted] (DCIB) and its adherence to current applicable codes and standards for the area. Both prescriptive and performance based design were analyzed for the DCIB located in [redacted], MN.

A new tenant is investigating converting the DCIB from a building which is currently utilized as a data center to an office building which has an open office type concept. As discussed further, Section 7 – Conclusion and Recommendations, significant building modification will be required for this building to provide the adequate egress components required for the proposed tenant modifications to meet the applicable codes and standards outlined below.

A prescriptive analysis of this building was performed to determine adherence of the life safety, fire suppression, fire alarm and structural requirements to the applicable codes and standards listed below.

A performance-based analysis was performed for this building utilizing computer-based modeling software. A single fire scenario was modeled with two separate fire plume exhaust rates in the atrium to determine if the building occupants have adequate time to safely egress the building prior to untenable conditions.

1.2 Codes and Standards

This building was constructed in 1990 in accordance with the 1985 edition of the Uniform Building Code (UBC) with 1985 State of Minnesota Amendments. This fire protection analysis was performed in accordance with the 2015 edition of the Minnesota Building Code (MNBC) and Minnesota Fire Code (MNFC) which modifies the 2012 International Building Code (IBC) and 2012 International Fire Code (IFC) respectively.

The 2015 MNBC enforces the following National Fire Protection Association (NFPA) codes and standards;

- NFPA 13 (2010) – Standard for the Installation of Sprinkler Systems
- NFPA 14 (2010) – Standard for the Installation of Standpipe and Hose Systems
- NFPA 25 (2011) – Inspection, Testing and Maintenance of Water-based Fire Protection Systems
- NFPA 70 (2011) – National Electric Code
- NFPA 72 (2012) – National Fire Alarm Code
- NFPA 92 (2012) – Standard for Smoke Control Systems

1.3 Building Description

DCIB is located [redacted], Minnesota. It is a six (6) story building with the highest occupied floor (5th) at seventy-two (72) feet above grade. The building includes a five (5)-story atrium that begins at street level and extends to the underside of the building roof. The basement and sixth level are not open to, nor included in the atrium enclosure. Both floors are rather used for mechanical equipment and are not part of this analysis. The building has a total area of 443,669 square feet (sq. ft.) throughout the five (5) occupied floors.

The original floor plan of the building indicates that the first and second floors were solely used for office type activities. Level three through level five each had a fifty-thousand (50,000) sq. ft. data center, which is roughly sixty (60) percent of the total floor area. The new tenant is proposing to make every level an open office. As detailed in this report, the new occupant load greatly exceeds the available capacity of the existing egress components.

The building is equipped throughout with an NFPA 13 compliant fire sprinkler system (See Section 3 – Fire Suppression Analysis). Additionally, the building is equipped with an NFPA 72 compliant fire alarm system (See Section 4 – Fire Alarm Analysis)

The building is treated as a mixed use, non-separated B/S-1.

1.3.1 First-Floor

The first-floor of the building is proposed to contain a large loading dock, mattress fabrication/testing area and other accessory office rooms including break rooms, conference rooms and storage rooms. The first floor is open to the atrium and has the main entrance to the building. The first floor contains four (4) areas for building occupants to exit the building. In addition, the first floor has the vents required for make-up air of the smoke control system.

Figure 1 – First-Floor Anticipated Tenant Change

The following image, Figure 1 – First-Floor Anticipated Tenant Change, is the first-floor architectural layout showing the anticipated tenant changes. The red arrows indicate exits to the exterior. See Appendix A – Life Safety Analysis for full size life safety plans of all floors. Figure 2 – First Floor Lobby is the main lobby of the building in the northwest corner. Figure 3 – Existing Make-up Air Vents shows the existing make-up vents for the smoke control system located in the first-floor lobby.

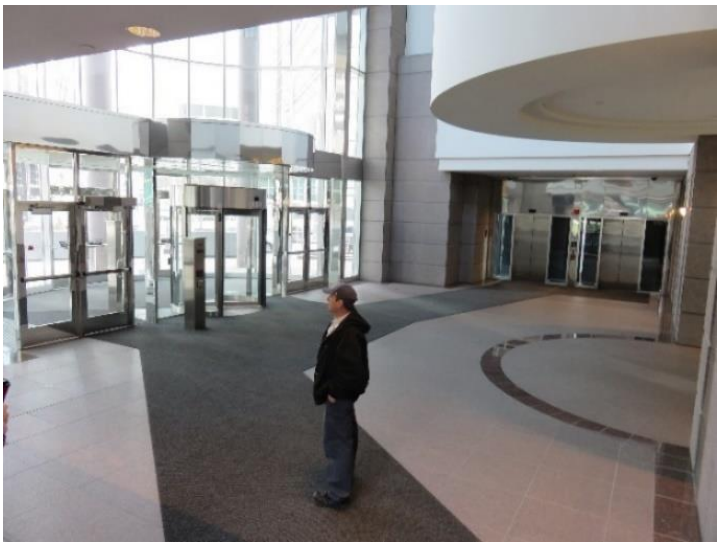


Figure 2 – First-Floor Lobby

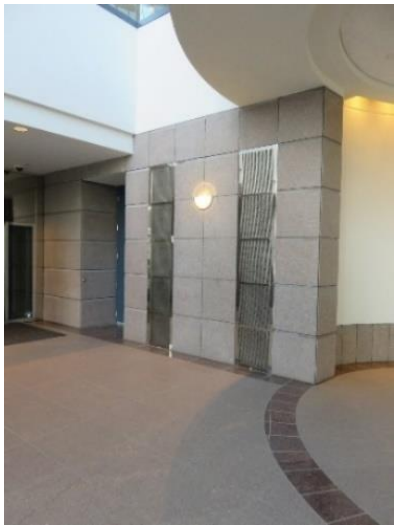


Figure 3 - Existing Make-up Air Vents

1.3.2 Second-Floor

The second-floor consists of mainly open office space, break rooms, conference rooms and miscellaneous storage. The second-floor is open to the atrium and is the location for the design fire in the performance based design. Figure 5 – Second-Floor Lobby shows the open atrium with the fifth-floor overhang in addition to the design fire location. The floors main egress components are four (4) stairway enclosures with one (1) open stairway enclosure which is open to the atrium. Three (3) stairways have a single 36-inch door leading into the 60-inch stairway, one (1) stair has a 72-inch door leading to a 60-inch stairway and, there's one (1) stairway which is open to the circulation space. Figure 4 – Second-Floor Anticipated Tenant Change shows the second-floor architectural layout showing the anticipated tenant changes. The red arrows indicate exits to the stairways mentioned above. See Appendix A – Life Safety Analysis for full size life safety plans of all floors.

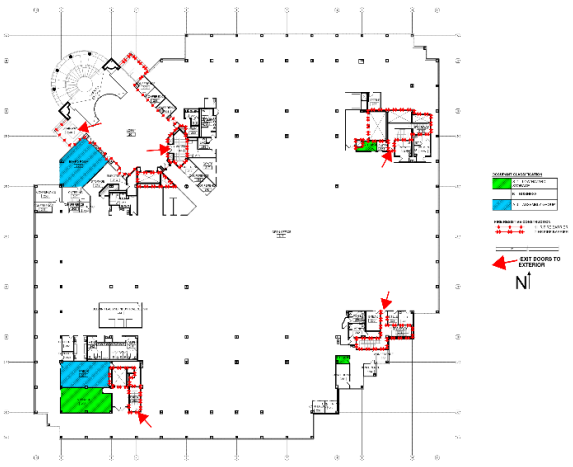


Figure 4 – Second-Floor Anticipated Tenant Change

Figure 5 - Second Floor Lobby

1.3.3 Third-Floor

The third-floor consists of mainly open office space, break rooms, conference rooms and miscellaneous storage. The third-floor is open to the atrium. The floors main egress components consist of four (4) stairway enclosures. Three (3) stairways have a single 36-inch door leading into the 60-inch stairway while one (1) stairway has a 72-inch door leading to a 60-inch stairway. The average ceiling height throughout the third-floor is nine (9) feet. Figure 6 – Third-Floor Anticipated Tenant Change shows the third-floor architectural layout showing the anticipated tenant changes. The red arrows indicate exits to the stairways mentioned above. See Appendix A – Life Safety Analysis for full size life safety plans of all floors.

Figure 6 – Third-Floor Anticipated Tenant Change

1.3.4 Fourth-Floor

The fourth-floor consists of mainly open office space, break rooms, conference rooms and miscellaneous storage. The fourth-floor is open to the atrium. The floor's main egress components consist of four (4) stairway enclosures. Three (3) stairways have a single 36-inch door leading into the 60-inch stairway while one (1) stairway has a 72-inch door leading to a 60-inch stairway. The average ceiling height throughout the fourth floor is nine (9) feet. Figure 7 – Fourth-Floor Anticipated Tenant Change shows the fourth-floor architectural layout showing the anticipated tenant changes. The red arrows indicate exits to the stairways mentioned above. See Appendix A – Life Safety Analysis for full size life safety plans of all floors.

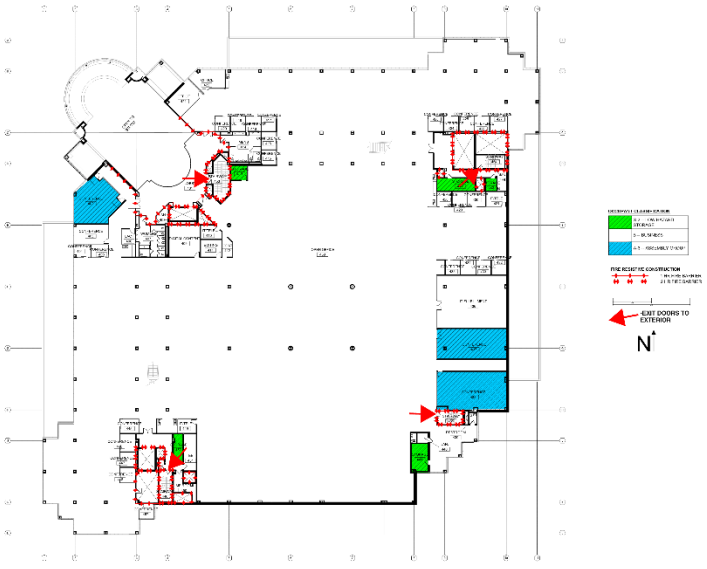


Figure 7 – Fourth-Floor Anticipated Tenant Change

1.3.5 Fifth-Floor

The fifth-floor consists of mainly open office space, break rooms, conference rooms, cafeteria space and miscellaneous storage. The fifth-floor is open to the atrium. The floor's main egress components consist of four (4) stairway enclosures. Three (3) stairways have a single 36-inch door leading into the 60-inch stairway while one (1) stairway has a 72-inch door leading to a 60-inch stairway. The average ceiling height throughout the fifth-floor is nine (9) feet throughout the office space. Figure 8 – Fifth-Floor Anticipated Tenant Change shows the fifth-floor architectural layout showing the anticipated tenant changes. The red arrows indicate exits to the stairways mentioned above. See Appendix A – Life Safety Analysis for full size life safety plans for all floors.

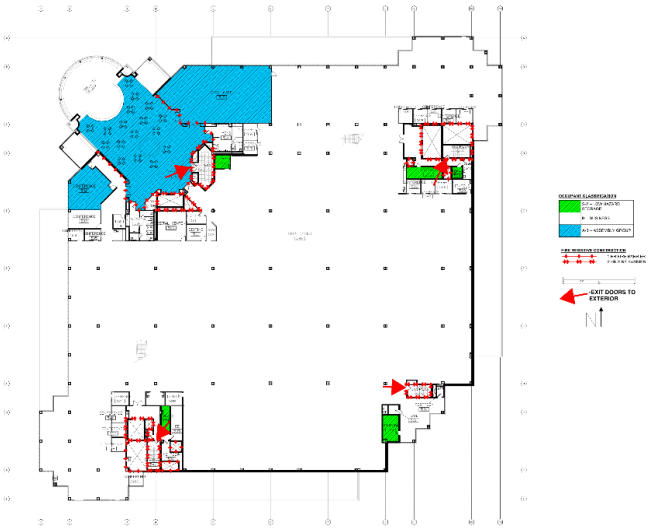


Figure 8 – Fifth-Floor Anticipated Tenant Change

1.4 Existing Smoke Control System

The existing smoke control system consists of a mechanical exhaust system and a make-up air supply. The exhaust fan inlet is located in the plenum space above the atrium. The inlet into the plenum from the atrium is through a concealed round access cut-away vent in the ceiling pocket above the atrium (See Figure 9 - Existing Atrium Ceiling Pocket Inlet). Per the 1985 UBC, the requirement for smoke control for atriums are dependent on whether the volume of the atrium is greater than or less than six-hundred thousand (600,000) cubic feet. Because the volume of this atrium is greater than six-hundred thousand (600,000) cubic feet, the requirement for smoke control is not less than four (4) air changes per hour for the entire atrium volume. For the original design of this atrium, four (4) air changes per hour would require an exhaust rate of approximately forty-three thousand five hundred (43,500) cubic feet per minute (CFM). The existing atrium smoke control system can provide fifty-six thousand (56,000) CFM and therefore meets the 1985 UBC requirements for exhaust rate.

At the time that this building was constructed, the requirements of the 1985 UBC required a minimum of fifty (50) percent of the exhaust volume to be brought in as make-up air. Make-up air is provided from four (4) supply vents located on the first-floor. A review of the existing system indicated the make-up air was capable of supplying up to fifty thousand (50,000) CFM of make-up air which meets the 1985 UBC requirements.

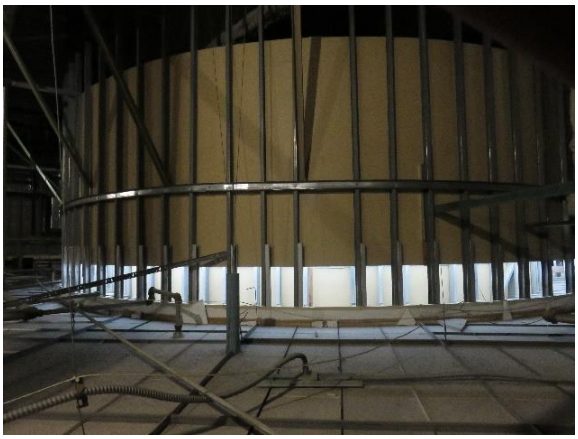


Figure 9 - Existing Atrium Ceiling Pocket Inlet

Now that the existing building and components have been identified, one can begin investigating the building to determine adherence to the prescriptive codes starting with a life safety analysis.

2.0 LIFE SAFETY ANALYSIS

The purpose of this section is to determine if the proposed tenant modifications to DCIB adhere to the prescriptive requirements set forth in the MNBC.

2.1 Type of Construction

DCIB was constructed to UBC Type I construction which is equivalent to the current MNBC Type IA construction. Per MNBC Section 602.2, Type I construction are those types of construction in which major building elements are constructed of non-combustible materials i.e. (steel, concrete, etc.). The minimum fire resistive construction of the building elements is defined in MNBC Table 601 – Fire-Resistance Rating Requirements for Building Elements (Hours) and outlined in Table 1 – Type of Construction below.

Table 1 - Type of Construction (MNBC Table 601)

Building Element	Type of Construction	Fire Resistance Rating (Hours)
Primary Structural Frame	IA	3***
Bearing Exterior Wall	IA	3**
Bearing Interior Wall	IA	3*
Non-Bearing Exterior Wall	IA	1**
Non-Bearing Interior Wall	IA	0*
Floor Construction Including Supporting Beams and Joists	IA	2*
Roof Construction Including Supporting Beams and Joists	IA	1-1/2

* Except as required for incidental use (including atrium separation) and other passive fire protection.
** Except as required for building separation.
*** Except as required to support horizontal assembly (MNBC 714.4)

Type IA construction is the most stringent of the types of construction defined by the MNBC. Once the type of construction is determined, one can investigate the occupant classification of the building.

2.2 Occupant Classification

The occupant types found in the building are defined and indicated below. It should be noted, for the purpose of occupant classification, areas of "Assembly" are only considered Group A-3 when there are more than forty-nine (49) people, which equates to an area greater than seven hundred and fifty (750) sq. ft.

Assembly Group A-3 as defined by MNBC Section 304.3 are rooms intended for worship, recreation, or amusement and other assembly uses not classified elsewhere in Group A. For the DCIB, conference rooms, break rooms, and cafeterias larger than seven hundred and fifty (750) sq. ft. were defined as Assembly Group A-3 occupancy.

Section 306.2 of the MNBC defines Moderate-hazard Factory Industrial Group F-1 as the portion of the building where assembling, disassembling, fabricating, finishing, manufacturing, packaging, repair or processing operations take place. One (1) area of the DCIB is classified as Group F-1 and that is the Mattress Fab. Room located on the first-floor. In this room, the new tenant will test small pieces of mattress to determine the reliability and quality from different mattress fabricators.

Moderate-hazard Storage Group S-1 are areas where storage of moderately combustible materials occurs. One (1) area of the DCIB is classified as Group S-1 and that is the Loading Dock located on the first floor. In this room, the new tenant can pull trucks into the building to load/unload different components associated with their business.

Section 304.1 of the MNBC defines Business Group B as the use of a building or structure, or portion thereof, for office professional or service-type transactions, including storage of records and accounts. For the DCIB, a majority of the building, and main occupancy is considered Business Group-B. See Table 2 – Classification of Occupancy for a summary of the occupancies located in the DCIB.

Table 2 - Classification of Occupancy

Area	Occupancy	MNBC
Conference Room > 49 Occupants	Assembly Group A-3	303.1
Open Office, Circulation, Restrooms, Lobby, Breakroom	Business Group B	304.1
Mattress Fab.	Factory Industrial Moderate-Hazard Group F-1	306.2
Loading Dock/Accessory Storage	Moderate-Hazard Storage Group S-1	311.2

To better clarify the building layout and different occupancies, Appendix A – Life Safety Analysis shows the floor plans of the building with different occupancies identified in addition to rated fire barriers and exit locations.

2.3 Accessory Occupancy

Accessory occupancies are those occupancies that are ancillary to the main occupancy of the building or portion thereof. Accessory occupancies are limited to ten (10) percent of the total floor area. If an occupancy is greater than ten (10) percent of the floor area then it is to be treated as a main occupancy. The advantages of accessory occupancies are that these occupancies do not limit the building height, building area, or egress component limits.

For this building, one is able to treat all occupancies as accessory to Business Group B except for the Group S-1 Loading Dock located on the first floor as indicated below in Table 3 – Accessory Occupancy 10% Limitation. Therefore, this building has two occupancies, B and S-1.

Table 3 - Accessory Occupancy 10% Limitation (MNBC 508.2)

Floor	Floor Area	Accessory	Accessory Area (sq. ft.)	Area Limitation (sq. ft.)	Percentage of Floor Area
Level 1	87,650	F-1	2,685	Unlimited	3.1%
Level 1 Total	-	-	-	-	5.5%
Level 2	93,069	A-3	1,823	Unlimited	2.0%
Level 2	93,069	S-1	1,066	Unlimited	1.1%
Level 2 Total	-	-	-	-	3.1%
Level 3	87,650	A-3	7,420	Unlimited	8.5%
Level 3	87,650	S-1	802	Unlimited	0.9%
Level 3 Total	-	-	-	-	9.4%

Level 4	87,650	A-3	2,895	Unlimited	3.3%
Level 4	87,650	S-1	802	Unlimited	0.9%
Level 4 Total	-	-	-	-	4.2%
Level 5	87,650	A-3	5,686	Unlimited	6.5%
Level 5	87,650	S-1	436	Unlimited	0.5%
Level 5 Total	-	-	-	-	7.0%

2.4 Multiple Occupancies

As indicated previously, there are two occupancies in the DCIB, B and S-1, the remainder can be treated as accessory to the main occupancies. Table 4 – Multiple Occupancies summarizes the occupancies present on each floor.

Table 4 - Multiple Occupancies (MNBC 508)

Floor/Occupancy	Separation	Floor/Occupancy	Separation Rating	MNBC
Level 1 / B	Separated	Level 1 / S-1	0 HR Barrier	508.4.4
Level 1 / B	Accessory	Level 1 / F-1	0 HR Barrier	508.2.4
Level 2 / B	Accessory	Level 2 / S-1	0 HR Barrier	508.2.4
Level 2 / B	Accessory	Level 2 / A-3	0 HR Barrier	508.2.4
Level 3 / B	Accessory	Level 3 / S-1	0 HR Barrier	508.2.4
Level 3 / B	Accessory	Level 3 / A-3	0 HR Barrier	508.2.4
Level 4 / B	Accessory	Level 4 / S-1	0 HR Barrier	508.2.4
Level 4 / B	Accessory	Level 4 / A-3	0 HR Barrier	508.2.4
Level 5 / B	Accessory	Level 5 / S-1	0 HR Barrier	508.2.4
Level 5 / B	Accessory	Level 5 / A-3	0 HR Barrier	508.2.4

While the table above indicates B and S-1 as separated, Table 508.4 does not require a fire separation between said occupancies. Calling the building separated allows one to treat each individual occupancy classification as its own stringent occupancy.

2.5 Modified Allowable Area

The building has a maximum floor area of ninety-three thousand six hundred and sixty-nine (93,069) sq. ft. on the second-floor. Due to this building being constructed of Type IA construction, the allowable area for the occupancies located in this building is unlimited as shown in Table 5 – Modified Allowable Area.

However, if another type of construction was used and this building did not have an unlimited area allowance, the following equation can be used to modify the building area;

$$A_a = \{A_t + [A_t \; x \; I_f] + [A_t \; x \; I_s]\}$$

$A_a = Allowable\ building\ area\ per\ story\ (sq.ft.)$

$A_t = Tabular\ building\ area\ per\ sotry\ in\ accordance\ with\ Table\ 503\ (sq.ft.)$

$I_f = Area\ increase\ factor\ due\ to\ frontage\ as\ calculated\ in\ accordance\ with\ Section\ 506.2$

$I_s = Area\ increase\ factor\ due\ to\ sprinkler\ protection\ in\ accordance\ with\ Section\ 506.3$

The frontage increase in accordance with Section 506.2 can be calculated as follows;

$I_f = \left[\frac{F}{P} - 0.25\right] W/30$

$I_f = Area\ increase\ due\ to\ frontage$

$F = Building\ perimeter\ that\ fronts\ on\ a\ public\ way\ or\ open\ space\ having\ 20\ feet\ open$

$P = Perimeter\ of\ entire\ building\ (feet)$

$W = Width\ of\ public\ way\ or\ open\ space\ (feet)$

Table 5 - Modified Allowable Area (MNBC 503)

Occupancy	*Allowable Area (sq. ft.)	Sprinkler Increase (sq. ft.)	Frontage Increase (sq. ft.)	Modified Allowable Area (sq. ft)
B	Unlimited	-	-	Unlimited
S-1	Unlimited	-	-	Unlimited

* Based on Type IA Construction.

2.6 Modified Allowable Height

Due to this building being of Type IA construction, the allowable height for the occupancies located in this building is unlimited as shown in Table 6 – Modified Allowable Height.

Table 6 - Modified Allowable Height (MNBC 504)

Occupancy	Sprinkler Increase (sq. ft.)	Modified Allowable Height* (ft / story)
B / S-1	-	Unlimited

* Based on Type IA Construction.

If this building was of another construction type where the allowable height is not unlimited, an increase of twenty (20) feet of one (1) story is acceptable for a fully sprinkled building.

2.7 Protection from Hazards and Other Passive Fire Protection

The following fire barriers are provided throughout the building and are shown on the occupancy drawings located in Appendix A – Life Safety Analysis. Table 7 – Protection from Hazards and Other Passive Fire Protection is a summary of the required fire barriers other than the fire barriers required for occupancy separation.

Table 7 - Protection from Hazards and Other Passive Fire Protection

Area	Required Rating	MNBC
Shaft Enclosure 3 Stories or Less	1 HR Fire Barrier	708.4
Corridor	No Rating	1020.1
Elevator Machine Room	1 HR Fire Barrier	3005.4
Shaft Enclosure 4 Stories or More	2 HR Fire Barrier	708.4
Atrium Space	1 HR Fire Barrier	404.6

2.8 Building Separation

This building sits on a corner of 3rd Ave South and South 10th Street in downtown Minneapolis. The building has 60-foot clear distance in all directions, therefore a fire resistive exterior rating is not required per the Table 8 – Building Separation. See Figure 10 – Building Separation for site plan of building.

Table 8 - Building Separation (MNBC Table 602)

Occupancy	Elevation	Restrictive Fire Separation Distance (ft)*	Fire Resistive Rating of Exterior Wall
B, S-1	North/South/East/West	> 30	No Rating Required

* MNBC 702 – Fire separation distance = distance from building's face to closest interior lot line, centerline of alley or public way, or imaginary line between two buildings.

Figure 10 - Building Separation

2.9 Opening Protection for Fire Resistive Construction

Table 9 – Opening Protection for Fire Resistive Construction provides a summary of the required rating of penetrations into rated barriers. See Appendix A – Life Safety Analysis for location of fire barriers.

Table 9 - Opening Protection for Fire and Smoke Resistive Construction

Component	Fire Door / Shutter Assemblies	Duct Penetrations	Other Penetrations	MNBC
1 HR Fire Barrier	3/4 HR	-	1 HR	714.3, 716.5
2 HR Fire Barrier	1-1/2 HR	1-1/2 HR Damper	2 HR	714.3, 716.5
2 HR Fire Barrier for Horizontal Exit	1-1/2 HR	1-1/2 HR Fire / Smoke Damper	2 HR	715.4
1 HR Fire Barrier for Means of Egress (Including Stairwells)	1 HR	Not Permitted	1 HR	714.3, 716.5
1 HR Fire Barrier for Shaft Enclosure Not Used for Egress	1 HR	1-1/2 HR Fire / Smoke Damper	1 HR	714.3, 716.5

*Where protected openings are required

2.10 Occupant Load Calculations

Table 10 – Occupant Load Calculations provides a summary of the occupant load throughout the building. In addition, see Appendix A – Life Safety Analysis for graphical representations of occupant load and anticipated egress paths.

Table 10 - Occupant Load Calculations (MNBC Table 1004.1.2)

Floor	Area	Function of Space	Area	Occupant Load Factor (sq. ft. / person)	Occupants
Level 1	Industrial Area	Mattress Fab.	3,075	100	31
Level 1	Open Office, Bathroom, Circulation Space	Business Area	57,986	100	580
Level 1	Conference Room/Break Room	Assembly without Fixed Seating	1,346	15	90
Level 1	Mech. Room/Elec. Room/Storage Room	Accessory Storage	25,243	300	84
Level 1	Total	-	87,650	-	785

Level 2	Open Office, Bathroom, Circulation Space	Business Area	87,915	100	879
Level 2	Conference Room/Break Room	Assembly without Fixed Seating	4,023	15	268
Level 2	Mech. Room/Elec. Room/Storage Room	Accessory Storage	1,131	300	4
Level 2	Total	-	93,069	-	1,151
Level 3	Open Office, Bathroom, Circulation Space	Business Area	75,546	100	756
Level 3	Conference Room/Break Room	Assembly without Fixed Seating	10,669	15	711
Level 3	Mech. Room/Elec. Room/Storage Room	Accessory Storage	1,435	300	5
Level 3	Total	-	87,650	-	1,472
Level 4	Open Office, Bathroom, Circulation Space	Business Area	80,321	100	803
Level 4	Conference Room/Break Room	Assembly without Fixed Seating	6,078	15	405
Level 4	Mech. Room/Elec. Room/Storage Room	Accessory Storage	1,251	300	4
Level 4	Total	-	87,650	-	1,213
Level 5	Open Office, Bathroom, Circulation Space	Business Area	75,674	100	757
Level 5	Conference Room/Break Room/Cafeteria	Assembly without Fixed Seating	10,091	15	673
Level 5	Mech. Room/Elec. Room/Storage Room	Accessory Storage	1,885	300	6
Level 5	Total	-	87,650	-	1,436

The total occupant load for the building is six thousand fifty-seven (6,057) occupants with the most occupants being located on the third-floor. Now that the occupant load is known, the existing egress component capacity can be investigated to determine if additional egress components are required for the proposed tenant change.

2.11 Occupant Load Summary and Minimum Exits from Floor

Table 11 – Occupant Load Summary and Minimum Exits from Floor summarizes the area and occupant load for each floor and indicates the minimum number of exits required per floor. See Figure 11 – Figure 13 for graphical representation showing location and spacing of exits.

Table 11 - Occupant Load Summary and Minimum Exits from Floor

Floor	Gross Area	Occupants	Required Exits (MNBC 1006.2.1)	Required Exit Separation (MNBC 1007.1.1)
Level 1	87,650	785	3	1/3 Diagonal
Level 2	93,069	1,151	4	1/3 Diagonal
Level 3	87,650	1,472	4	1/3 Diagonal
Level 4	87,650	1,213	4	1/3 Diagonal
Level 5	87,650	1,436	4	1/3 Diagonal

Figure 11 - First Floor Door Separation

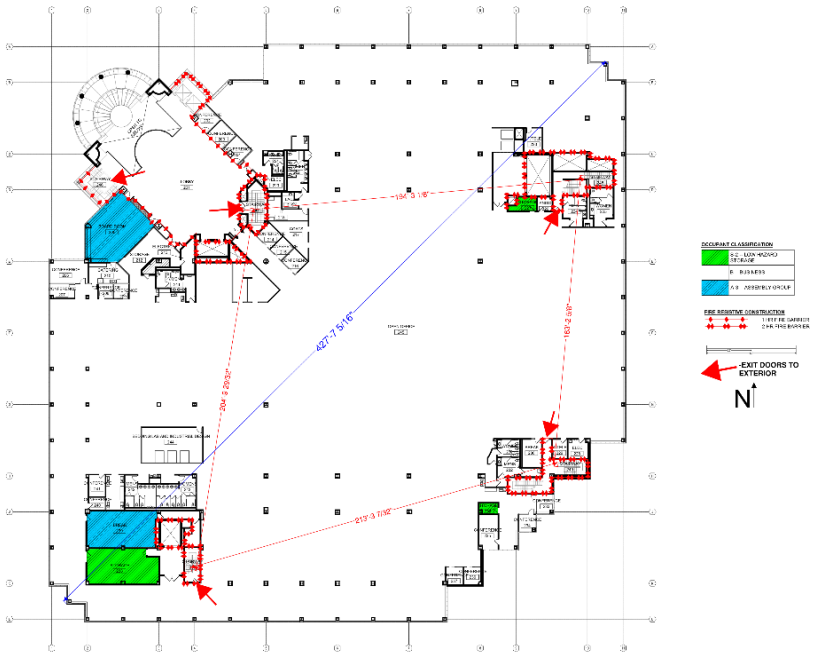


Figure 12 - Second Floor Door Separation

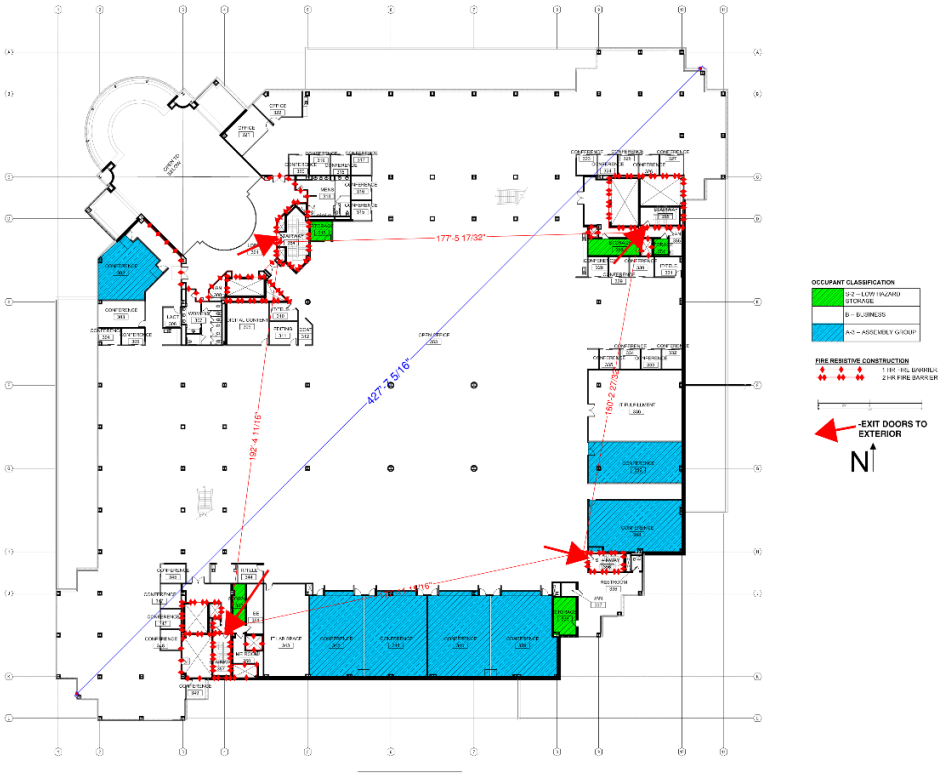


Figure 13 - Floor 3 - Floor 5 Door Separation

This building meets the door quantity and spacing requirement set forth by the MNBC. Additionally, the minimum exits from an area or room was investigated and outlined below.

2.12 Minimum Exits or Exit Accesses from A Space or Area

Table 12 – Minimum Exits or Exit Access from a Space or Area indicates the maximum occupant load from a room or space before additional exits are required. Currently, multiple rooms and spaces do not meet the requirements in the table below.

Table 12 - Minimum Exits or Exit Accesses from a Space or Area (MNBC 1015.2)

Occupancy	Occupant Load Permitting One Exit	Occupant Load Requiring Two Exits
Group B/A	49 or Less	50 or Greater
Group S-1	29 or Less	30 or Greater

The R&D Room 137 located on the first-floor has a single double door to provide exit from the space and a total area of fifty-five hundred (5,500) sq. ft (See Figure 14 – R&D Room 137 Modification). The resulting area has an occupant load of fifty-five (55) based on one hundred (100) sq. ft./person which requires two exits spaced at one-third (1/3) the diagonal distance of the room. See the same figure for anticipated location for the second door.

Board Room 205 located on the second floor has an occupant load of sixty (60) based on an occupant load factor of fifteen (15) sq. ft./person. Two (2) exits from the space are required for an occupant load greater than 49 since the Assembly occupancy is an accessory to the B occupancy. Two exits are provided for the space at a distance greater than one-third (1/3) the diagonal distance of the room (See Figure 15 – Board Room 205). Therefore, this room meets the requirements of the MNBC as outlined in Table 12 - Minimum Exits or Exit Accesses from a Space or Area above.

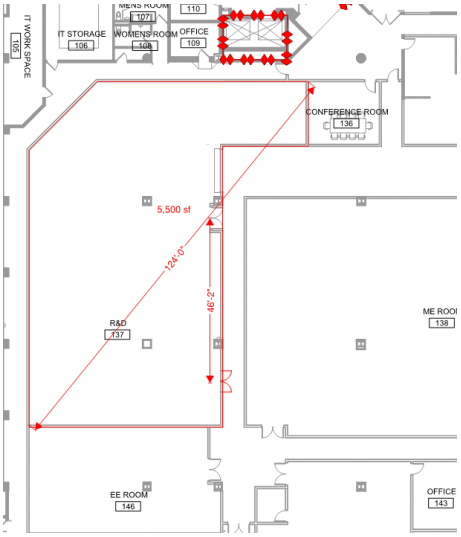


Figure 14 - R&D Room 137 Modification

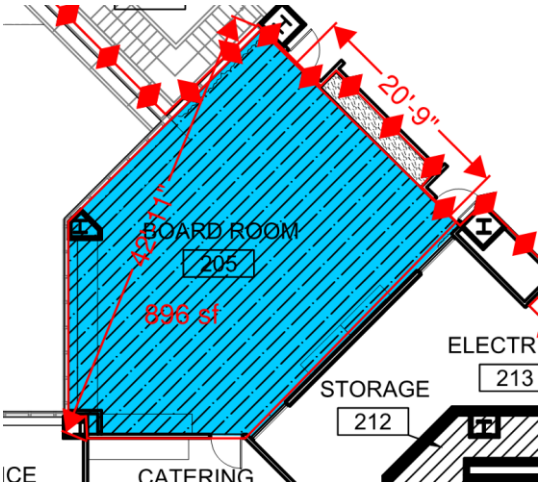
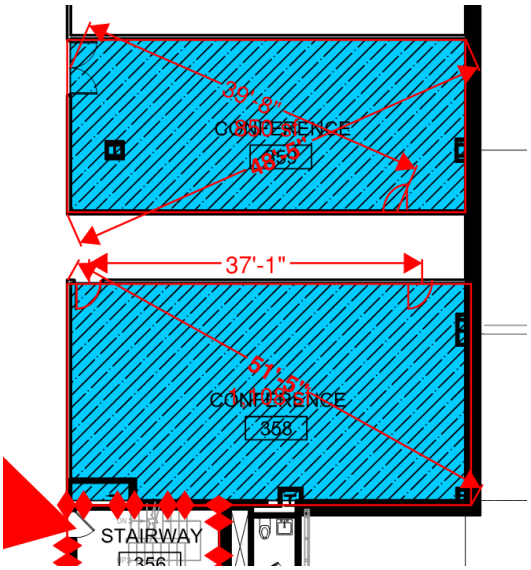


Figure 15 - Board Room 205

Conference Room 358 and Conference Room 359 located on the third-floor both have occupant loads greater than forty-nine (49) based on an occupant load factor of fifteen (15) sq. ft./person which requires two (2) exits spaced at one-third (1/3) the diagonal (See Figure 16 – Third-Floor Conference Room Modification). Conference Room 339, Conference Room 340, Conference Room 341, Conference Room 342 meet the requirements set forth by the MNBC as shown in Figure 17 – Third-Floor Conference Rooms.



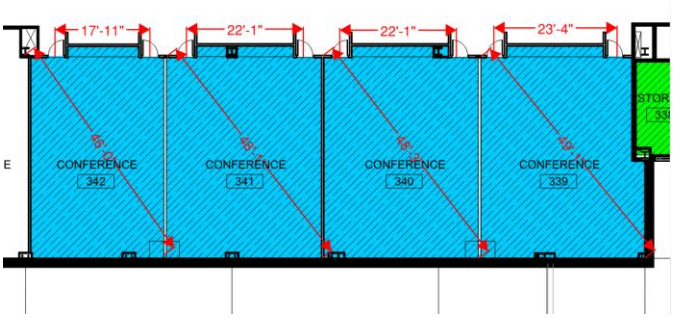


Figure 16 – Third-Floor Conference Room Modifications **Figure 17 – Third-Floor Conference Room**

Conference Room 437 and Conference Room 438 located on the fourth-floor both have occupant loads greater than forty-nine (49) based on an occupant load factor of fifteen (15) sq. ft./person which requires two (2) exits spaced at one-third (1/3) the diagonal (See Figure 18 – Fourth-Floor Conference Room Modification).

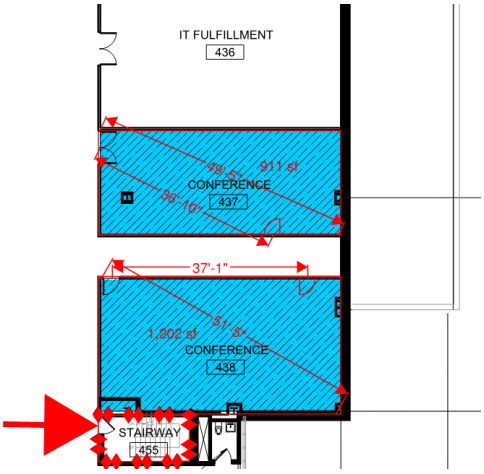


Figure 18 – Fourth-Floor Conference Room Modification

Executive Cafe Room 517 and Conference Room 502 and Cafeteria 501 located on the fifth-floor all have occupant loads greater than forty-nine (49) based on an occupant load factor of fifteen (15) sq. ft./person which requires two (2) exits spaced at one-third (1/3) the diagonal (See Figure 19 – Fifth-Floor Modifications).

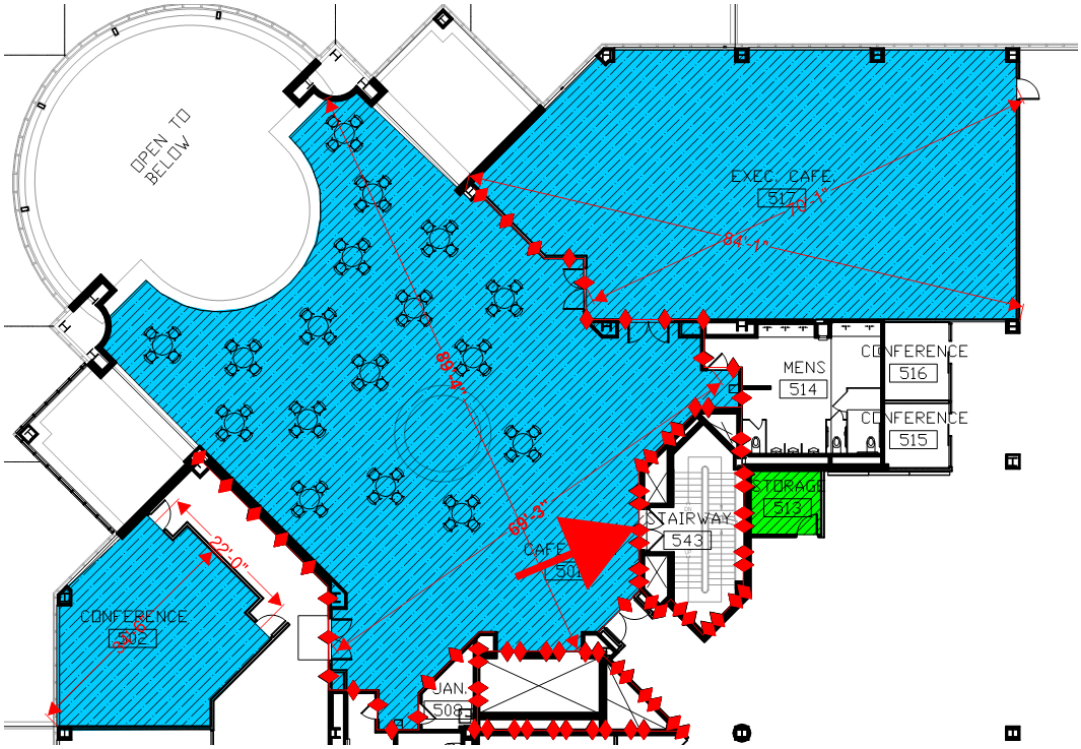


Figure 19 – Fifth-Floor Modifications

2.13 Common Path, Dead-End and Travel Distance Limits

Table 13 – Common Path, Dead-end and Travel Distance Limits indicates the maximum common path, dead end and travel distance limit for each occupancy in accordance with the MNBC. This building does not meet the travel distance limit as described below.

Table 13 – Common Path, Dead-end and Travel Distance Limits

Occupancy	Common Path Limit* (MNBC 1014.3) (ft)	Dead-end Limit* (MNBC 1020.4) (ft)	Travel Distance Limit (MNBC 1016.2) (ft)
B	100	50	300
A	75	20	250
S-1	100	50	250

* Means of egress limitations shall apply to each portion of the building base on the occupancy of that space. Where an occupancy is required to egress through another occupancy the limitations of the more stringent occupancy will be used. (MNBC 1004.9)

Due to Stairway 159 not being open to the first floor, the travel distance and common path limit from the north-east area of the first floor is three hundred and sixty-five (365) feet and one hundred and thirty-one (131) feet respectively. This distance is above the limitations set forth by MNBC and the only area which exceeds Table 13-Common Path, Dead-end and Travel Distance limitations. See Appendix A – Life Safety Analysis for life safety floor plans showing the limits indicated above are not exceeded. Opening Stairway 159 to the first floor will decrease the common path and travel distance to acceptable values and allow faster egress times.

2.14 Minimum Egress Widths

Table 14 – Minimum Egress Widths indicates the minimum widths for egress components as required by the MNBC. All egress components in the DCIB meet the minimum widths set forth by the MNBC and are outlined in the following table.

Table 14 - Minimum Egress Widths

Component	Requirement	Width (in)	MNBC
Doors in Egress Access	Per Component	32	1010.1.1
Corridor Serving 50 or More Occupants	Per Component	44	1020.2
Other Egress Components	Per Person	0.2	1005.3
Stairways	Per Person	0.3	1005.3

2.15 Egress Component Capacity

Table 15 – Egress Component Capacity indicates the egress component capacity of the limiting existing egress components. Lines in red indicate the required exit component occupant load exceeds the maximum occupant capacity of the component. As mentioned earlier in this report, roughly fifty thousand (50,000) sq. ft. of floors three (3) through five (5) consisted of data centers with an occupant load factor of three hundred (300) sq. ft. / person. The new tenant is looking to convert that space back into an office type setting requiring an occupant load of one hundred (100) sq. ft. / person. The new occupant load, in addition to the new Assembly occupant loads (break rooms, conference rooms, cafeteria) results in the occupant load being much greater than the capacity of the existing components. The first-floor is the only floor which does not require additional egress width.

Table 15 - Egress Component Capacity

Floor	Exit Area	Restricting Egress Component / Width	Maximum Occupancy Capacity of Component	Occupant Loading
Level 1	Door Area 1	Doorway / 136 inches (Clear)	680	275
Level 1	Door 2	Doorway / 34 inches (Clear)	170	170
Level 1	Door 3	Doorway / 34 inches (Clear)	170	170
Level 1	Door 4	Doorway / 34 inches (Clear)	170	170
Level 2	Stairway 1	Stair / 60 inches (Clear)	200	320
Level 2	Stairway 2	Doorway / 34 inches (Clear)	170	170
Level 2	Stairway 3	Doorway / 34 inches (Clear)	170	170
Level 2	Stairway 4	Doorway / 34 inches (Clear)	170	170
Level 2	Stairway 5	Stair / 60 Inches (Clear)	200	321
Level 3	Stairway 1	Stair / 60 Inches (Clear)	200	200
Level 3	Stairway 2	Doorway / 34 Inches (Clear)	170	424
Level 3	Stairway 3	Doorway / 34 Inches (Clear)	170	424
Level 3	Stairway 4	Doorway / 34 Inches (Clear)	170	424

Level 4	Stairway 1	Stair / 60 Inches (Clear)	200	200
Level 4	Stairway 2	Doorway / 34 Inches (Clear)	170	338
Level 4	Stairway 3	Doorway / 34 Inches (Clear)	170	338
Level 4	Stairway 4	Doorway / 34 Inches (Clear)	170	337
Level 5	Stairway 1	Stair / 60 Inches (Clear)	200	200
Level 5	Stairway 2	Doorway / 34 Inches (Clear)	170	338
Level 5	Stairway 3	Doorway / 34 Inches (Clear)	170	338
Level 5	Stairway 4	Doorway / 34 Inches (Clear)	170	337

2.16 Required Egress Component Capacity

Table 16 – Egress Component Summary provides a summary of the existing egress components in addition to the required width based on the occupant load of the building utilizing prescriptive based design.

Table 16 - Egress Component Summary

FLOOR	OCCUPANT LOAD FOR FLOOR	REQUIRED DOOR WIDTH (IN)	PROVIDED DOOR WIDTH (IN)	REQUIRED STAIR WIDTH (IN)	PROVIDED STAIR WIDTH (IN)
Level 1	785	157	238	-	-
Level 2	1,151	231	170	346	300
Level 3	1,472	295	170	442	240
Level 4	1,213	243	170	364	240
Level 5	1,436	288	170	431	240

The first-floor meets the required egress width for the occupant load as shown in the table above. For the second-floor, an additional sixty-one (61)-inches of door width and forty-six (46)-inches of stairway width is required to adhere to the prescriptive requirements of the MNBC. The third-floor, which has the highest occupant load, requires an additional one hundred and twenty-five (125)-inches of door width and two hundred and two (202)-inches of stairway width. The fourth-floor requires an additional seventy-three (73)-inches of door width and one hundred and twenty-four (124)-inches of stairway width while the fifth-floor requires an extra one hundred and eighteen (118)-inches of door width and one hundred and ninety-one (191)-inches of stairway width to adhere to the prescriptive requirements set forth by the MNBC.

2.17 Minimum Interior Finish Ratings

Table 17 – Minimum Interior Finish Ratings indicate the minimum interior finish ratings set forth by the MNBC. The existing interior finishes of the DCIB meet or exceeds the following requirements.

Table 17 - Minimum Interior Finish Ratings (MNBC Table 803.9)

OCCUPANCY	EXIT ENCLOSURE AND EXIT PASSAGEWAYS	CORRIDORS	ROOMS AND ENCLOSED SPACES
B, S-1, A-3	Class C	Class C	Class C
Atrium	Class B	Class B	Class B

2.18 Conclusion

The existing building does not adhere to the prescriptive requirement set forth by the MNBC based on the new potential tenant modifications. Floors 2 – Floors 5 require additional door and stairway widths to meet the requirements. Additional doors are required throughout the building to meet the minimum quantity of doors from room or spaces.

During the life safety analysis, exceptions for having a fully sprinkled building in accordance with NFPA 13 were utilized. The following section describes the fire suppression systems utilized throughout the building.

3.0 FIRE SUPPRESSION ANALYSIS

Many exceptions for having a fully sprinkled building were utilized in the life safety analysis. Therefore, a sprinkler system as described below and in accordance with NFPA 13 and NFPA 14 was provided for the DCIB.

Additionally, per section 903.2.11.3 of the MNBC, an automatic sprinkler system must be installed throughout the building since there is an occupied floor level that is located greater than fifty-five (55) feet above the lowest level of fire department vehicle access.

3.1 Water Supply

The new eight (8)-inch water supply (red) is fed from the existing (blue) twenty-four (24)-inch looped domestic system. The underground fire protection contractor will tap into the twenty-four (24)-inch ductile iron line running parallel to 3rd avenue via a hot-tap to prevent shut down of the domestic system (See Figure 20 – Underground Tie-Point 01).

To hot-tap a line, the contractor will need to provide a tapping sleeve and a tapping valve. A tapping sleeve (See Figure 21 – Tapping Sleeve) is like a clamp on tee with a flanged outlet perpendicular to the line the contractor is tapping in to. A tapping valve will be placed on the flanged outlet of the tapping sleeve. The tapping valve can recede its resilient wedge into its body to allow an obstruction free water (See Figure 22 - Tapping Valve). The contractor will connect a drill to the tapping valve and drill a new waterway into the twenty-four (24)-inch ductile iron line. When removing the drill, the contractor can close the valve which will pressurize the tie-point. For this building, an eight (8)-inch cement lined ductile iron pipe will then be routed to the building to feed the fire suppression system.

A flow test was conducted on June 12, 2015 near the building and was utilized for the hydraulic calculations. The results were 89 psi static, 81 psi residual, flowing 1437 gpm. Per the City of Minneapolis, any flow tests within the previous five years can be utilized for designing the hydraulic fire suppression system.

Figure 20 - Underground Tie-Point 01

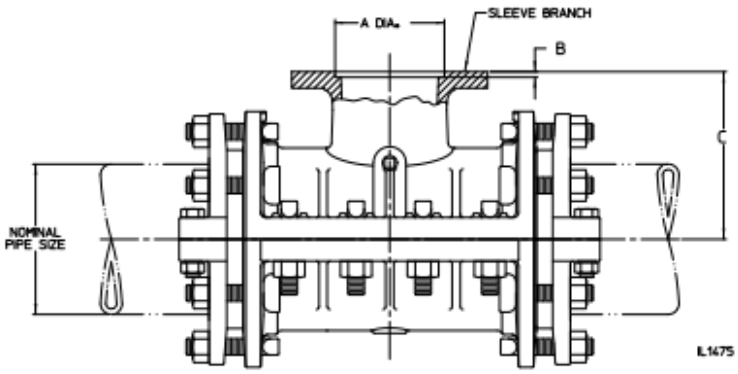


Figure 21 – Tapping Sleeve

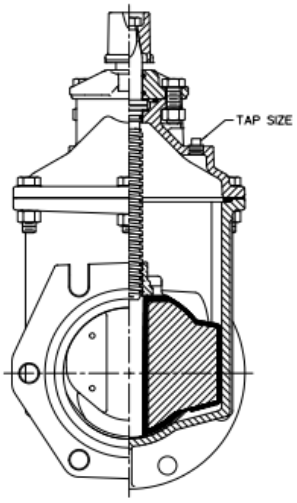


Figure 22 - Tapping Valve

3.2 Suppression Systems

In total, the fire suppression system will consist of ten (10) wet-pipe systems, five (5) pre-action systems, one (1) dry-pipe system and a standpipe system all designed, installed and tested in accordance with NFPA 13 and NFPA 14.

3.2.1 Elevators

The elevators located in the DCIB are hydraulic type, constructed in accordance with ANSI/ASME A17.1 and located in a non-combustible elevator shaft. Per NFPA 13 Section 8.15.5.2, a sprinkler is required at the bottom of the hoist way due to the combustible hydraulic fluids and rubbish. Means will be provided by the fire alarm contractor to stop the elevator before the sprinkler in the pit activates. A sprinkler is not required at the top of the hoist way due to the elevator being constructed in accordance with ANSI/ASME A17.1 per NFPA 13 Section 8.15.5.5.

3.2.2 Wet-Pipe Systems

There are ten (10) wet-pipe systems throughout the building, two (2) per each floor. Each floor requires two (2) wet-pipe sprinkler systems due to the floor area being greater than the maximum allowable area of fifty-two (52,000) square feet set forth by NFPA 13 Section 8.2.1. This building will be utilizing acoustical tile ceilings (ACT) throughout the office spaces, therefore return-bends with a white semi-recessed (See Figure 23 – White Semi-Recessed Sprinkler) will be utilized for areas where there is ACT. Where there is no ceiling (i.e. mechanical rooms, loading docks), brass upright sprinklers will be utilized (See Figure 24 – Brass Upright Sprinkler).

Figure 23 – White Semi-Recessed Sprinkler

Figure 24 – Brass Upright Sprinkler

3.2.3 Double Interlock Pre-action Systems

There are five (5) double interlock pre-action systems throughout the building, one (1) for each floor. These systems will protect areas where there is a high concentration of electronics, i.e. (Information Technology (IT) related rooms) to provide an extra layer of protection. Pre-action systems are a normally "dry" system unless smoke or heat is sensed via a detector in the protected room. It takes an activation of a fire alarm detector in addition to a sprinkler being activated to release the pre-action system. One or the other will not activate the pre-action system. Many owners elect to provide these systems over high-valued electronics. Due to the redundancy required to activate these systems, the chance of false discharges is decreases. ACT will be provided in a majority of the IT and electrical rooms, therefore the white semi-recessed sprinkler (Figure 23 – White Semi-Recessed Sprinkler) on a return-bends will be a majority of the sprinklers on these pre-action systems.

3.2.4 Dry-pipe System

There is one (1) dry-pipe system in this building which is protecting the Loading Dock on the first-floor. A dry-pipe system is provided since temperatures inside the loading dock can be below 40°F. Per NFPA 13, if the space or room can reach temperatures below 40°F then a dry system is required. Like a pre-action systems, this system sits normally "dry". How a dry-pipe system differs from a pre-action system is it takes the activation of the sprinkler bulb only to activate the system, no additional detection is required. The loading dock will be open to the deck, therefore brass upright sprinklers (See Figure 24 – Brass Upright Sprinkler) on sprigs will be provided throughout the space.

3.2.5 Standpipe System

The final system being installed throughout the building is a stand-pipe system as required by MNBC Section 905.3 and installed in accordance with NFPA 14. The exception allows Class I standpipe be provided in lieu of Class III due to the building being equipped throughout with an automatic sprinkler system in accordance with NFPA 13. Per NFPA 14, a Class I standpipe provides a 2-1/2 – inch hose connection for use by trained personnel of fire department with no attached hose. Section 5.4.1 of NFPA 14 allows Class I standpipes to be manual wet system in buildings like the DCIB which is not considered a high-rise. Therefore, there are no pressure requirements associated with the standpipe system.

3.3 Hazard Groups

As with most buildings, there are multiple hazard groups throughout the DCIB. See Appendix B – Fire Suppression Analysis for a graphical representation of the different hazard groups and locations throughout the building.

A majority of the building will be Light Hazard with a density of 0.10 gpm / sq. ft. over the most remote fifteen hundred (1500) sq. ft. as required by NFPA 13 Figure 11.2.3.1.1 (See Figure 25 – Density / Area Curve). Additionally, Light Hazard requires a hose stream allowance of one hundred (100) gallons per minute (gpm) and maximum sprinkler spacing of fifteen (15) feet and two hundred and twenty-five (225) square feet per head.

The Loading Dock Room 141 on the first floor will be treated as an Ordinary Hazard Group II with a density of 0.20 gpm / square foot over the most remote fifteen hundred (1500) sq. ft. as required by NFPA 13 Figure 11.2.3.1.1 (Figure 25 – Density / Area Curve). Ordinary Hazard Group II requires a hose stream allowance of two hundred and fifty (250) gpm and maximum spacing of fifteen (15) feet for sprinklers and one hundred and thirty (130) square feet per head.

The final hazard group, and the most demanding is Extra Hazard Group II over the Mattress Fabrication Room 130 on the first floor. Extra Hazard Group II requires a density of 0.40 gpm / sq. ft. over the most remote twenty-five hundred (2500) sq. ft. as required by NFPA 13 Figure 11.2.3.1.1 (Figure 25 – Density / Area Curve), a hose stream allowance of five hundred (500) gpm and maximum sprinkler spacing of twelve (12) feet and one hundred (100) square feet per head. As show in Appendix B – Fire Suppression Analysis, this room is the hydraulically most demanding area of the building.

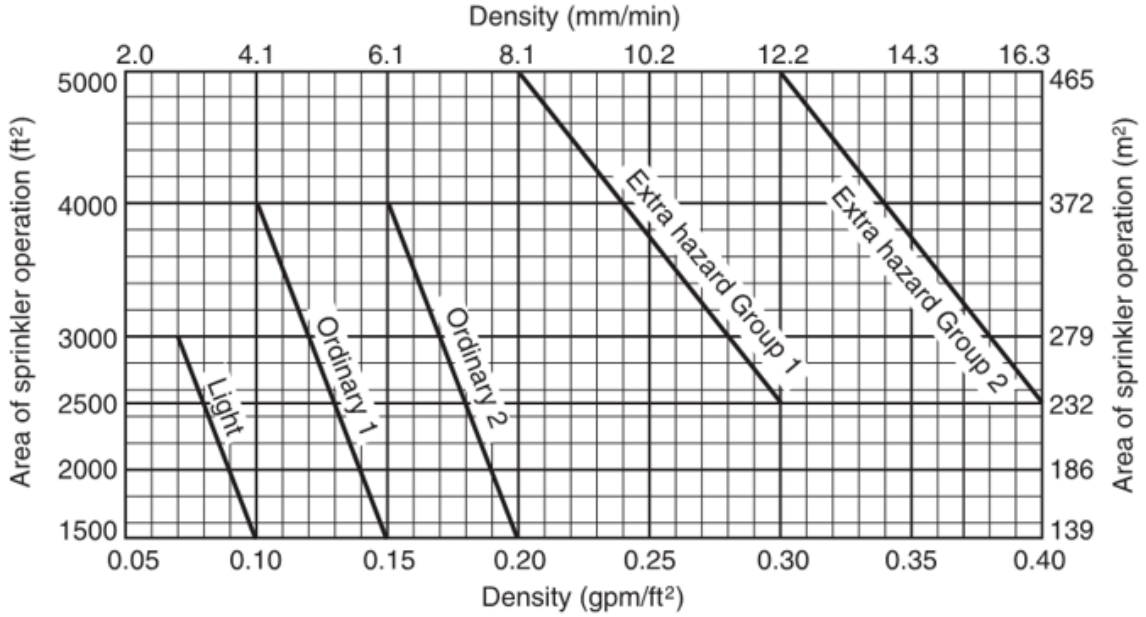


Figure 25 – Density / Area Curve

3.4 Hydraulic Analysis

See Appendix B – Fire Suppression Analysis for a detailed hydraulic calculation. The preliminary calculations determined a demand of one thousand one hundred and fifty (1,150) gpm at seventy-six 76 psig with an additional five hundred (500) gpm hose stream allowance. The most demanding area is surprisingly on the first floor, but it is the Extra Hazard Group II occupancy. Per the calculations, and assuming an overflow of 15%, which is conservative, this building does not need a fire pump. As shown in Figure 26 – Water Supply Requirements, the demand of the system is below that of the supply curve. The fire suppression contractor will perform detailed design of the suppression system in accordance with applicable codes and Appendix G – Specifications.

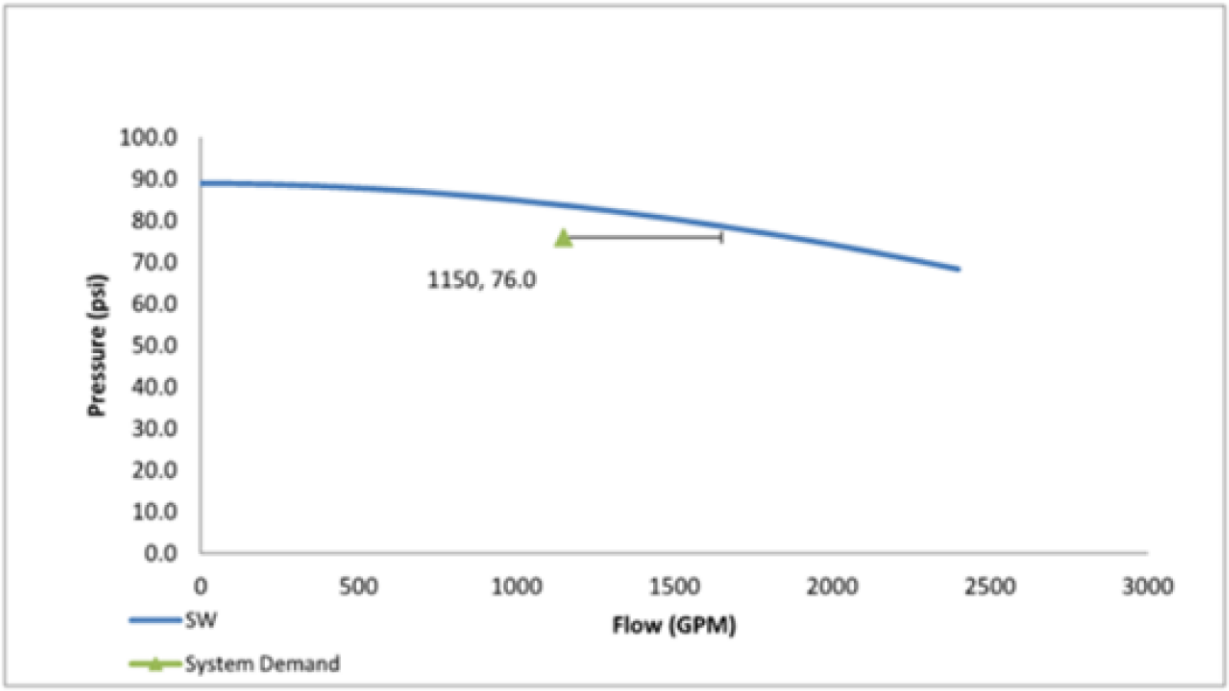


Figure 26 – Water Supply Requirements

3.5 Hangers and Bracing

The State of Minnesota has no bracing requirements due to its low seismic zone per MNBC Chapter 16. Hanger and spacing requirements will meet the requirements of Chapter 9 of NFPA 13. Spacing of hangers will be in accordance with Figure 27 – Maximum Distance Between Hangers.

	Nominal Pipe Size (in.)											
	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8
Steel pipe except threaded lightwall	N/A	12-0	12-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0
Threaded lightwall steel pipe	N/A	12-0	12-0	12-0	12-0	12-0	12-0	N/A	N/A	N/A	N/A	N/A
Copper tube	8-0	8-0	10-0	10-0	12-0	12-0	12-0	15-0	15-0	15-0	15-0	15-0
CPVC	5-6	6-0	6-6	7-0	8-0	9-0	10-0	N/A	N/A	N/A	N/A	N/A
Ductile iron pipe	N/A	N/A	N/A	N/A	N/A	N/A	15-0	N/A	15-0	N/A	15-0	15-0

Figure 27 –Maximum Distance Between Hangers

3.6 Inspection, Testing and Maintenance

Inspection, testing and maintenance will be done in completed with NFPA 25 and outlined in Figure 28 – Inspection, Testing and Maintenance below.

Item	Inspection Frequency	Testing	Maintenance	Reference NFPA 25
Gauges	Weekly/Monthly	Position-Annually Operation-Annually	Only if leak occurs	5.2.5.2, 5.2.4.3, 5.2.4.4
Control Valves	Quarterly	Annually	Only if leak occurs	Table 13.1
Waterflow alarm device	Quarterly	Annually with control valve	Only if leak occurs	5.2.5
Piping and fittings	Annually	When you test the control valve, flows water through pipes	Only if leak occurs	5.2.2
Sprinklers	Annually	At 50 years and every 10 years after	Only if leaks occur	5.2.1

Figure 28 – Inspection, Testing and Maintenance

The fire suppression system will be designed, installed and tested in accordance with NFPA 13 and NFPA 14 to provide the DCIB a complete automatic suppression system as required by the MNBC.

The fire suppression system works in conjunction with a fire alarm system to provide the safest building for the occupants. The fire alarm system is used not only detect fire, but modify and alert occupants and the fire department in case of a fire or activation of the suppression system.

4.0 FIRE ALARM ANALYSIS

4.1 Introduction

An addressable fire alarm system will be provided throughout the building as required by MNBC Section 907.2.14 and designed, installed and tested in accordance with NFPA 70 and NFPA 72.

Transmission of signals to a supervised monitoring station will be via a Digital Alarm Communicator Transmitter (DACT). The DACT will require two phone lines be dedicated to this unit. Power panels capable of mounting Notification Appliance Circuits (NAC) will be used in lieu of NAC Panels. It is assumed one power panel will provide twenty-five thousand (25,000) sq. ft. of notification appliances.

All system wiring will be Class B which with an end-of-line resistor at the end of the circuit.

4.2 Fire Suppression

As previously discussed, an automatic sprinkler system will be installed throughout the building in accordance with NFPA 13. In addition to the sprinkler system, the fire suppression subcontractor is required to provide the following initiating devices on their system. The devices will be provided by the fire suppression subcontractor but wired and monitored by the fire alarm subcontractor.

4.2.1 Valve Supervisory Device

A valve supervisory switch monitors the integrity of the fire suppression system by monitoring the "position" (i.e. Open or Closed) of a control valve. A control valve is a valve is defined as a valve that could hinder the sprinkler system if left in the wrong position. A valve supervisory device is required on all fire suppression system control valves.

Per NFPA 72 Section 17.16.1, the valve supervisory switch shall have separate and distinct signals: one indicating movement of the valve from its normal position, and the other indicating restoration of the valve to its normal position. For example, assume the switch on the valve is a normally open contact. As the operator begins to turn the valve, the switch closes, indicating a supervisory condition. The switch stays in the closed position as the operator continues to close the valve. When the operator reopens the valve, the closed contact transfers back to the open state when the valve is completely open. The opening of the valve provides the second distinct signal. See the fire suppression rise one-line diagram in Appendix B - Fire Suppression Analysis for location and quantity of supervised valves. See Figure 29 - Valve Supervisory Switch for a typical tamper switch.

Figure 29 - Valve Supervisory Switch

4.2.2 Water Flow Switch

For the wet-pipe sprinkler systems, vane-type water flow switch will be provided (See Figure 30 – Vane – Type Water Flow Switch) to initiate the fire alarm system of a waterflow condition. As required by code, a pressure type water flow switch will be provided for normally "dry" systems (See Figure 31 – Pressure-Type Water Flow Switch). These initiating devices will signal an alarm condition on any flow of water in the piping.

The water in a wet-pipe sprinkler system riser is typically static, but due to pressure surges water can move upward in the riser. Therefore, water flow must occur for a minimum of 90 seconds for these devices to initiate an alarm condition. Most municipalities allow you to reduce this time to 45 or 60 seconds.

Figure 30 - Vane-Type Water Flow Switch

Figure 31 - Pressure-Type Water Flow Switch

4.3 Fire Alarm Components

4.3.1 Fire Alarm Control Unit (FACU)

The fire alarm control unit will be a Notifier NFS320 intelligent addressable FACU (See Figure 32 – Notifier NFS 320 FACU). The unit is located in the EE Room on the first floor.

The FACU provides the monitoring and control of all fire alarm and fire suppression system devices. A majority of the initiating devices in the building are addressable, where an addressable device is not obtainable for a specific device (i.e. beam detectors), an addressable input module will be provided. Addressable devices or modules allows the FACU to quickly identify the specific device type and location to alert the responding fire department.

Additionally, the FACU provides activation of the audible and visual notifications throughout the building. Audible notification will be provided for all rooms and areas throughout the building while visual notification will be provided for all common use and public areas. See Appendix C – Fire Alarm Analysis for graphical representation showing location of these requirements.

Figure 32 - Notifier NFS 320 FACU

4.3.2 Fire Alarm Annunciator (FAA)

Following good engineering practice, a Notifier LCD2-80 fire alarm annunciator (See Figure 33 – Notifier LCD2-80) will be provided in the first-floor lobby. The FAA is essentially an extension of the FACU and shows fire alarm, trouble or supervisory signals to allow the responding fire department quickly asses what floor a device has been activate.

Figure 33 - Notifier LCD2-80

4.3.3 Manual Pull Stations

Manual pull stations (See Figure 34 – Manual Pull Station) are provided at all the ground floor exits in addition to the entrance to each stairwell. Additional pull stations are provided as required to ensure that the horizontal travel distance from any point in the building to the nearest pull station does not exceed 200 feet per NFPA 72 section 17.14.8. Figure 35 – Manual Pull Station Wiring provides typical wiring of the addressable manual pull station for Class B wiring.

Figure 34 - Manual Pull Station

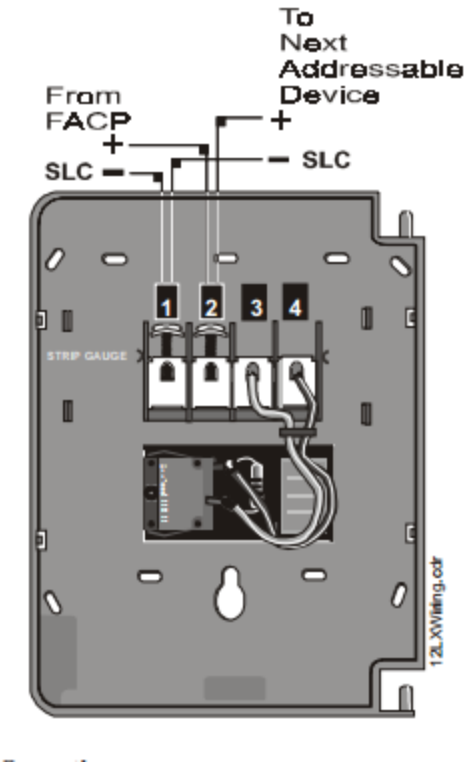


Figure 35 - Manual Pull Station Wiring

4.3.4 Photoelectric Smoke Detectors

Photoelectric type smoke detectors (See Figure 36 – Photoelectric Smoke Detector) will be provided at the following locations;

- Atrium (At all overhangs and the ceiling of the atrium).
- Elevator lobbies.
- Rooms with pre-action sprinkler systems for activation.
- Above FACU's and above NAC Units.

Figure 36 - Photoelectric Smoke Detector

4.3.5 Duct Smoke Detectors

Duct smoke detectors (See Figure 37 – Duct Smoke Detector) listed for air distribution systems will be located as follows and in accordance with NFPA 90A Section 6.4.2. Typical wiring of duct smoke detector is provided in Figure 38 – Duct Smoke Detector Wiring.

- On the return side of the AHU, downstream of air filters and ahead of any branch connection in air supply systems have a capacity greater than 2000 cfm.
- At each story prior to the connection to a common return and prior to any recirculation or fresh air inlet connection in air return systems having a capacity greater than 15,000 cfm and serving more than one story.

Figure 37 - Duct Smoke Detector

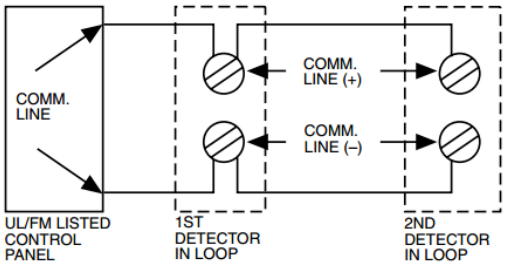


Figure 38 - Duct Smoke Detector Wiring

4.3.6 Heat Detectors

Heat detectors (See Figure 39 – Heat Detector) will be provided in mechanical rooms and elevator machine rooms. A heat detector with a lower temperature rating than the adjacent sprinkler head will be located in the hoist way. If the heat detector is activated, it will shut down power to the elevator motor before the motor gets wet from the sprinkler system. Figure 40 – Heat Detector Wiring Detail provides the typical wiring detail for a non-addressable heat detector located on a Class B circuit.

Figure 39 - Heat Detector

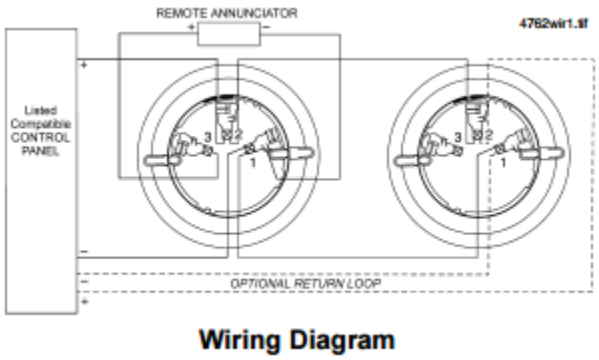


Figure 40 - Heat Detector Wiring Detail

4.3.7 Beam Detectors

Beam type smoke detectors will be located at the atrium ceiling pocket where exhaust air is drawn out in addition to the atrium skylight.

4.4 Fire Alarm Notification Devices

Audible and visual notification appliances will be provided throughout the building. Visual will only be provided in public and common areas which make up a majority of the building. Ceiling mounted devices were used in all areas with a ceiling. If an area did not have a ceiling, wall mounted devices will be utilized.

4.4.1 Horn Strobe

Combination horn strobes will be provided for all areas which require audible and visual notification. See Figure 41 – Ceiling Mounted Speaker Strobe for the typical ceiling mounted speaker strobe and Figure 42 – Wall Mounted Speaker Strobe for typical wall mounted speaker strobe. The horn strobes provided have adjustable candela ratings on the device for field modifications.

Figure 41 - Ceiling Mounted Horn Strobe

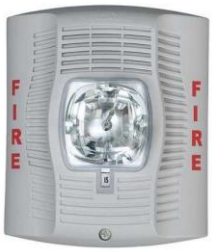


Figure 42 - Wall Mounted Horn Strobe

4.4.2 Audible Notification

A minimum of fifteen (15) dBa over the ambient noise level in the space is required by NFPA 72. A typical horn produces eighty-four (84) dBa at 10 ft away from the speaker. Using the rule of thumb of 6 dBa loss every time the distance is doubled, it allows forty (40) + foot of travel distance before the sound rating it below seventy (70) dBa (assuming fifty-five (55) dBa ambient throughout the space). Figure 43 – dBA Loss shows a graphical representation of the dBA loss based on distance.

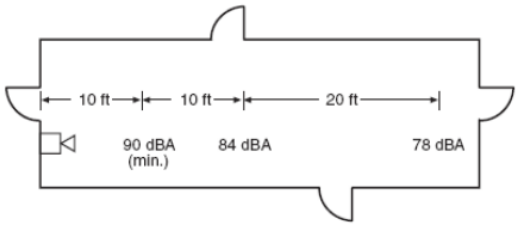


Figure 43 - dBA Loss

4.4.3 Visual Notification

Visual notification devices are provided in all public and common areas as required by MNBC Section 907.5.2.3.1. This includes offices due to the fact the office may belong to a deaf individual. Ceiling mounted notification appliances will be provided were applicable due to the greater spacing requirements compared to wall mounted devices. (See Figure 44 – Room Spacing for Visual Notification).

TABLE 18.5.4.3.1(b) *Room Spacing for Ceiling-Mounted Visible Appliances*

Maximum Room Size		*Maximum Lens Height*		*Minimum Required Light Output (Effective Intensity); One Light (cd)*
ft	*m*	*ft*	*m*	
20 × 20	6.1 × 6.1	10	3.0	15
30 × 30	9.1 × 9.1	10	3.0	30
40 × 40	12.2 × 12.2	10	3.0	60
44 × 44	13.4 × 13.4	10	3.0	75
50 × 50	15.2 × 15.2	10	3.0	95
53 × 53	16.2 × 16.2	10	3.0	110
55 × 55	16.8 × 16.8	10	3.0	115
59 × 59	18.0 × 18.0	10	3.0	135
63 × 63	19.2 × 19.2	10	3.0	150
68 × 68	20.7 × 20.7	10	3.0	177
70 × 70	21.3 × 21.3	10	3.0	185
20 × 20	6.1 × 6.1	20	6.1	30
30 × 30	9.1 × 9.1	20	6.1	45
44 × 44	13.4 × 13.4	20	6.1	75
46 × 46	14.0 × 14.0	20	6.1	80
50 × 50	15.2 × 15.2	20	6.1	95
53 × 53	16.2 × 16.2	20	6.1	110
55 × 55	16.8 × 16.8	20	6.1	115
59 × 59	18.0 × 18.0	20	6.1	135
63 × 63	19.2 × 19.2	20	6.1	150
68 × 68	20.7 × 20.7	20	6.1	177
70 × 70	21.3 × 21.3	20	6.1	185
20 × 20	6.1 × 6.1	30	9.1	55
30 × 30	9.1 × 9.1	30	9.1	75
50 × 50	15.2 × 15.2	30	9.1	95
53 × 53	16.2 × 16.2	30	9.1	110
55 × 55	16.8 × 16.8	30	9.1	115
59 × 59	18.0 × 18.0	30	9.1	135
63 × 63	19.2 × 19.2	30	9.1	150
68 × 68	20.7 × 20.7	30	9.1	177
70 × 70	21.3 × 21.3	30	9.1	185

Figure 44 - Room Spacing for Visual Notification

4.4.4 Battery and Voltage Drop Calculations

Battery calculations to support twenty-four (24) hours of standby time in addition to five (5) minutes of alarm time is provided for the FACU and all power panels supporting the notification appliance circuits in accordance with NFPA 72. Per the calculations below, 18 amp hours of battery capacity is required for the FACU. (See Figure 45 – FACU Typical Battery Calculations). Detailed audible/visual notification layout and calculations will be completed by the fire alarm subcontractor in accordance with applicable codes and standards and Appendix G – Specifications.

NOTIFIER by Honeywell

System Power Requirements

Notifier NFS-320 Fire Alarm Control Panel

Protected Premises: DCI DATA CENTER BUILDING Date: 06/03/2017
Address:
City: MINNEAPOLIS State: MN Zip:

AC Branch Current Requirements 5.00 AMPS @ 120 VAC
Current required by source to power the fire alarm system.

Primary Standby Load 0.58 Amps
Current load on the primary power supply during **non-alarm** conditions.

Primary Alarm Load 0.55 Amps
Current load on the primary power supply during **alarm** conditions.

Secondary Load Requirements 16.20 Amp Hours
Total Secondary Load from the calculation table below.

Current Draw		Time (hours)	Total (AH)
Secondary Standby Load 0.560 A	x	Required Standby Time 24 hours	13.45
Secondary Alarm Load 0.588 A	x	Required Alarm Time (hours) 0.084 hours	0.05
		Total Secondary Load	13.50
		Derating factor	x 1.2
		Secondary Load Requirements (Amp Hours)	**16.20** AH

Battery Selection 18 Amp Hours
Select batteries from the list below.
18 AH BAT-12180 Battery (12 volt)
(•) Two ( ) Four (two 12VDC sets in parallel)

NOTIFIER by Honeywell

Device Current Draw

NFS-320 Fire Alarm Control Panel

Quantity x [device current draw] = total current draw per device (in amps)

Part Number	Qty	Primary Non-Alarm	Primary Alarm	Secondary Non-Alarm
CPU-320	1	x [0.25000] = 0.25000	x [0.25000] = 0.25000	x [0.25000] = 0.25000
CPS-24	1	x [0.00000] = 0.00000	x [0.00000] = 0.00000	x [0.04000] = 0.04000
NCA2 - Backlight Off	1	x [0.20000] = 0.20000	x [0.20000] = 0.20000	x [0.20000] = 0.20000
LCD2-80	1	x [0.10500] = 0.10500	x [0.09800] = 0.09800	x [0.04500] = 0.04500
FSP-851	14	x [0.00030] = 0.00420	x [0.00000] = 0.00000	x [0.00030] = 0.00420
NBG-12LX	16	x [0.00038] = 0.00600	x [0.00000] = 0.00000	x [0.00038] = 0.00600
FSP-851R	5	x [0.00030] = 0.00150	x [0.00000] = 0.00000	x [0.00030] = 0.00150
RTS151KEY	5	x [0.00000] = 0.00000	x [0.00000] = 0.00000	x [0.00000] = 0.00000
ISO-X	4	x [0.00040] = 0.00160	x [0.00000] = 0.00000	x [0.00040] = 0.00160
FMM-1	26	x [0.00035] = 0.00910	x [0.00000] = 0.00000	x [0.00035] = 0.00910
FRM-1	6	x [0.00026] = 0.00153	x [0.00000] = 0.00000	x [0.00026] = 0.00153
FCM-1	3	x [0.00049] = 0.00146	x [0.00000] = 0.00000	x [0.00049] = 0.00146
Total (Amperes):		**0.5804 A**	**0.5480 A**	**0.5604 A**

Part Number	Qty	Secondary Alarm
Total Primary Alarm Load - C2	1	x [0.54800] = 0.54800
CPS-24	1	x [0.04000] = 0.04000
Total (Amperes):		**0.5880 A**

Figure 45 - FACU Typical Battery Calculations

Voltage calculations is required for all control units to verify adequate power of the specific device is provided to the most remote notification appliances. 20.4V is the starting power of a circuit after derating. The fire alarm subcontractor will perform the detailed battery and voltage calculations, see Figure 46 – Typical Voltage Drop Calculations for an estimate.

POTTER
The Symbol of Protection

Project Name: DCI DATA CENTER BLDG

Standby Hours: 24
Alarm Mins: 5
Batt Efficiency %: 80%

PSN-106
Battery & Voltage Drop
Calculations

Installed By:
Designed By:
Date: 06/03/2017

NAC Source Voltage: 20.4

Model #: PSN-106
Panel ID: NAC 1.1
Location: FIRST FLOOR

Max Panel Current (amps): 10

User assumes all responsibility to ensure the quantities and current draw values in this worksheet are accurate prior to submittal.

Panel Qty	Part #	Description	Standby (amps) Each	Standby (amps) Total	Alarm (amps) Each	Alarm (amps) Total
1	PSN-106	NAC Power Expander	0.075	0.075	0.075	0.075
			Panel Standby:	**0.075**	**Panel Alarm:**	**0.075**

NAC Circuits (See NAC Configuration below) Ckt	Use	Description	Standby (amps) Total	Alarm (amps) Total
1	Notification	1st Floor NW	0.00000	0.82700
2	Notification	1st Floor SW	0.00000	1.06400
3	Notification	1st Floor SE	0.00000	0.76700
4	Notification	1st Floor NE	0.00000	0.83400
5			0.00000	0.00000
6			0.00000	0.00000
AUX			0.00000	0.00000
			NAC Standby: **0.00000**	**NAC Alarm:** **3.49200**

Battery Calculation Summary	Standby (amps)	Alarm (amps)
Panel Current:	0.07500	0.07500
NAC Circuit Current:	0.00000	3.49200
Total Standby:	**0.075000**	**Total Alarm:** **3.56700**
Standby Hours:	24	**Alarm Mins:** 5
AH Required:	**1.80**	**AH Required:** **0.30**
Total Combined Standby & Alarm AmpHours Required:		2.10
Efficiency Factor:		80%
Required Battery AmpHours:		**2.63**
Battery AmpHours Provided:		**7**

Figure 46 - Voltage Drop Calculations

4.4.5 Inspection, Testing and Maintenance

Prior to the fire alarm system being commissioned, the installing fire alarm subcontractor will be required to complete System Record of Completion form in Section 8, Chapter 7 of NFPA 72.

Additionally, testing in accordance with NFPA 72 Table 14.4.2.2 is required for all devices throughout the building.

The fire alarm system will be designed, installed and tested in accordance with NFPA 70 and NFPA 72 to provide the DCIB a complete automatic fire alarm system as required by the MNBC.

The fire suppression system works in conjunction with a fire alarm system to provide the safest building for the occupants.

5.0 PRESCRIPTIVE ATRIUM DESIGN REQUIREMENTS

5.1 Summary of Prescriptive MNBC Atrium Requirements

Per Chapter 2 of the MNBC, an atrium is defined as *"an opening connecting two or more stories other than enclosed stairways, elevators, hoist ways, escalators, plumbing, electrical, air-conditioning, or other equipment which is closed at the top and not defined as a mall. Stores as used in this definition, do not include balconies within assembly groups or mezzanines that comply with Section 505*."

Per the above definition, this building is equipped with a five-story atrium, therefore Section 404.2 through Section 404.9 apply and is summarized below. See Figure 47 – Section View of Atrium for the section view of the atrium and layout.

404.2 Use. *The floor of the atrium shall not be used for other than low fire hazard uses and only approved materials decorations in accordance with the MNFC shall be used in atrium space.*

Exception: *The atrium floor area is permitted to be used for any approved use where the individual space is provided with an automatic sprinkler system.*

Section 404.2 is in place to limit the fuel load which can be in the atrium. Due to the open nature of the atrium, smoke can spread vertically to multiple floors. The design fire used for the performance based design utilized a couch fire which is the highest fuel load located in the atrium.

404.3 Automatic sprinkler protection. *An approved automatic sprinkler system shall be installed throughout the entire building.*

As previously discussed, the MNBC requires an automatic sprinkler system be installed throughout the building. Having a suppression system greatly increases the safety of the occupants.

404.4 Fire alarm system. *A fire alarm system shall be provided in accordance with Section 907.2.14.*

As previously discussed, the MNBC requires an alarm system be installed throughout the building. See Section 4 – Fire Alarm Analysis for additional information. Having an alarm system in a building with an atrium allows for occupants to be notified in case of a fire and evacuated while the fire department is notified.

404.5 Smoke control. *A smoke control system shall be installed in accordance with Section 909.*

As will be discussed in further detail in Section 6 – Performance Based Analysis, a mechanical smoke control system will be provided for the atrium. This system allows smoke to be quickly move vertically through the atrium and discharged outside to allow occupants a tenable environment to egress the building safely.

404.6 Enclosure of atriums. *Atrium spaces shall be separated from adjacent spaces by a 1-hour fire barrier constructed in accordance with Section 707 or a horizontal assembly constructed in accordance with Section 711, or both.*

As shown on the life safety plans in Appendix A – Life Safety Analysis, a one (1)-hour fire barrier is separating the atrium from the remainder of the building. The purpose of this section is if a fire occurs in the atrium, the smoke will not spread throughout the building. Automatic door holds in said 1-hour barrier are required and will activate once a smoke detector in the atrium activates. An exception to this section, one can locate automatic sprinklers along both sides of a wall or door and within four (4)-inches to twelve (12)-inches away from said wall or door to provide equivalent protection. The sprinkler exception is especially useful for when architects are looking to design rooms that overlook the atrium via glass walls.

404.7 Standby power. *Equipment required to provide smoke control shall be connected to a standby power system in accordance with Section 909.11.*

The purpose of this Section is to keep the smoke control active and ready, even in a situation of power failure in the remaining parts of the building. Keeping the smoke control system active provides an increased level of protection to all occupants. This building is equipped in an uninterrupted power supply which does power the smoke control system.

404.8 Interior finish. *The interior finish of walls and ceilings of the atrium shall not be less than Class B with no reduction in class for sprinkler protection.*

The purpose of this Section is to limit the flammability of components located in the atrium. A fire in the atrium can be detrimental to all occupants throughout the building, that is why it is so important to limit the fire load in the atrium.

404.9 Travel distance. *In other than the lowest level of the atrium, where the required means of egress is through the atrium space, the portion of exit access travel distance within the atrium space shall not be greater than 200 feet. The travel distance requirements for areas of buildings open to the atrium and where access to the exits is not through the atrium, shall comply with the requirements of Section 1016.*

The purpose of this Section is to limit the travel distance for occupants located in the atrium. This building has a small area open to the atrium, the two-hundred-foot travel limit is met. See Appendix A – Life Safety Analysis for egress analysis and routes.

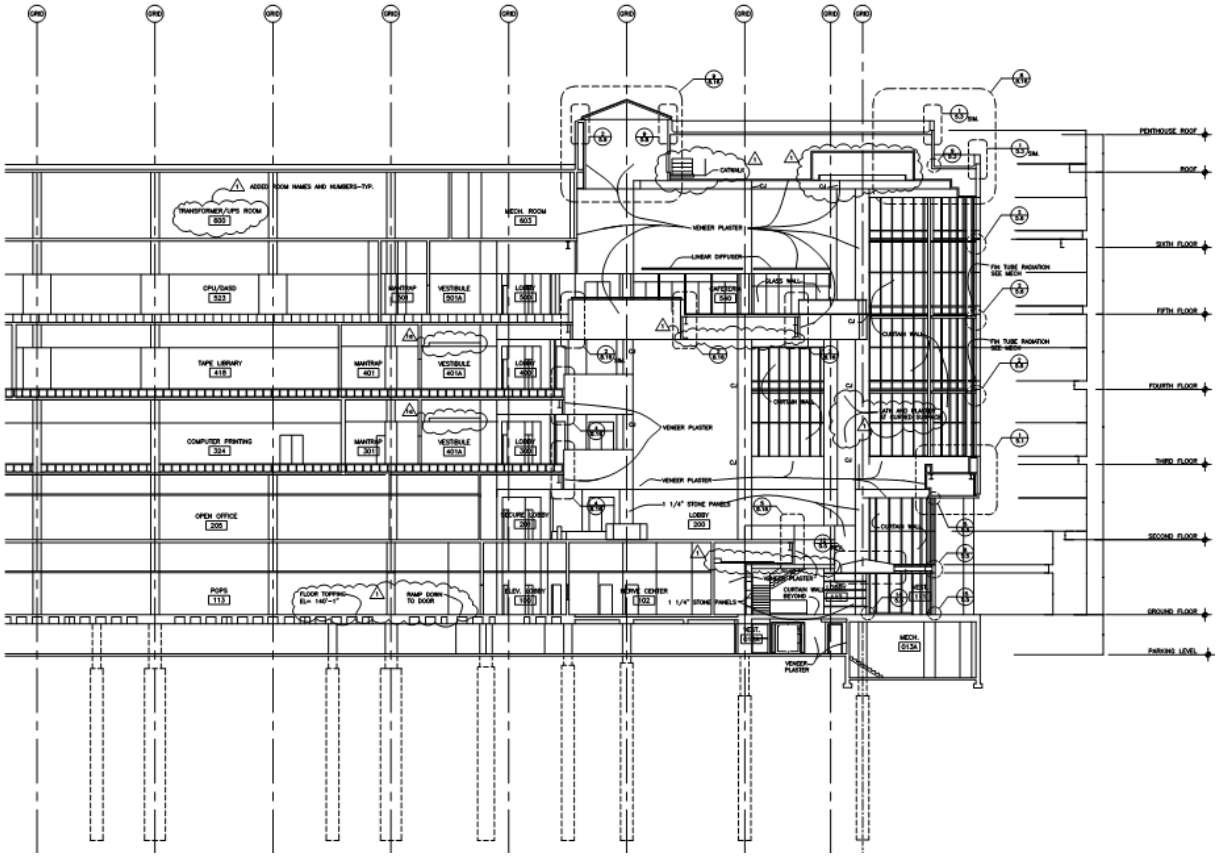


Figure 47 - Section View of Atrium

6.0 PERFORMANCE BASED ANALYSIS

Section 6 – Performance Based Analysis is a review of the fire protection features in the DCIB which are beyond the prescriptive code requirements. A Fire Dynamic Simulator (FDS) model was ran utilizing Pyrosim to ensure tenability limits set forth in the fifth edition of the Society of Fire Protection Engineers Fire Protection Engineering Handbook (SFPEHB) are achieved. In addition, a Pathfinder model was run to determine the required safe egress time of the building occupants based on the tenants potential building modifications. The purpose of this performance based analysis is to prove occupants have adequate time to evacuate from the building, even though the building does not meet the prescriptive code requirements. See Figure 48 – Street View of DCIB for a street view of DCIB and Figure 49 – FDS Model for the FDS model created for the atrium of the DCIB.

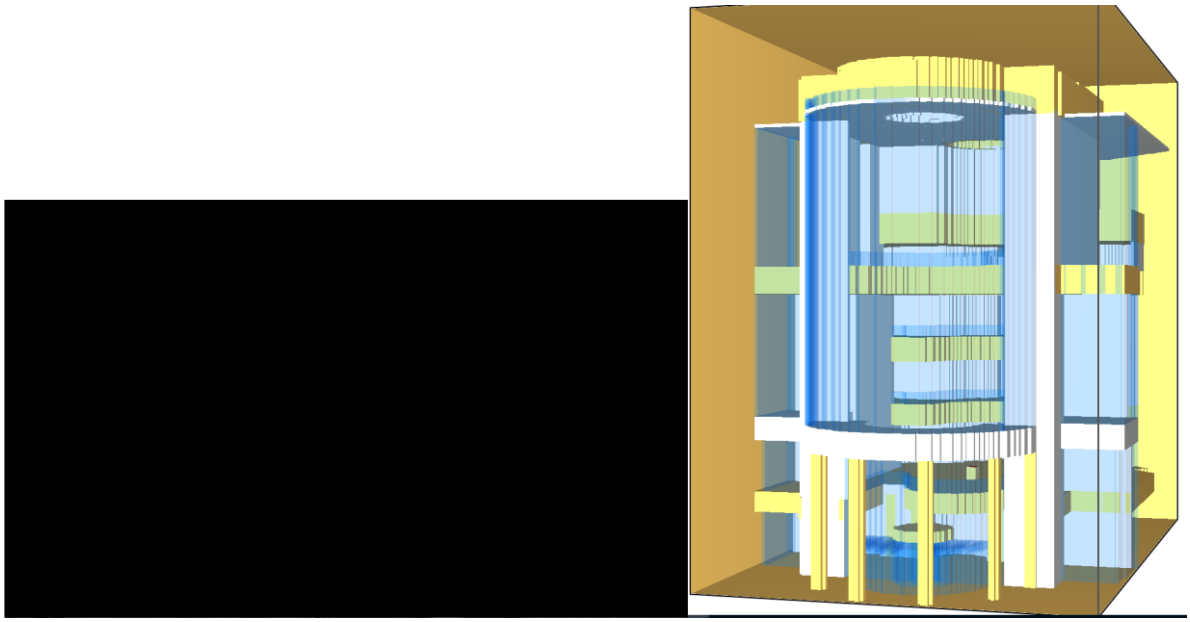


Figure 48 - Street View of DCIB

Figure 49 - FDS Model

6.1 Summary of MNBC Prescriptive Smoke Control Requirements

As discussed in Section 5 – Prescriptive Atrium Design Requirements, a smoke control system in accordance with Section 909 of the MNBC is required for the atrium space of the building and the requirements are summarized below.

909.4.6 Duration of operation. *All portions of the active or passive smoke control system shall be capable of continued operation after detection of the fire event for a period of not less than 20 minutes. System design shall be for 20 minutes; however, fans shall continue to operate after 20 minutes and shall continue to operate automatically for smoke removal during fire suppression overhaul efforts for a minimum of 5 minutes for every 10 feet vertically of protected space.*

It should be noted; this definition differs from the 2012 IBC which states;

All portions of the active or passive smoke control system shall be capable of continued operation after detection of the fire event for a period of not less than 20 minutes or 1.5 times the calculated egress time, whichever is less.

The 2015 IBC amends this section modifying "*whichever is less"* to "*whichever is greater".* This would ensure that the available safe egress time is always greater than the required safe egress time.

As discussed later in this analysis, a Pathfinder model was completed and indicated a required evacuation time greater than 20 minutes. Good engineering judgment would indicate to provide an available safe egress time of one and a half (1.5) times the egress time of the Pathfinder model, even though code only requires 20 minutes. Due to the FDS model only being ran for twelve hundred (1200) seconds, in accordance with the MNBC and for the purpose of this analysis, an available safe egress time of twenty (20) minutes was considered.

909.8 Exhaust method. *When approved by the fire code official, mechanical smoke control for large enclosed volumes, such as in atriums or malls, shall be permitted to utilize the exhaust method. Smoke control systems using the exhaust method shall be designed in accordance with NFPA 92B.*

> ***909.8.1 Smoke layer****. The height of the lowest horizontal surface of the smoke layer interface shall be maintained at least 6 feet above any walking surface that forms a portion of a required egress system within the smoke zone.*

The atrium will utilize a mechanical smoke control system and defers design of the smoke control system to NFPA 92B. MNBC requires the smoke layer be maintained six (6) feet above the highest walking surface for the entire available safe egress time of twenty (20) minutes.

909.9 Design fire. *The design fire shall be based on a rational analysis performed by the registered design professional and approved by the fire code official. The design fire shall be based on the analysis in accordance with Section 909.4 and this Section.*

The design fire is discussed in detail in the following section.

6.2 Design Fire

Per MNBC Section 909.9, the design fire scenario must be approved by the fire code official. The characteristics of the design fire is based on published fire test data found in SFPEHB and publications by National Institute of Science and Technology (NIST).

The design fire used for this analysis is based on the effects of furniture located on the second-floor in the reception area as shown in in Figure 52 – Location of Design Fires. The second-floor furniture layout is capable of the largest fire load compared to other furniture layouts located in the atrium.

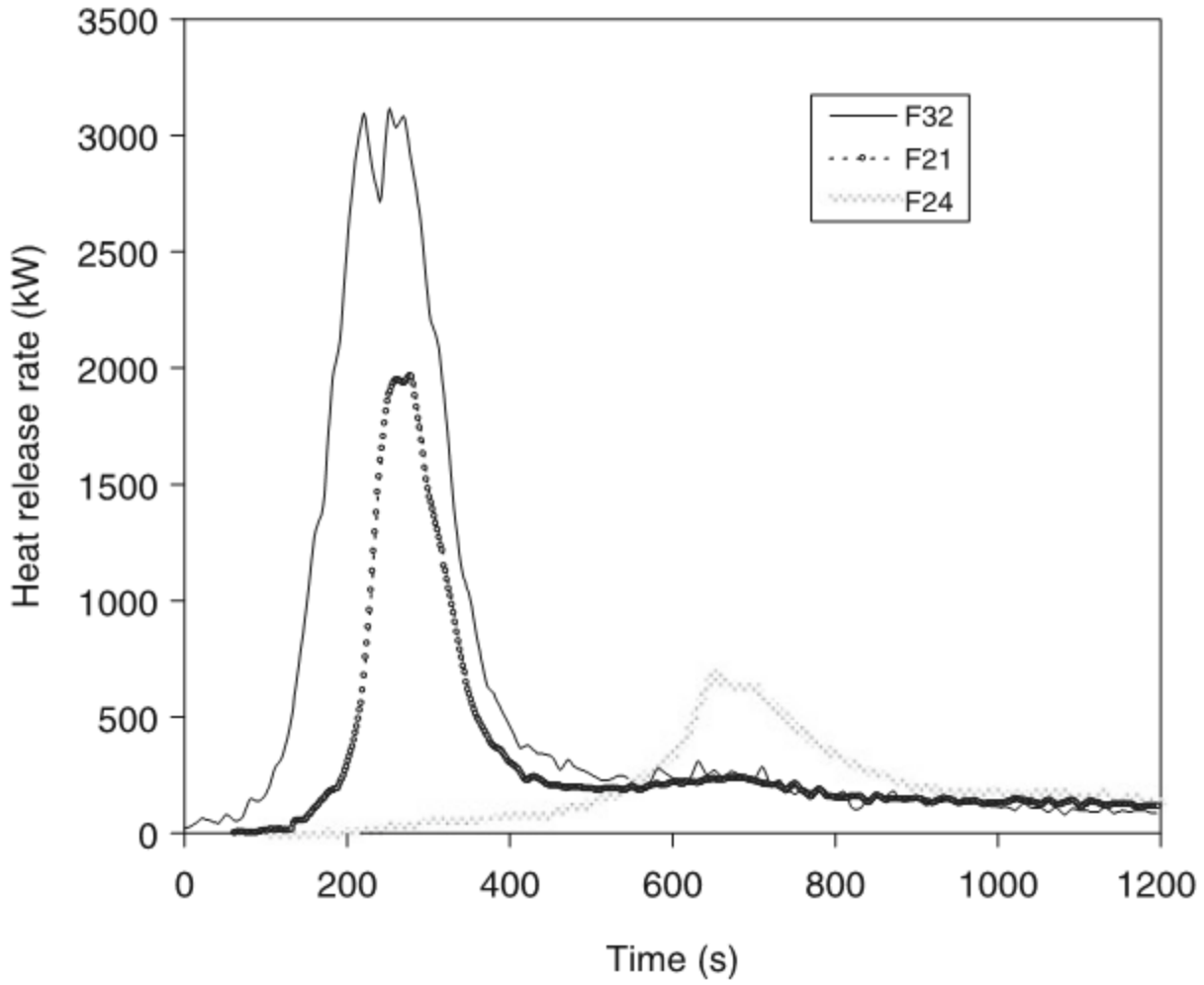


Figure 50 - Heat Release Rate of Upholstered Furniture

Figure 50 – Heat Release Rate of Upholstered Furniture illistrutates several upholstered furniture items tested at NIST. F32 is a sofa constructured of polyurethane foam complying with the 1975 California TB 117 standard and polyolefin fabric. A sofa constructred utilizing ordinary polyurethane foam gave essentially the same heat release rate per NIST. Based on Figure 50, a typical sofa widely bought by consumers would have a peak heat release rate of thirty-two hundred (3,200) kilowatts (kW).

Due to the proximity of other furniture pieces as seen in Figure 52 – Location of Design Fire, it was assumed a fire on the sofa would spread to adjacent pieces of furniture. The resulting heat release rate with the additional fuel load is considered to be approximately five thousand (5,000) kW. This fuel load takes into account the ignition of nearby fuel packages.

The design fire consisted of a custom-ramped fire following Figure 50 – Heat Release Rate of Upholstered Furniture with the peak heat release rate of five thousand (5,000) kW occurring at 256 seconds (See Figure 51 – Heat Release Rate of Design Fire). After the peak heat release rate the fire will decay to roughly four hundred (400) kW at five hundred (500) seconds where it will stay for the remaining available safe egress time of twenty (20) minutes. See Figure 51 for the heat release rate of the design fire utilized in the FDS model.

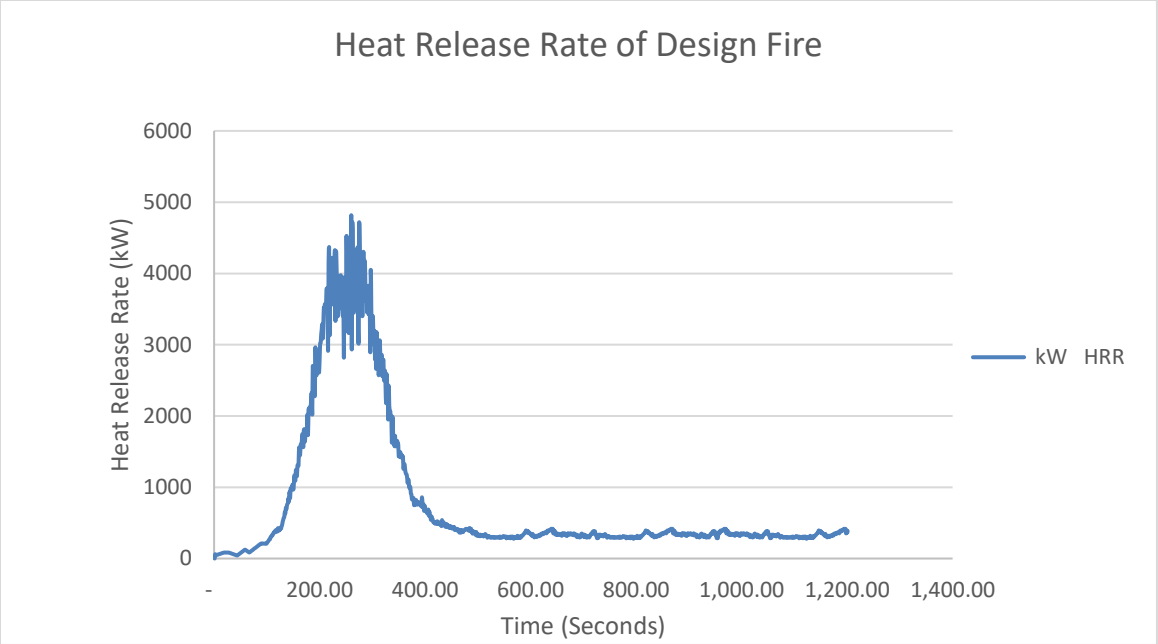


Figure 51 - Heat Release Rate of Design Fire

Figure 52 – Design Fire Location

6.3 Tenability Limits

The tenability limits for the DCIB are conditions that cause incapacitation to the occupants such that they are unable to escape from the building. Table 63.1 – Acute Survival Hazards During Fires of the SFPEHB lists the acute physiological fire hazards affecting escape capability in the order which they tend to be encountered. See Figure 53 – Acute Survival Hazards During Fire for graphical representation.

- Impaired vision from smoke obstruction
- Impaired vision, pain, and breathing difficulties from effects of smoke irritants on eyes and respiratory tract.
- Asphyxiation from toxic gases leading to confusion and loss of consciousness
- Pain to exposed skin and respiratory tract followed by burns from exposure to radiant and convected head leading to collapse.

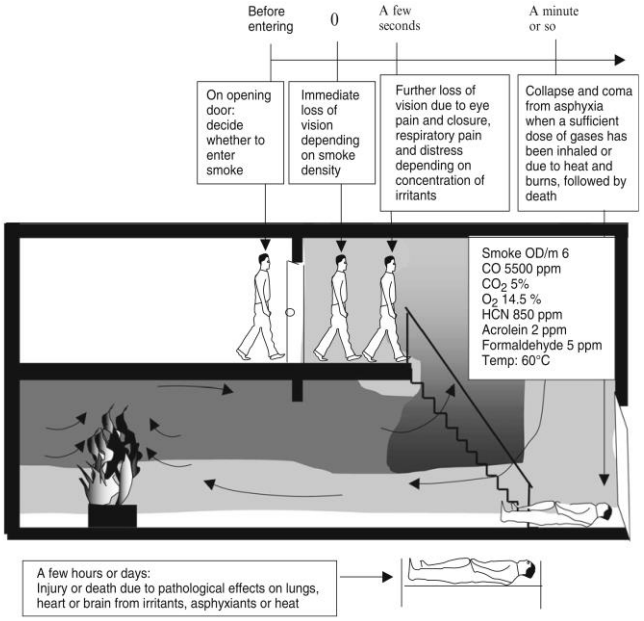


Figure 53 – Acute Survival Hazards During Fire

For the purpose of the analysis, two tenability limits were investigated;

1. Impaired vision from smoke.
2. Temperature limits of the fire and associated plume.

Utilizing an FDS model, one can determine if the tenability limits outlined below are ever exceeded within the available safe egress times.

6.3.2 Visibility Limits

The smoke control system must maintain a visibility distance of four (4)-meters (smoke density of 0.5 1/m) at a location of six (6)-feet above the fifth-floor walking surface as required by the MNBC. The four (4)-meter requirement is outlined in the SFPEHB and shown in Figure 54 – SFPE Visibility Requirements. Due to the DCIB being an office building, a majority of occupants should be very familiar with the environment since they are there for forty (40) hours a week. If the building occupants are unfamiliar with the environment, a visibility distance of thirteen (13)-meters will be required.

Visibility less than four (4)-meters of smoke density of 0.5 1/m at a point six (6)-feet above the highest walking surface will cause failure of the performance based analysis.

Table 61.3 Allowable smoke densities and visibility that permits safe escape

Degree of familiarity with inside of building	Smoke density (extinction coefficient)	Visibility
Unfamiliar	0.15 1/m	13 m
Familiar	0.5 1/m	4 m

Figure 54 - SFPE Visibility Requirements

6.3.3 Temperature Limits

The exhaust system must maintain the temperate six (6)-feet above the highest walking surface below 195°F per Figure 55 – Temperature Tenability from the SFPEHB. The effects of thermal radiation depend on the duration of exposure, humidity level, clothing worn and how the individual is exposed. For the purpose of this analysis, a "dry" atmosphere is assumed since it is located in Minnesota. Temperatures above 195°F will compromise the egress path and result in a failure of the performance based design.

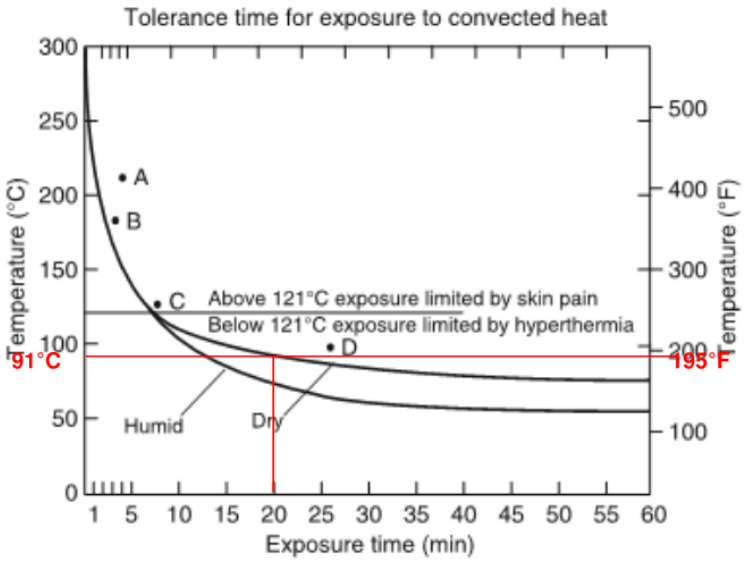


Figure 55 – Temperature Tenability

6.4 Available Safe Egress Time (ASET)

The ASET is defined as the time available for occupants to evacuate from the building. As previously discussed, the ASET for this project is twenty (20) minutes. Per the MNBC, 20 minutes is the largest time for which tenability limits must be maintained. See Figure 56 – Egress Time for a graphical representation of the available safe egress time versus the required safe egress time from a building.

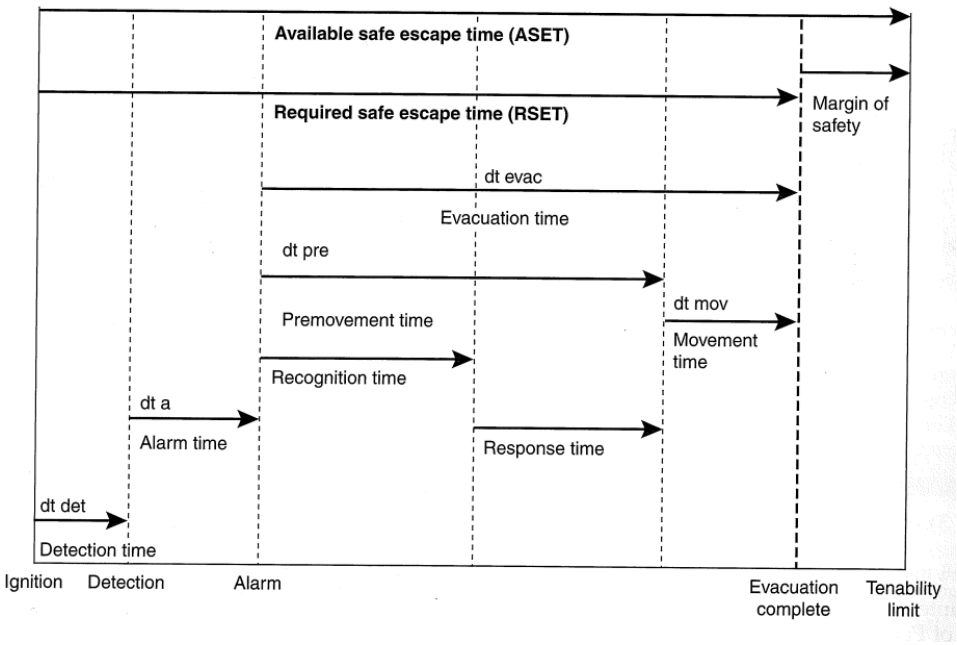


Figure 56 - Egress Time

6.5 Required Safe Egress Time (RSET)

The RSET was calculated utilizing means from the SFPEHB in addition to computer software which model egress paths and times. The RSET is the total time from fire ignition until total evacuation of the building. Figure 56 – Egress Time indicates the sequence for which the RSET is to be calculated and is outlined below.

6.5.1 Detection Time

The detection time is the time from fire ignition to the point of an alarm signal throughout the building. The detection time will vary depending on the location of the fire and the proximity of an initiating device. Due to the openness, a fire with the same heat release rate in the atrium was assumed to have the longest response time.

The United States Nuclear Regulatory Commission provides three equations to calculate the smoke detector response time. A scenario where a detector located on the fifth-floor ceiling, with the resulting design fire on the second floor was utilized to determine the detection time. The Milke Method was the most conservative at 96 seconds (See Figure 57– Smoke Detector Response Time) and was utilized to determine the RSET.

INPUT PARAMETERS

Heat Release Rate of the Fire (Q) (Steady State)	5000.00	kW
Radial Distance to the Detector (r) **never more than 0.707 or 1/2·√2 of the listed spacing**	7.07	m
Height of Ceiling above Top of Fuel (H)	26.00	m
Activation Temperature of the Smoke Detector ($T_{activation}$)	30.00	°C
Smoke Detector Response Time Index (RTI)	5.00	(m-sec)$^{1/2}$
Ambient Air Temperature (T_a)	22.20	°C
Convective Heat Release Rate Fraction (χ_c)	0.70	
Plume Leg Time Constant (C_{p2}) (Experimentally Determined)	0.67	
Ceiling Jet Leg Time Constant (C_{c2}) (Experimentally Determined)	1.2	
Temperature Rise of Gases Under the Ceiling (ΔT_c)	10.00	°C
for Smoke Detector to Activate		
r/H =	0.27	

	Calculation Method	Smoke Detector Response Time (sec)
Summary of Results	METHOD OF ALPERT	1.76
	METHOD OF MOWRER	3.36
	METHOD OF MILKE	95.62

Figure 57 – Smoke Detector Response Time

6.5.2 Alarm and Pre-movement Time

The alarm and pre-movement time is the time it takes from a notification (i.e horn/strobes) until the occupant begins to egress. Since this is an office building, one can assume occupants are individuals between age 22-65 who are familiar with the building. Per Figure 58 – Pre-movement Time, a maximum pre-movement time of 240 seconds can be estimated for a mid-rise office building based on actual testing on a warm day.

Table 64.4 Delay times (min) derived from actual fires and evacuation exercises reported in the referenced literature [37]

Event description	*N*	Min	1st Q	Median	3rd Q	Max	Mean	Factors
High-rise hotel	536	0	3.3	60.0	130.9	290	NA	MGM Grand Hotel fire, no alarm notification, grouped data from questionnaires
High-rise hotel	47	0	2.0	5.0	17.5	120	NA	Westchase Hilton Hotel fire, no alarm in early stages, grouped data from questionnaires
High-rise office building	85	0	2.0	5.0	10.0	245	11.3	World Trade Center explosion and fire, no alarm notification (building closer to explosion)
High-rise office building	46	0	4.5	10.0	31.5	185	28.4	World Trade Center explosion and fire, no alarm notification (building farther from blast)
High-rise office building	107	1.0	1.0	1.0	1.0	≈6.0	NA	Fire incident, no alarms, data from interviews with occupants of four floors of building (11 interviewees were trapped)
High-rise office building	12	0.5	NA	1.0	NA	2.3	1.2	Unannounced drill on three floors; data for first person to reach each of four stairwell doors to wait for voice instruction; trained staff; data from video recordings
Mid-rise office building	92	0	0.4	0.6	0.8	<4	0.6	Unannounced drill, good alarm performance; fire wardens; warm day
Mid-rise office building	161	0	0.5	0.9	1.4	<5	1.1	Unannounced drill, good alarm performance; fire wardens; cool day
One-story department store	95	1	0.2	0.3	0.5	0.9	0.4	Unannounced drill; trained staff; data here derived from grouped data for 95 participants
Three-story department store	122	0.05	NA	NA	NA	1.6	0.6	Unannounced drill; trained staff; times distilled from analysis of videotapes
One-story department store	122	0.07	NA	NA	NA	1.7	0.5	Unannounced drill; trained staff; times distilled from analysis of videotapes
One-story department store	71	0.03	NA	NA	NA	1.0	0.4	Unannounced drill; trained staff; times distilled from analysis of videotapes
High-rise apartment building	NA	0	NA	NA	NA	NA	10.5	Forest Laneway fire; for occupants who attempted to evacuate in the first hour, based on questionnaire responses
	219	0	NA	187.8	NA	720	190.8	Forest Laneway fire, for all occupants
High-rise apartment building	33	0.3	0.8	1.3	4.4	10.2	2.8	Unannounced drill; good alarm performance
High-rise apartment building	93	0.4	1.5	3.6	6.9	18.6	5.3	Unannounced drill; good alarm performance; heavy snow during drill
High-rise apartment building	27	1.0	2.0	8.0	14.0	>20	NA	Fire incident in early morning, alarm functioned, fewer than half the occupants evacuated
Mid-rise apartment building	42	0.6	1.0	1.4	3.0	>14	2.5	Unannounced drill; good alarm performance
Mid-rise apartment building	55	>0.5	1.6	4.4	13.5	>21	8.4	Unannounced drill; poor alarm performance
Mid-rise apartment building	77	>0.3	1.9	7.7	19.1	>24	9.7	Unannounced drill; poor alarm performance
Mid-rise apartment building	80	>0.3	1.2	2.5	3.7	>12	3.1	Unannounced drill; good alarm performance
Training facility	56	<0.2	0.7	1.1	1.5	>5	NA	Testing sleeping subjects at a training facility

NA not reported

Figure 58 - Pre-movement Time

6.5.3 Movement Time

The final phase of egress is the movement time of the buildings occupants to exit the building. A Pathfinder model was completed to determine the movement time for the building occupants. As previously discussed, due to the occupant load being roughly 3 times greater than what was originally designed, it can be assumed the egress time is 3 times longer than what was originally intended. The following assumptions were used in the Pathfinder model;

- All occupants will travel at the same speed.
- All occupants begin egress at the same time.

Per the Pathfinder model, it will take nineteen (19) minutes for all occupants to exit the building based on the proposed tenant layout (See Figure 59 – Pathfinder Model @ 2 minutes on North Wall Looking South). As indicated in Figure 60 – Pathfinder Model @ 15 Minutes on North Wall Looking South, the fifth-floor is evacuated at the fifteen (15)-minute mark.

Figure 59 - Pathfinder Model @ 2 Minutes on North Wall Looking South

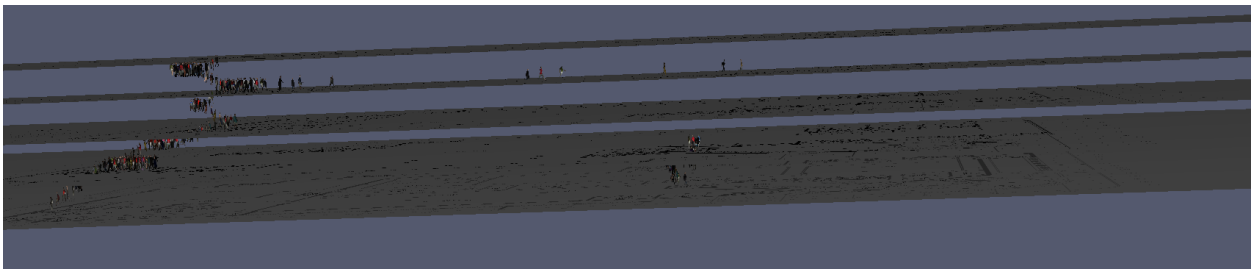


Figure 60 - Pathfinder Model @ 15 Minutes on North Wall Looking South

It should be noted, within 15 seconds occupants the building occupants are beginning to que at the thirty-six (36)-inch doorway feeding the stairwells. Thirty-six (36)-inch doorways are provided on three of the four exit stairwells for floors three (3) through five (5) and are the limiting egress component for the evacuation.

6.5.4 Summary of Egress Time

Summary of Required Safe Egress Time:

- Detection time: ninety-six (96) seconds
- Pre-movement time: two hundred and forty (240) seconds
- Movement time: one thousand one hundred and forty-seven (1,147) seconds
- Safety factor of 25%

Total required safe egress time for building occupants is 31 minutes. It should be noted, generally the available safe egress time must be larger than the required safe egress time which is of good engineering judgement. For the reasons previously discussed, the available safe egress time is 20 minutes as per the MNBC.

6.6 FDS Results

As will be discussed below, the FDS model was utilized to determine if the tenability limits discussed previously can be maintained for the minimum duration of 20 minutes per the MNBC.

6.6.1 Smoke Layer Interface

There were two plume types that were investigated to determine the required flow rate of the exhaust system, axisymmetric and balcony spill. Both plume types are explained in detail below.

6.6.1.1 Axisymmetric Plume

Section 6.2.1 of NFPA 92B was utilized to determine the required exhaust rate of the design fire utilizing an axisymmetric plume.

An axisymmetric plume (See Figure 61 – Axisymmetric Plume) is defined as a plume that rises above the fire, and does not come into contact with walls or other obstacles, and is not disrupted or deflected by airflow. This appeared to be the case for the DCIB, but once the model was completed, it was determined that the plume came in contact with the 5th floor overhang causing more of a balcony spill plume situation. (See Figure 62 – Smoke Spill on 4th Floor Ceiling).

Calculations can be seen in Appendix D – Smoke Exhaust Calculations. The required smoke exhaust rate for this scenario was calculated to be two hundred eighty-nine thousand three hundred and eleven (289,311) cfm.

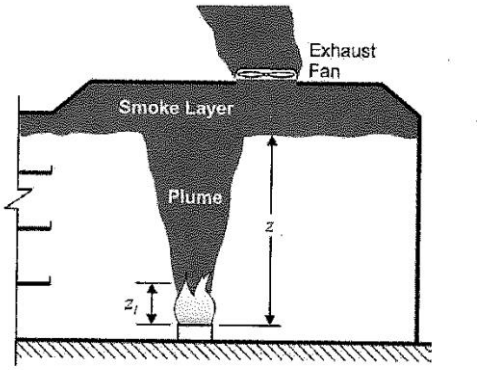


Figure 16.2 *Fire in an atrium with an axisymmetric plume.*

Figure 61 - Axisymmetric Plume

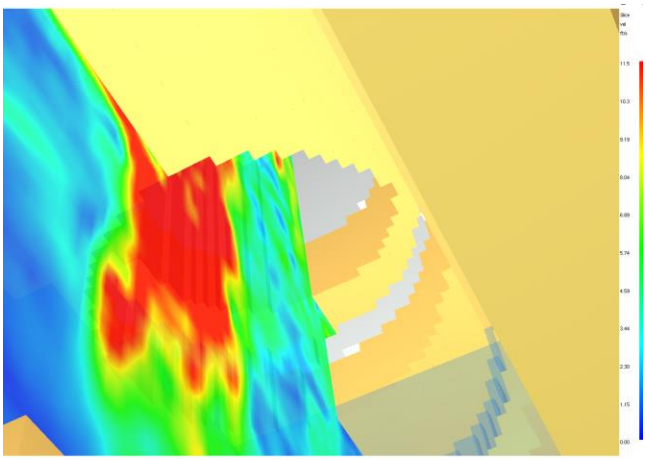


Figure 62 - Smoke Spill on 4th Floor Ceiling

6.7 Balcony Spill Plume

Section 6.2.2 of NFPA 92B was utilized to determine the required exhaust rate of the design fire utilizing a balcony spill plume. A balcony spill plume (See Figure 63 – Balcony Spill Plume) is defined as a smoke plume that originates from a compartment fire, flows out the doorway, flows under a balcony and flows upward after passing the balcony edge. The fire scenario modeled aligns more with a balcony spill plume than any other plumes listed in NFPA 92.

Calculations can be seen in Appendix D – Smoke Exhaust Calculations. The required smoke exhaust rate for this scenario was three hundred thirty-seven thousand six hundred and seventy-four (337,674) cfm.

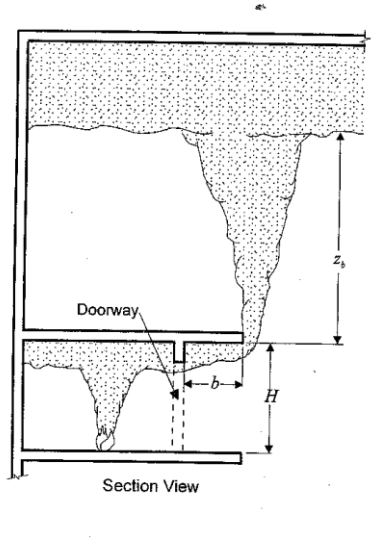


Figure 63 - Balcony Spill Plume

Figure 64 - Fifth Floor Overhang (View from Second Floor)

The first scenario that was modeled utilizing Pyrosim was utilizing the axisymmetric plume exhaust rate. See Figure 64 – Fifth Floor Overhang for location of design fire.

6.8 Axisymmetric Plume Visibility

The mechanical smoke control exhaust system must maintain the smoke optical density of 0.5 m/1 at a location six (6)-feet above the fifth-floor walking surface for a minimum duration of twenty (20) minutes. Figure 65 – Soot Optical Density Axisymmetric indicates a failure of the visual tenability limit at 279 seconds. The visibility at 279 seconds will cause incapacitation of the building occupants on the fifth-floor which is a failure of the performance based design.

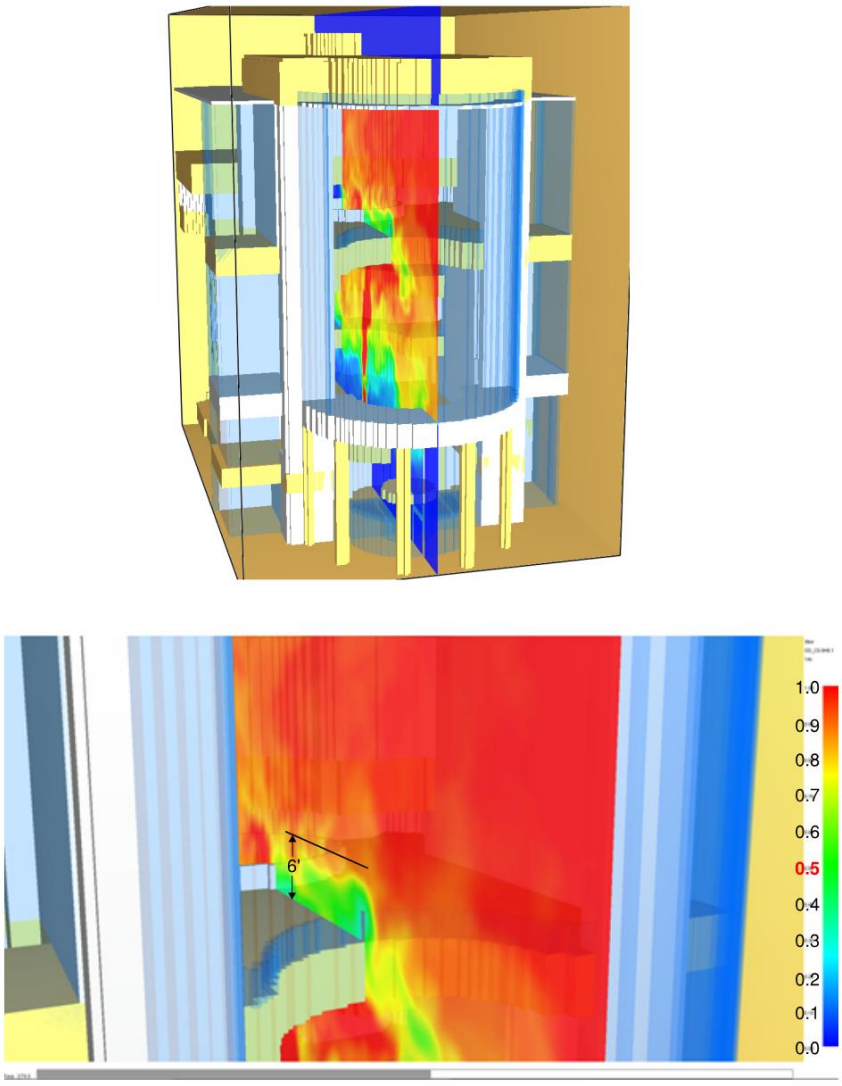


Figure 65 - Soot Optical Density Axisymmetric

6.8.1 Axisymmetric Plume Temperature

Additionally, the exhaust system must maintain the temperature at a location six (6)-feet above the fifth-floor walking surface at a temperature less than one hundred and ninety-five (195) °F for a minimum duration of twenty (20) minutes. Figure 66 – Temperature Tenability Axisymmetric indicates the highest temperature of this design fire is one hundred and twenty-five (125) °F which is below the tenability limits. Utilizing the axisymmetric fire plume exhaust rate, the temperature will not reach a point which will cause incapacitation of building occupants.

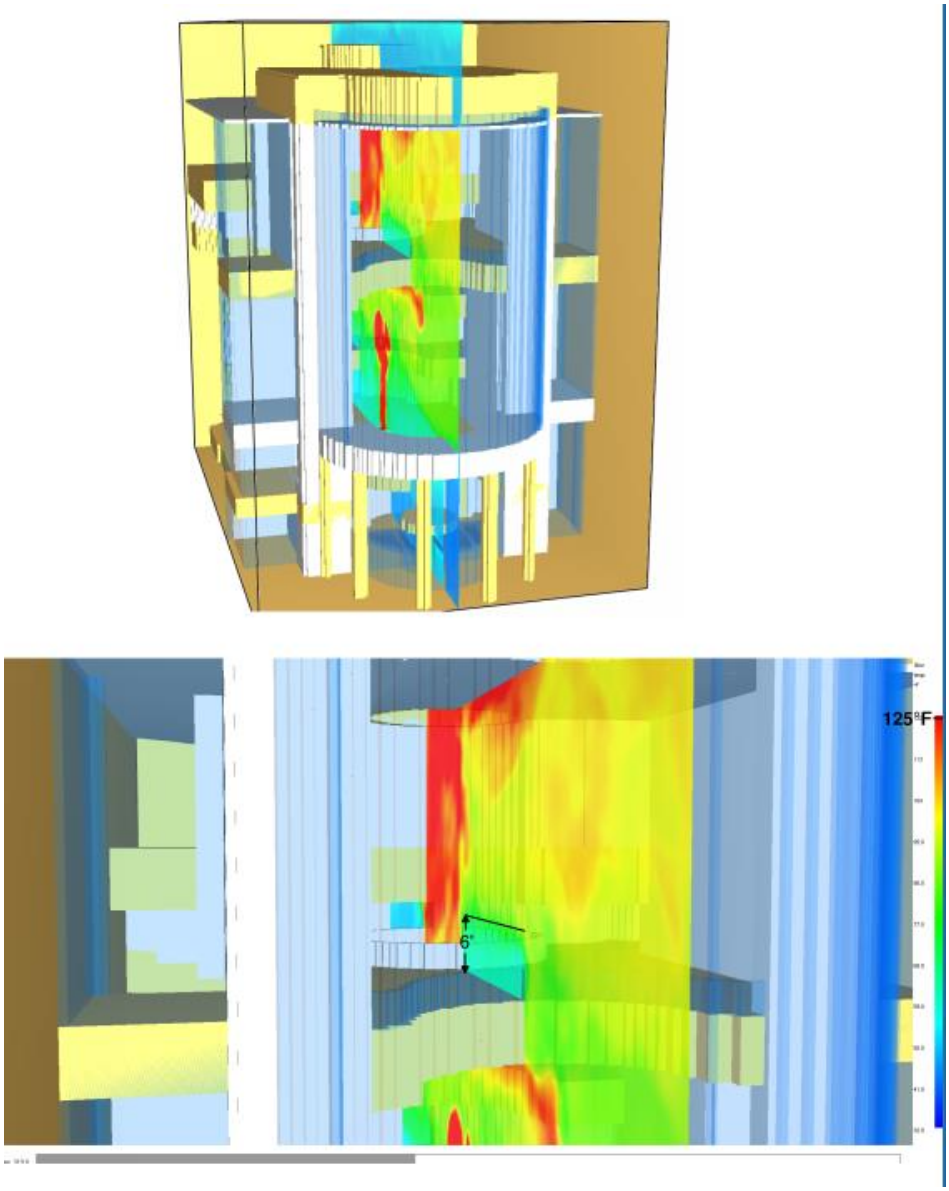


Figure 66 - Temperature Tenability Axisymmetric

Once the model was completed and reviewed, one could see that a higher exhaust rate is required due to a portion of the fire plume spilling along the ceiling of the fourth-floor. The resulting spill requires a balcony spill plume exhaust rate in lieu of the axisymmetric.

The same design fire was modeled utilizing the balcony spill plume exhaust rate. The balcony spill exhaust rate was roughly fifteen (15)-percent more than that of axisymmetric. The results of the higher exhaust rate are outlined below.

6.9 Balcony Spill Plume Scenario

Due to the axisymmetric plume exhaust rate resulting in a failure for the visibility tenability requirements, a second scenario utilizing the same design fire was modeled using a balcony spill plume exhaust rate.

6.9.1 Balcony Spill Plume Visibility

The mechanical smoke control exhaust system must maintain the smoke optical density of 0.5 m/1 at a location six (6)-feet above the fifth-floor walking surface for a minimum duration of twenty (20) minutes. Figure 67 – Soot Optical Density Balcony Spill indicates the minimum visibility limit is maintained for the 20-minute duration, as required by the MNBC. Utilizing the balcony spill fire plume exhaust rate, the visibility will not reach a point which will cause incapacitation of building occupants.

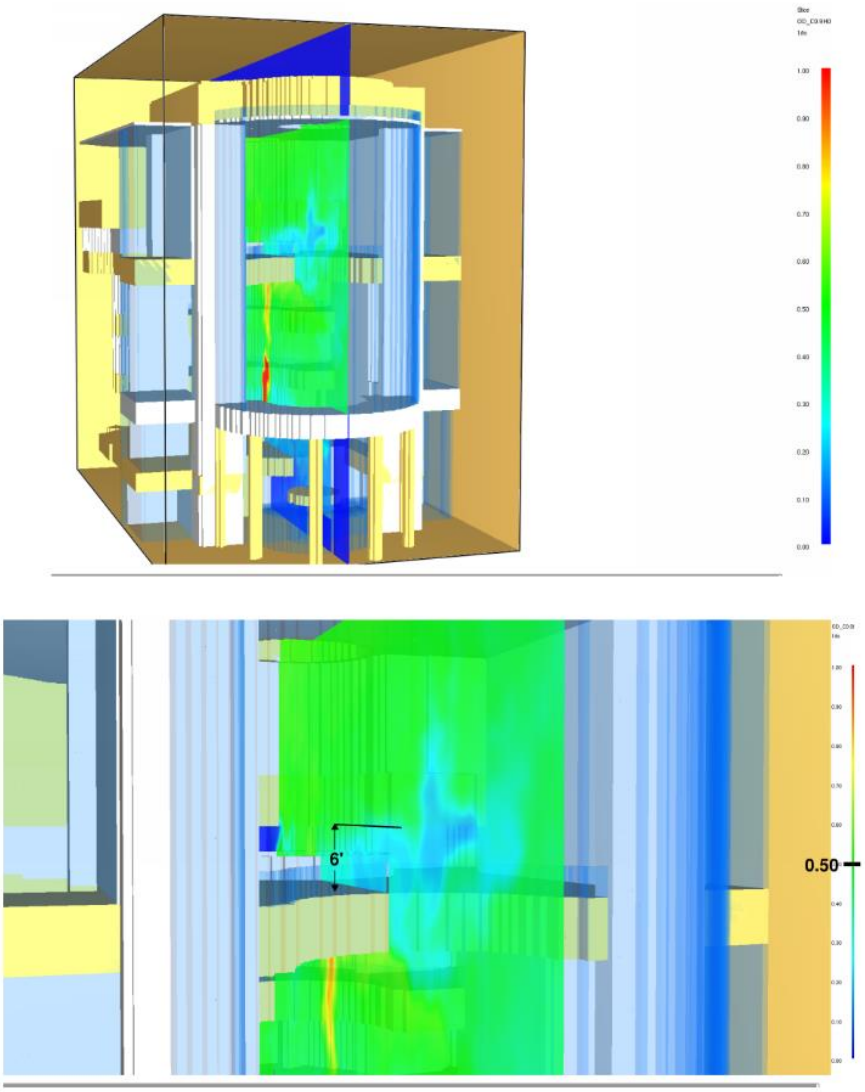


Figure 67 - Soot Optical Density Balcony Spill

6.9.2 Balcony Spill Plume Temperature

Additionally, the exhaust system must maintain the temperature at a location six (6)-feet above the fifth-floor walking surface at a temperature less than one hundred and ninety-five (195) °F for a minimum duration of twenty (20) minutes. Figure 68 – Temperature Tenability Axisymmetric indicates the highest temperature of this design fire is one hundred and twenty-five (125) °F which is below the tenability limits. Utilizing the balcony spill fire plume exhaust rate, the temperature will not reach a point which will cause incapacitation of a building occupant.

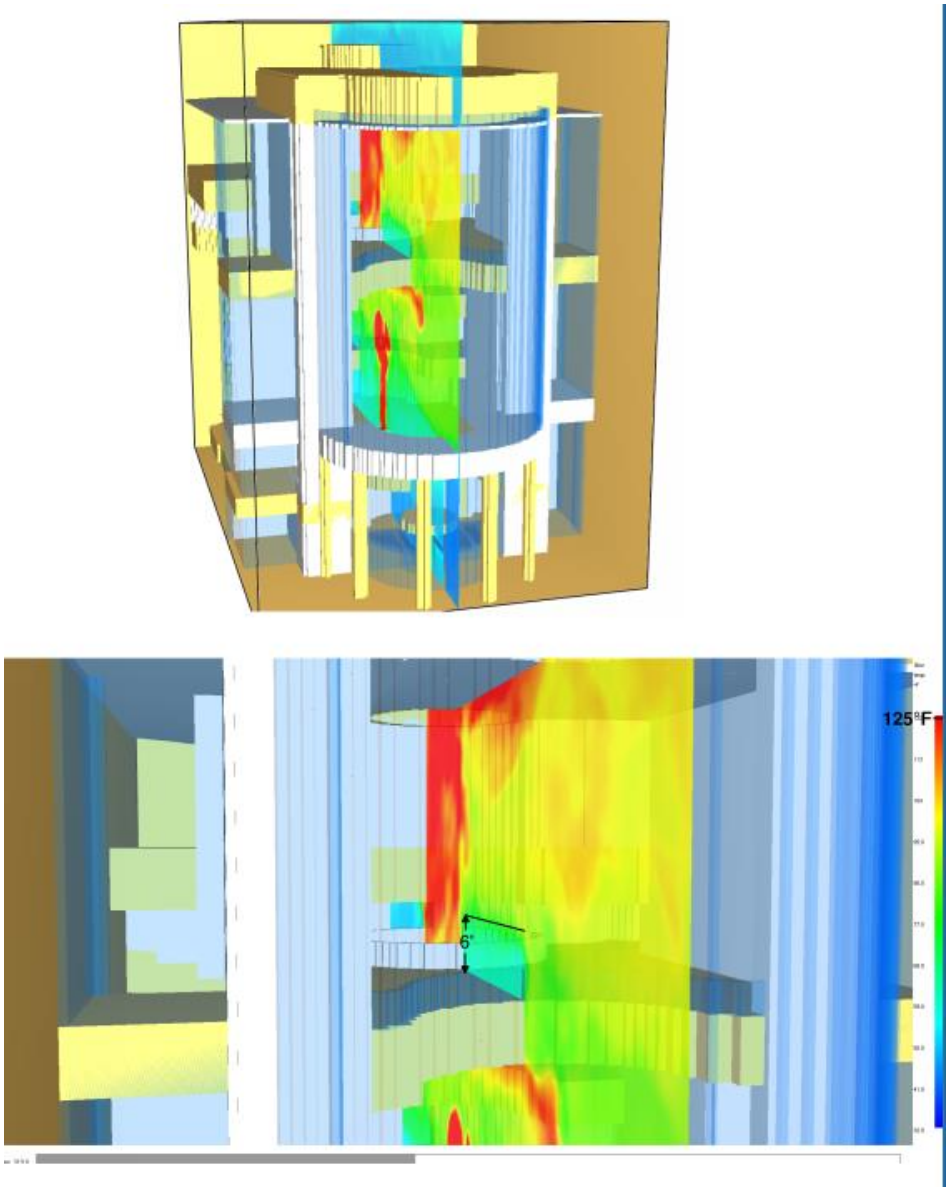


Figure 68 - Temperature Tenability Balcony Spill Plume

7.0 CONCLUSION AND RECOMMENDATIONS

The DCIB is a fully sprinkled and alarmed separated mixed-use office building. The building has a five (5)-story atrium with an automatic smoke control system capable of exhausting three hundred and thirty-eight thousand (338,000) cfm for a minimum duration of twenty-minutes. Additionally, the make-up air system takes up sixteen hundred (1,600) sq. ft. of real estate on the first-floor and can provide a supply rate of three hundred and twenty-one thousand (321,000) cfm.

7.1 Prescriptive Analysis

As discussed in Section 2 – Life Safety Analysis, the building does not meet many of the prescriptive codes as it relates to egress. One should recommend the new tenant or building owner fix all the discrepancies listed below;

- Add additional door to R&D Room 137.
- Add additional door to Conference Room 358.
- Add additional door to Conference Room 359.
- Add additional door to Conference Room 437.
- Add additional door to Conference Room 438.
- Open Stairway 159 to the first floor.
- Provide an additional sixty-one (61)-inches of door width and forty-six (46)-inches of stairway width to the second-floor.
- Provide an additional one hundred and twenty-five (125)-inches of door width and two hundred and two (202)-inches of stairway width to the third-floor.
- Provide an additional seventy-three (73)-inches of door width and one hundred and twenty-four (124)-inches of stairway width to the fourth-floor.
- Provide an additional one hundred and eighteen (118)-inches of door width and one hundred and ninety-one (191)-inches of stairway width to the fifth-floor.

The discrepancies to add additional doors and stairways for floors two (2) through five (5) have substantial cost associated with them.

7.2 Performance Based Analysis

The performance based analysis showed tenability limits can be maintained throughout the atrium for a minimum duration of twenty (20) minutes as required by the MNBC. Additional design fires should be modeled to indicate the exhaust system can maintain the tenability limits of other potential fires in the atrium. Additionally, the model should be ran for one and a half (1.5) times the required safe egress time, or forty-seven (47) minutes to ensure all occupants can evacuate safely from the building.

8.0 REFERENCES

- 2015 Minnesota Building Code
- 2015 Minnesota Fire Code
- NFPA 13 – Standard for the Installation of Sprinkler Systems
- NFPA 14 – Standard for the Installation of Standpipe and Hose Systems
- NFPA 20 – Installation of Stationary Pumps for Fire Protection
- NFPA 25 – Inspection, Testing and Maintenance of Water-based Fire Protection Systems
- NFPA 70 – National Electric Code
- NFPA 72 – National Fire Alarm Code
- NFPA 92 – Standard for Smoke Control Systems
- Milke, J. A., American Society of Heating, Refrigerating and Air-Conditioning Engineers, Turnbull, P. G., & Klote, J. H. (2012). *Handbook of Smoke Control Engineering*. ASHRAE Publications / American Society of Heating, Refrigerating and Air-Conditioning Engineers.
- Hurley, M. J. (2016). *SFPE Handbook of Fire Protection Engineering* (5th ed.). New York: Springer.
- Tuck, C. J., Laughlin, J. E., & Harmon, R. E. (1981). *Fire Protection Handbook* (20th ed.). Quincy, MA, National Fire Protection Association.

APPENDIX A – LIFE SAFETY ANALYSIS

OCCUPANT CLASSIFICATION

	S-1 MODERATE HAZARD STORAGE
	BUSINESS AREAS
	F-1 FACTORY INDUSTRIAL MODERATE HAZARD

FIRE RESISTIVE CONSTRUCTION

1 HR FIRE BARRIER
2 HR FIRE BARRIER

25' 50'

N

FIRST-FLOOR OCCUPANCY CLASSIFICATION

OCCUPANT CLASSIFICATION

	S-1 MODERATE HAZARD STORAGE
	B -- BUSINESS
	A-3 -- ASSEMBLY GROUP

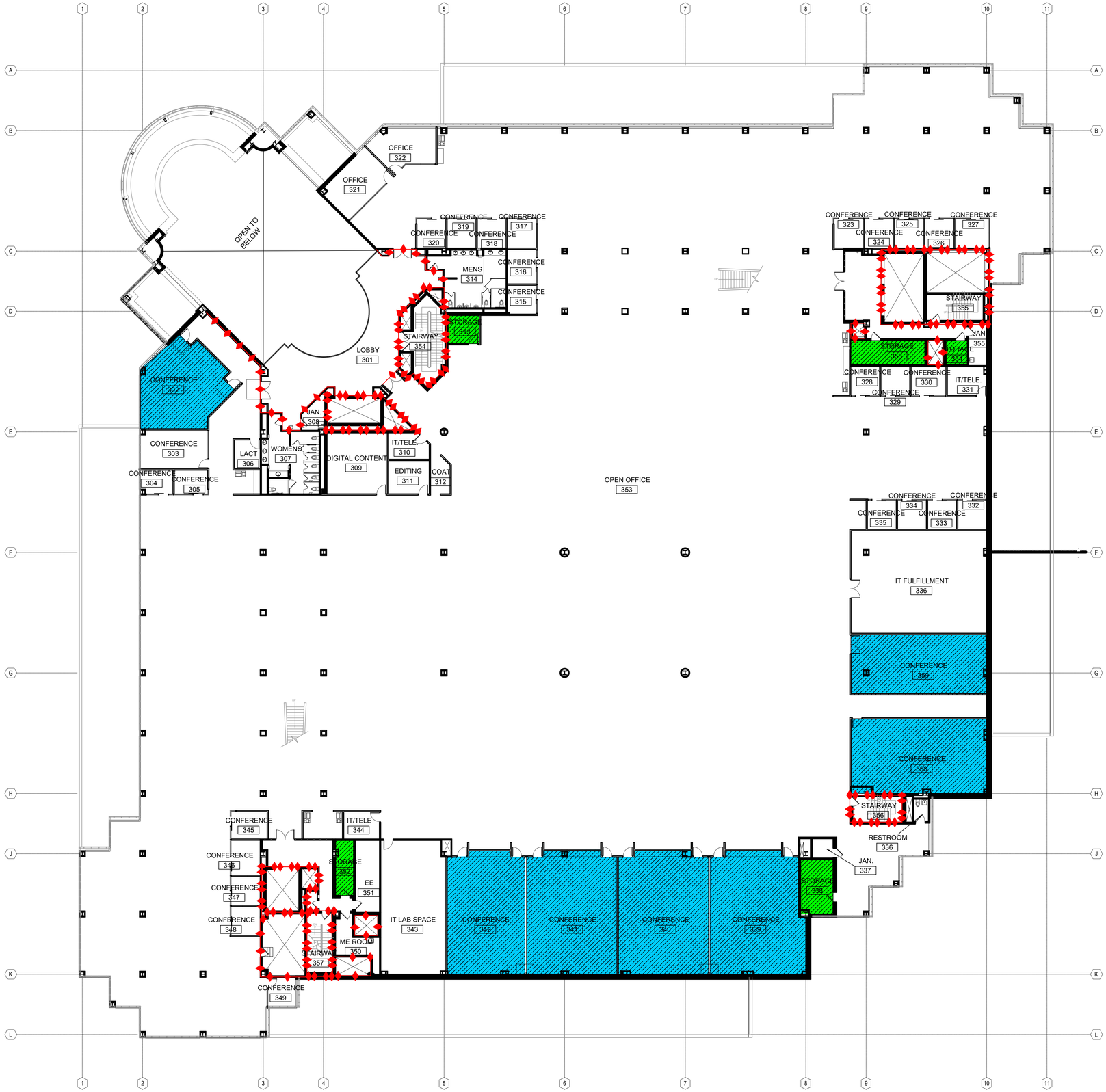
FIRE RESISTIVE CONSTRUCTION

1 HR FIRE BARRIER
2 HR FIRE BARRIER

25 50

N

SECOND-FLOOR OCCUPANCY CLASSIFICATION



OCCUPANT CLASSIFICATION

	S-1 MODERATE HAZARD STORAGE
	B -- BUSINESS
	A-3 -- ASSEMBLY GROUP

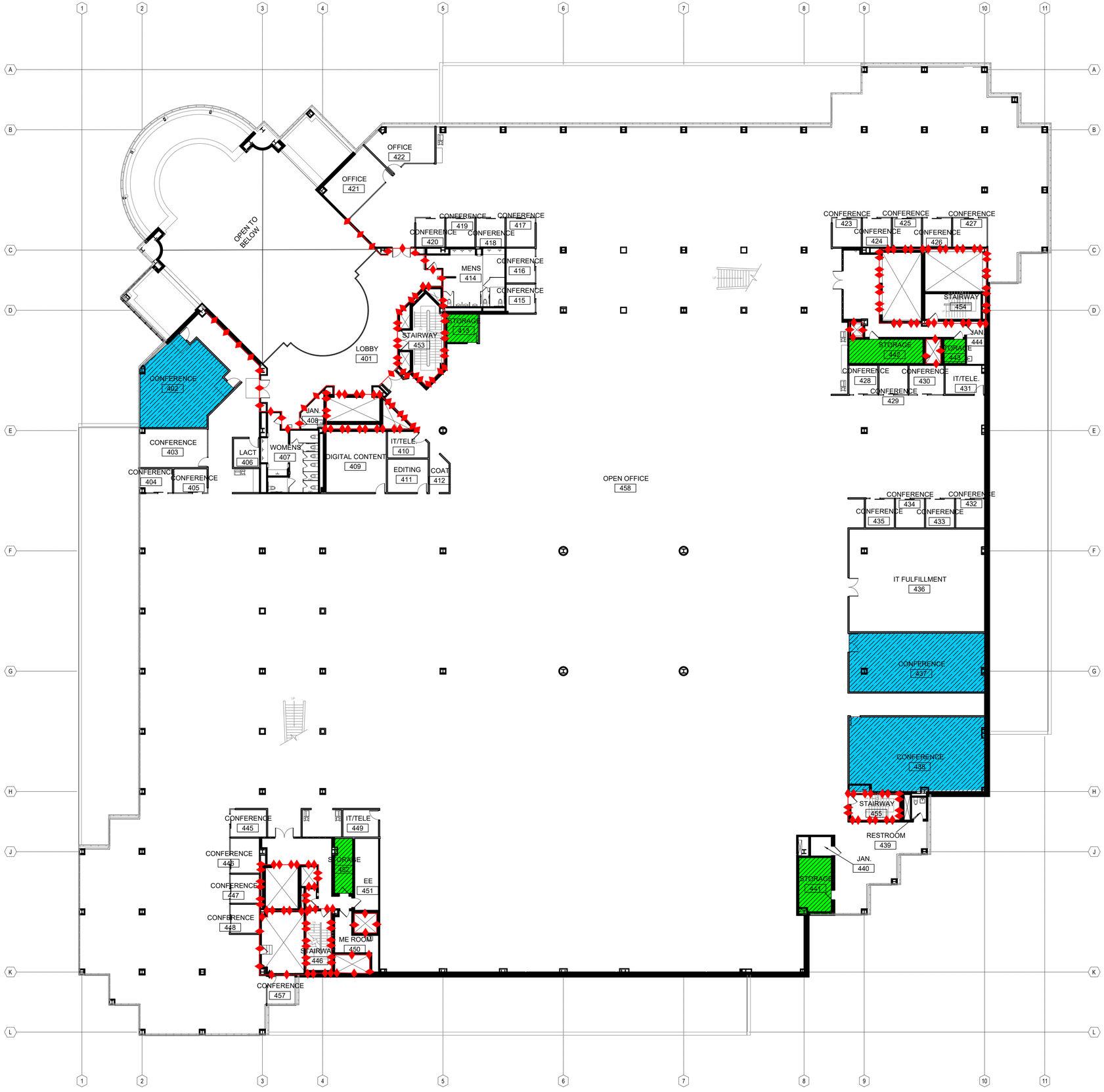
FIRE RESISTIVE CONSTRUCTION

1 HR FIRE BARRIER
2 HR FIRE BARRIER

25' 50'

N

THIRD-FLOOR OCCUPANCY CLASSIFICATION



OCCUPANT CLASSIFICATION

	S-1 MODERATE HAZARD STORAGE
	B -- BUSINESS
	A-3 -- ASSEMBLY GROUP

FIRE RESISTIVE CONSTRUCTION

1 HR FIRE BARRIER
2 HR FIRE BARRIER

25' 50'

N

FOURTH-FLOOR OCCUPANCY CLASSIFICATION

OCCUPANT CLASSIFICATION

	S-1 MODERATE HAZARD STORAGE
	B -- BUSINESS
	A-3 -- ASSEMBLY GROUP

FIRE RESISTIVE CONSTRUCTION

1 HR FIRE BARRIER
2 HR FIRE BARRIER

25' 50'

NT

FIFTH-FLOOR OCCUPANCY CLASSIFICATION

OCCUPANT LOAD LEGEND

	ASSEMBLY WITHOUT FIXED SEATS	1 PERSON / 15 SF NET
	BUSINESS AREAS	1 PERSON / 100 SF GROSS
	ACCESSORY STORAGE AREAS	1 PERSON / 300 SF GROSS
	INDUSTRIAL AREA	1 PERSON / 100 SF GROSS

EGRESS PATH

CP: 25' 50' — CP — EGRESS PATH

TRAVEL DISTANCE

COMMON PATH TERMINATION POINT

EXIT DOOR

COMMON PATH OF TRAVEL

DEAD END CORRIDOR

10' — TERMINATION OF DEAD END CORRIDOR

DEAD END DISTANCE

DOOR EGRESS TAG

78 — OCCUPANTS SERVED

180 — EXIT

32" — REQUIRED WIDTH

36" — PROVIDED WIDTH

STAIR EGRESS TAG

132 — OCCUPANTS SERVED

180 — EXIT

44" — REQUIRED WIDTH

54" — PROVIDED WIDTH

FIRE RESISTIVE CONSTRUCTION

1 HR FIRE BARRIER

2 HR FIRE BARRIER

25' 50'

N

FIRST-FLOOR OCCUPANT CLASSIFICATION

OCCUPANT LOAD LEGEND

	ASSEMBLY WITHOUT FIXED SEATS	1 PERSON / 15 SF NET
	BUSINESS AREAS	1 PERSON / 100 SF GROSS
	ACCESSORY STORAGE AREAS	1 PERSON / 300 SF GROSS

EGRESS PATH

CP: 25' 50' — CP — EGRESS PATH

- TRAVEL DISTANCE
- COMMON PATH OF TRAVEL
- COMMON PATH TERMINATION POINT
- EXIT DOOR

DEAD END CORRIDOR

10' — TERMINATION OF DEAD END CORRIDOR

DEAD END DISTANCE

DOOR EGRESS TAG

		STAIR EGRESS TAG
78	OCCUPANTS SERVED	132
180	EXIT	180
32"	REQUIRED WIDTH	44"
36"	PROVIDED WIDTH	54"

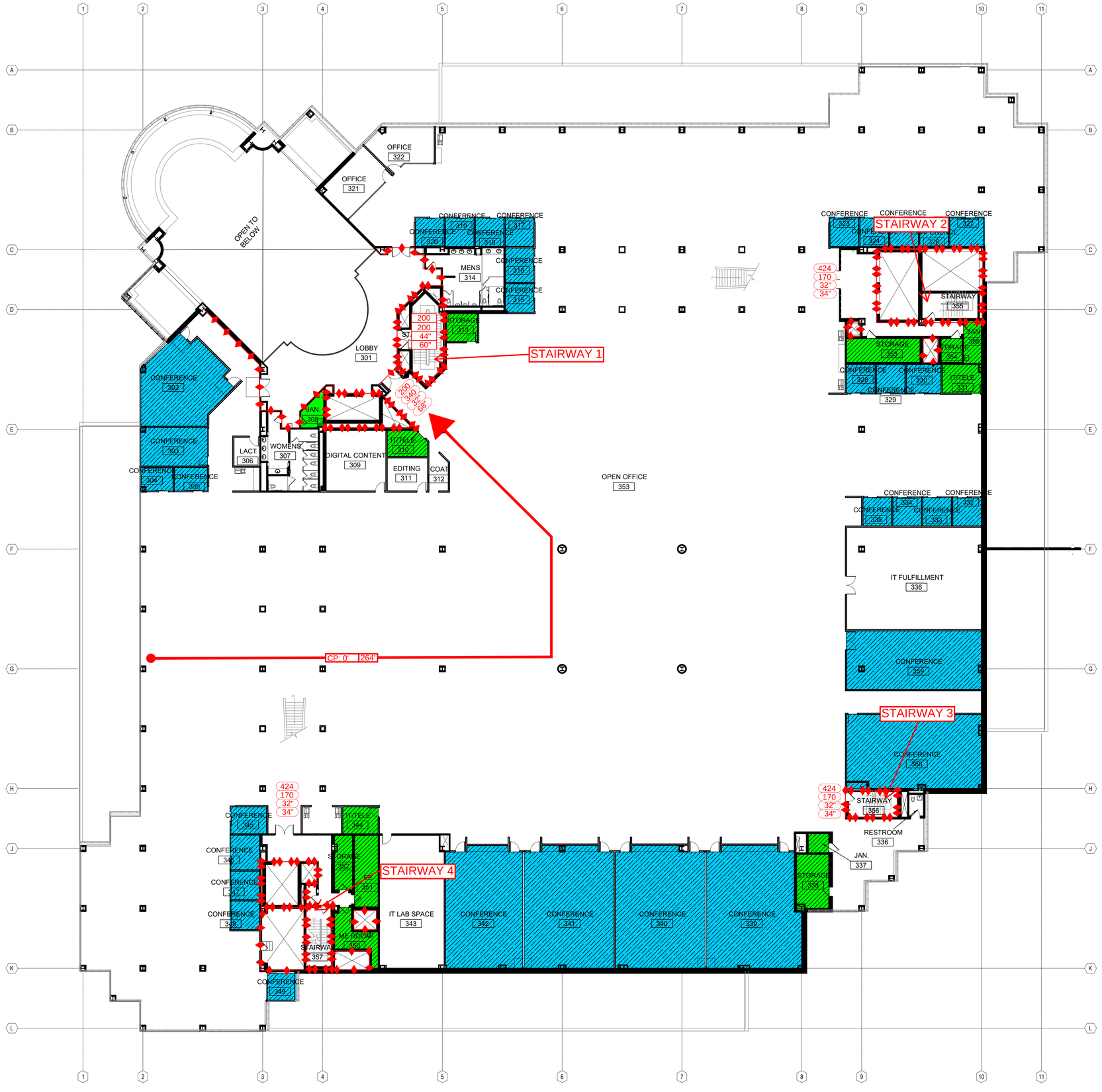
FIRE RESISTIVE CONSTRUCTION

- 1 HR FIRE BARRIER
- 2 HR FIRE BARRIER

25' 50'

N

SECOND-FLOOR OCCUPANT CLASSIFICATION



OCCUPANT LOAD LEGEND

	ASSEMBLY WITHOUT FIXED SEATS	1 PERSON / 15 SF NET
	BUSINESS AREAS	1 PERSON / 100 SF GROSS
	ACCESSORY STORAGE AREAS	1 PERSON / 300 SF GROSS

EGRESS PATH

CP: 25' | 50'

- CP — COMMON PATH TERMINATION POINT
- TRAVEL DISTANCE
- COMMON PATH OF TRAVEL
- EGRESS PATH — EXIT DOOR

DEAD END CORRIDOR

10'

- TERMINATION OF DEAD END CORRIDOR
- DEAD END DISTANCE

DOOR EGRESS TAG / **STAIR EGRESS TAG**

78	OCCUPANTS SERVED	132
180	EXIT	180
32"	REQUIRED WIDTH	44"
36"	PROVIDED WIDTH	54"

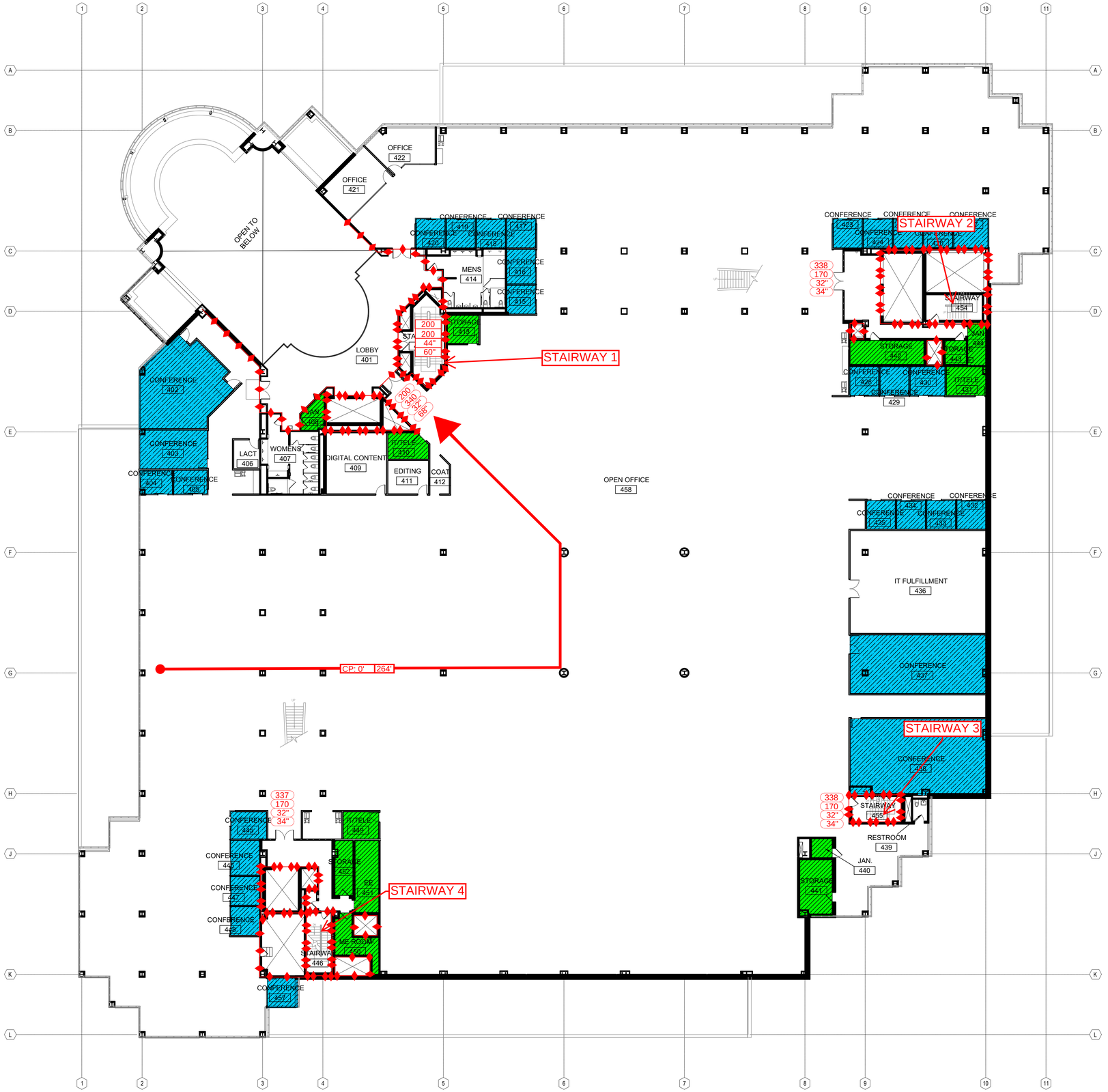
FIRE RESISTIVE CONSTRUCTION

- 1 HR FIRE BARRIER
- 2 HR FIRE BARRIER

25' 50'

N

THIRD-FLOOR OCCUPANT CLASSIFICATION



OCCUPANT LOAD LEGEND

	ASSEMBLY WITHOUT FIXED SEATS	1 PERSON / 15 SF NET
	BUSINESS AREAS	1 PERSON / 100 SF GROSS
	ACCESSORY STORAGE AREAS	1 PERSON / 300 SF GROSS

EGRESS PATH

CP: 25' 50'

CP — COMMON PATH TERMINATION POINT — EGRESS PATH — EXIT DOOR

TRAVEL DISTANCE

COMMON PATH OF TRAVEL

DEAD END CORRIDOR

10' — TERMINATION OF DEAD END CORRIDOR

DEAD END DISTANCE

DOOR EGRESS TAG — **STAIR EGRESS TAG**

78	OCCUPANTS SERVED	132
180	EXIT	180
32"	REQUIRED WIDTH	44"
36"	PROVIDED WIDTH	54"

FIRE RESISTIVE CONSTRUCTION

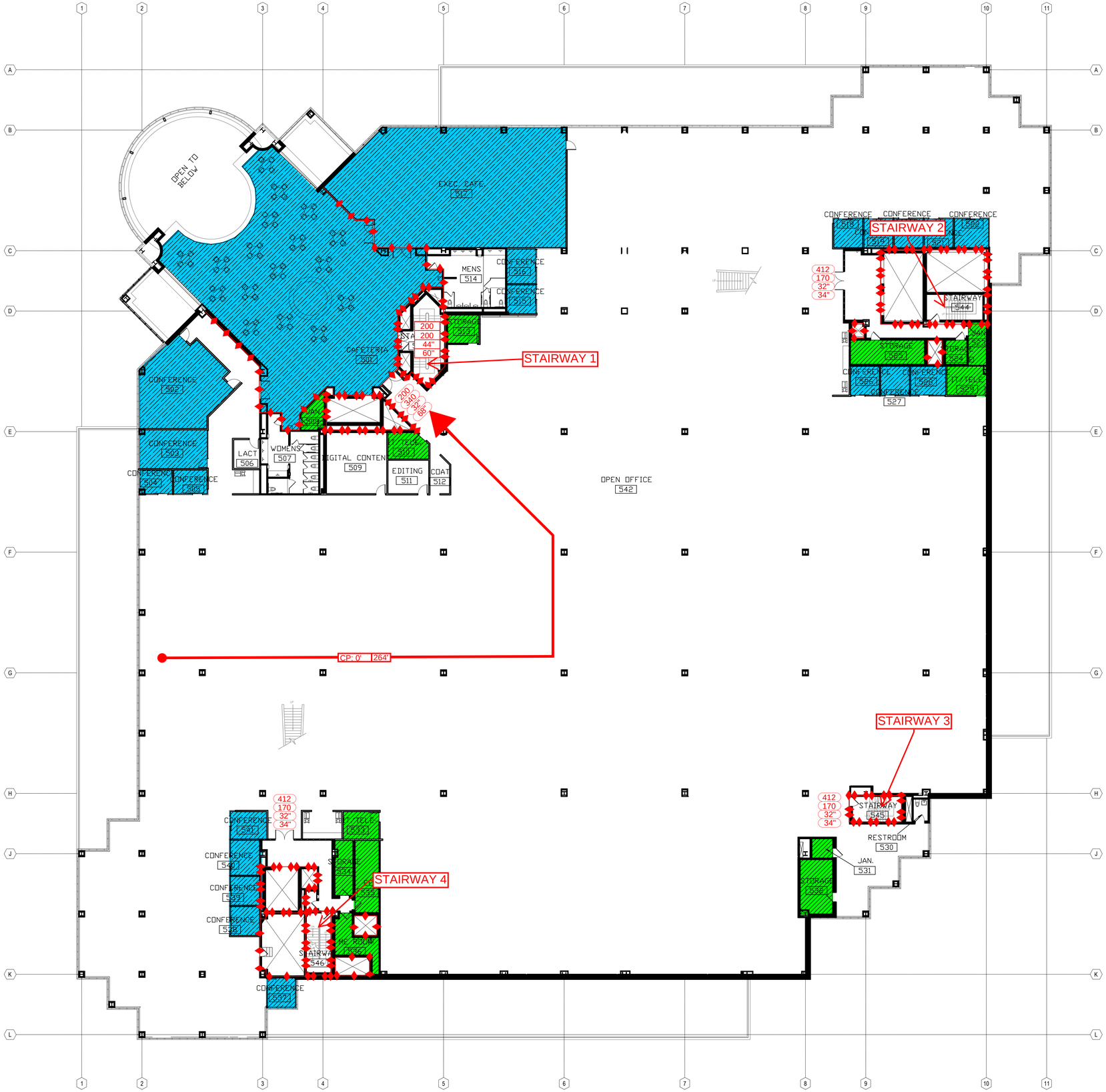
1 HR FIRE BARRIER

2 HR FIRE BARRIER

25' 50'

N

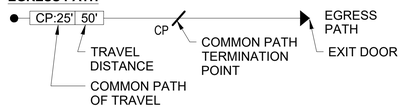
FOURTH-FLOOR OCCUPANT CLASSIFICATION



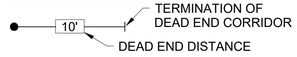
OCCUPANT LOAD LEGEND

	ASSEMBLY WITHOUT FIXED SEATS	1 PERSON / 15 SF NET
	BUSINESS AREAS	1 PERSON / 100 SF GROSS
	ACCESSORY STORAGE AREAS	1 PERSON / 300 SF GROSS

EGRESS PATH



DEAD END CORRIDOR



DOOR EGRESS TAG **STAIR EGRESS TAG**

FIRE RESISTIVE CONSTRUCTION

N

FIFTH-FLOOR OCCUPANT CLASSIFICATION

APPENDIX B – FIRE SUPPRESSION ANALYSIS

FIRE SUPPRESSION LEGEND

- OUTSIDE SCREW AND YOKE VALVE (OS&Y)
- VALVE
- ANGLE VALVE
- ALARM CHECK VALVE
- CHECK VALVE
- DOUBLE CHECK BACKFLOW PREVENTOR
- FIRE DEPARTMENT CONNECTION
- AUTOMATIC DRAIN VALVE
- PRESSURE GAUGE
- SIGHT GLASS
- PRESSURE SWITCH
- FLOW SWITCH
- AUTOMATIC AIR RELEASE VALVE
- FLOW TEST HEADER
- DRY VALVE
- PREACTION VALVE
- DRIP CUP
- FLANGED CONNECTION
- PIPE CONTINUATION

FIRE SUPPRESSION SYSTEM

- WET SYSTEM
- DRY SYSTEM
- PREACTION SYSTEM

FIRE SUPPRESSION DESIGN CRITERIA

1. THE FIRE SUPPRESSION SYSTEM WILL BE SERVED FROM THE DOMESTIC SYSTEM. AN 8" UNDERGROUND DUCTILE IRON SUPPLY LINE FROM THIRD AVE WILL BE ROUTED TO FEED THE FIRE PUMPS.

   HYDRANT FLOW TEST:

   DATE 6/12/2015
   STATIC 89 PSI
   RESIDUAL 81 PSI
   FLOW 1437 GPM

2. HYDRAULIC CALCULATIONS INCLUDE A 5 PSI SAFETY FACTOR, WHICHEVER IS GREATER.
3. HYDRAULIC CALCULATIONS SHALL INCORPORATE A 500 GPM HOSE STREAM ALLOWANCE.
4. ALL COMPONENTS AND ASSEMBLIES USED IN THIS FIRE PROTECTION SYSTEM WILL BE SPECIFICALLY UL LISTED / FM APPROVED FOR THEIR INTENDED USE.
5. FIRE WATER PIPING USED ON THIS PROJECT WILL BE SCHEDULE 40 BLACK STEEL. PIPING MATERIAL PRIOR TO THE BACKFLOW PREVENTER WILL BE DUCTILE IRON.

FIRE SUPPRESSION GENERAL NOTES

1. PROVIDE ALL NECESSARY COMPONENTS FOR A WET-PIPE SYSTEM, DRY-PIPE SYSTEM, AND PRE-ACTION SYSTEM WHERE INDICATED ON THE DRAWINGS.
2. THE FIRE WATER SUPPLY FOR THE FIRE SUPPRESSION SYSTEMS SHALL BE VIA FIRE PUMP FED FROM THE DOMESTIC WATER SYSTEM.
3. FINAL DESIGN REQUIREMENTS (DEVICE QUANTITY, SIZE, AND LOCATIONS) WERE NOT COMPLETED FOR THIS EXERCISE.
4. ALL VALVES INCLUDING CONTROL AND TRIM VALVES WILL BE WITHIN 6'-0" AFF.
5. INSTALL FIRE PROTECTION PIPE HANGERS PER THE FOLLOWING LIMITATIONS:

   A) THE SINGLE POINT DEAD LOAD APPLIED TO ANY STRUCTURALLY MEMBER WILL NOT EXCEED 300 LBS. PROVIDE TRAPEZE HANGERS TO DISTRIBUTE THE LOAD BETWEEN STRUCTURAL MEMBERS WHERE A SINGLE HANGER EXCEEDS THE LIMITATIONS.

   B) SWAY BRACES FOR PIPING LATERAL LOADS WILL NOT BE ATTACHED TO ROOF JOIST BOTTOM CHORDS. BRACE LOADS (WORKING STRESS) WILL BE LIMITED TO THE FOLLOWING:

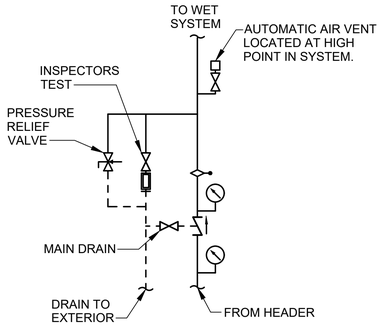
      500 LBS. WHEN ATTACHED TO JOIST TOP CHORD.

      500 LBS. WHEN ATTACHED TO FLOOR SLAB.

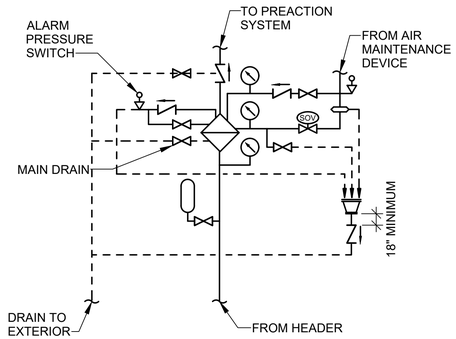
FIRE PROTECTION SPRINKLER SYSTEM DESIGN CRITERIA

MARK	HAZARD CLASSIFICATION	SYSTEM TYPE	DENSITY GPM/SF	REMOTE AREA SQ FT	MAXIMUM AREA PER HEAD SQ FT	HOSE DEMAND GPM	SPRINKLER CHARACTERISTICS				NOTES
							TEMP RATING	TYPE	K-FACTOR	FINISH	
NO HATCH	LIGHT HAZARD	WET	0.10	1500	225	100	ORDINARY	QUICK RESPONSE SEMI-RECESSED	5.6 OR 8.0	WHITE	1,2
	LIGHT HAZARD	PRE-ACTION	0.10	1500	225	100	ORDINARY	QUICK RESPONSE SEMI-RECESSED	5.6 OR 8.0	WHITE	2,4
	ORDINARY HAZARD GROUP II	DRY	0.20	1500	130	250	175	BRASS UPRIGHT	5.6 OR 8.0	BRASS	
	EXTRA HAZARD GROUP II	WET	0.40	2500	100	500	175	BRASS UPRIGHT	11.2	BRASS	

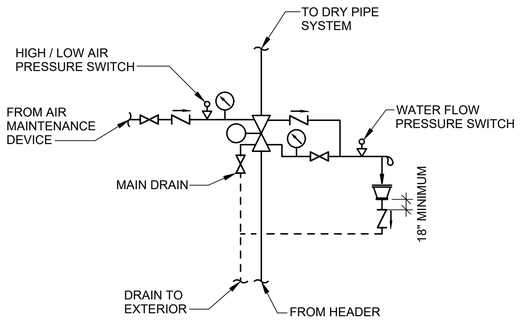
NOTE 1: PROVIDE 200 DEGREE F° RATED SPRINKLERS IN MECHANICAL AND COMMUNICATION ROOMS.
NOTE 2: WHERE CEILINGS ARE NOT PROVIDED USE BRASS UPRIGHT HEADS.
NOTE 3: WHERE CEILINGS ARE PRESENT USE WHITE QUICK RESPONSE SEMI-RECESSED HEADS.
NOTE 4: PROVIDE DOUBLE INTERLOCK PRE-ACTION SYSTEM IN IT RELATED ROOMS



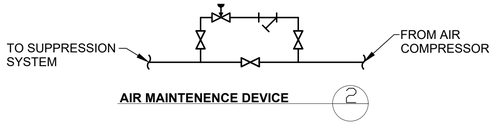
WET RISER DETAIL 3



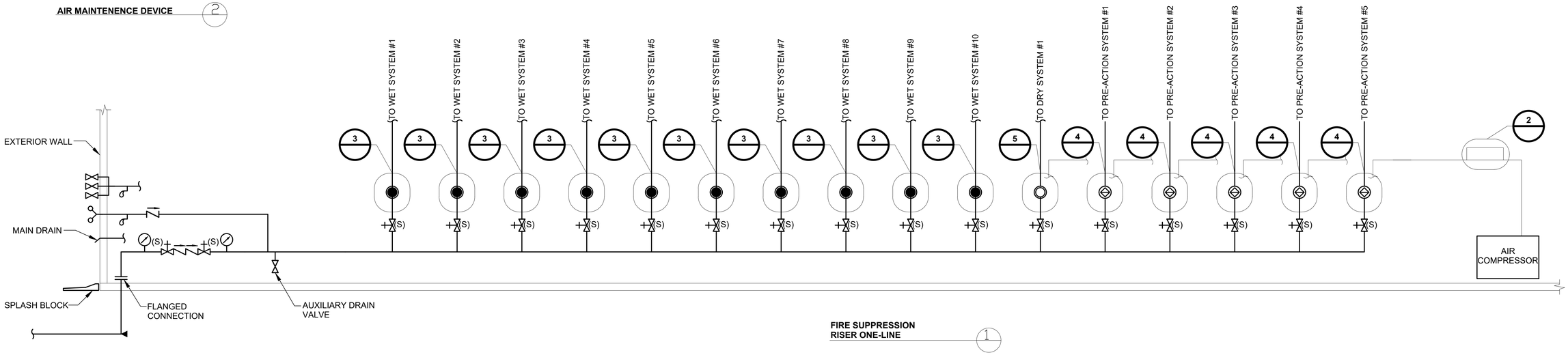
DOUBLE INTERLOCK PREACTION RISER - ELECTRIC 4



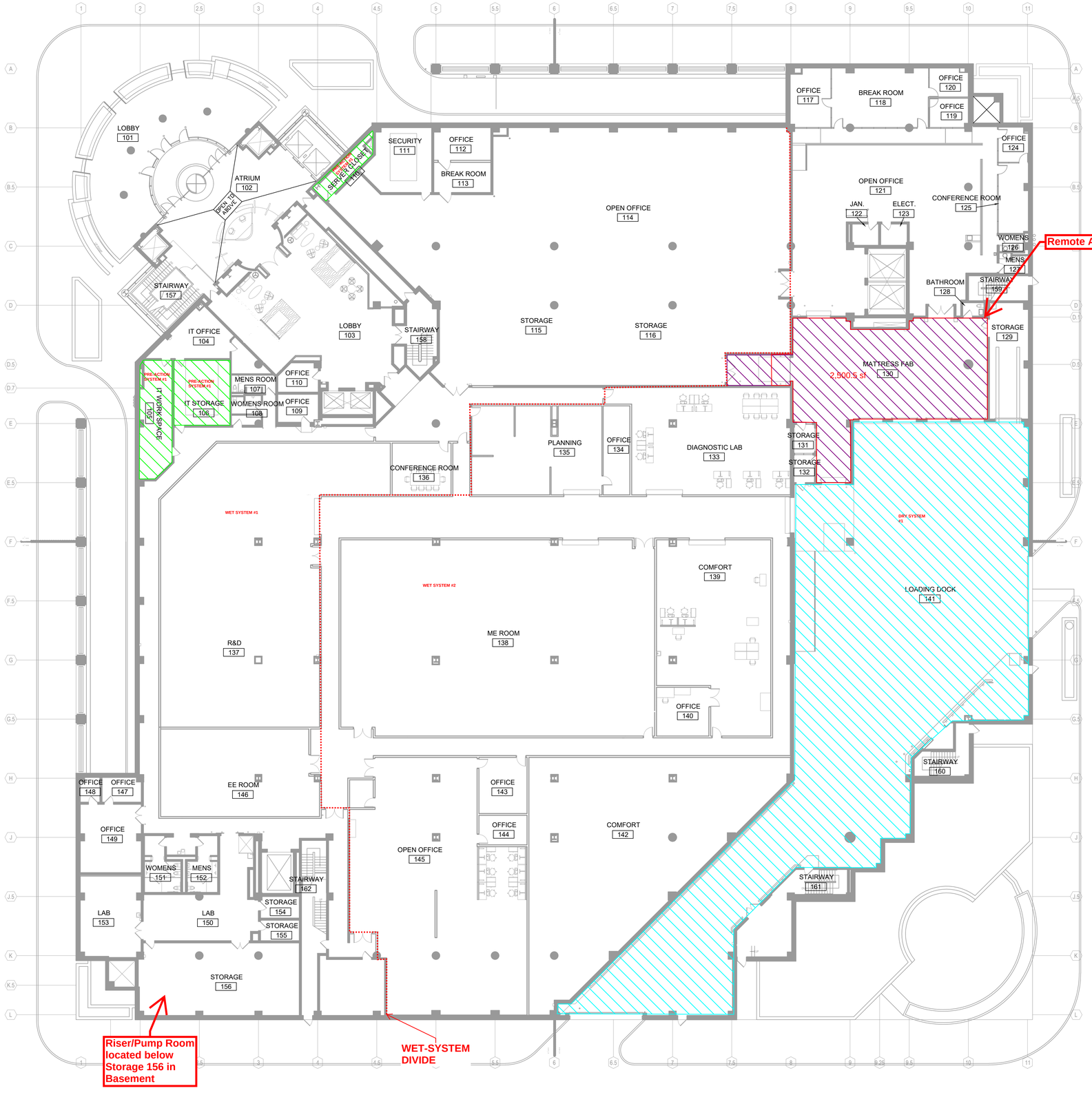
DRY PIPE VALVE DETAIL 5



AIR MAINTENENCE DEVICE 2



FIRE SUPPRESSION RISER ONE-LINE 1



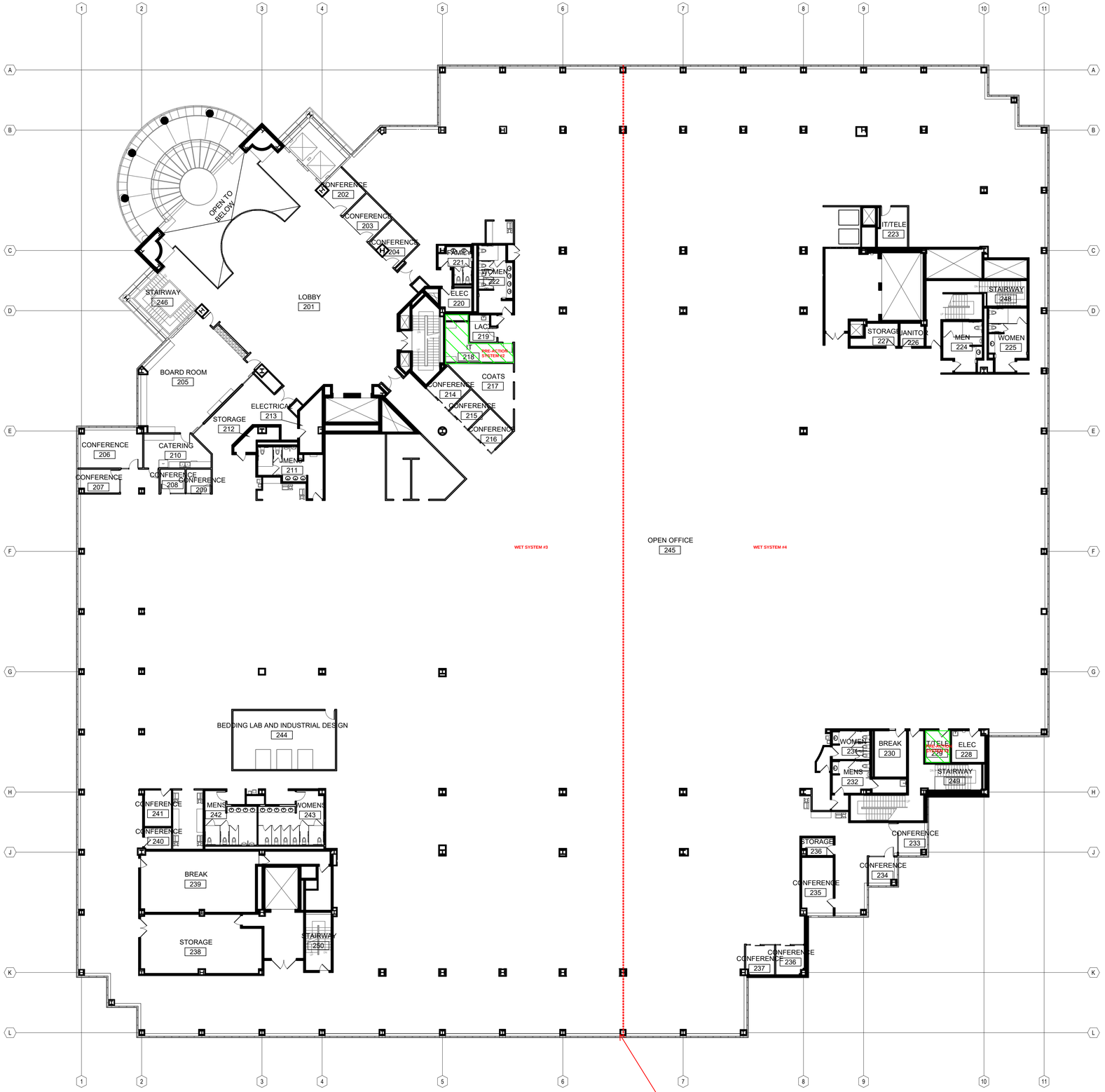
FIRE PROTECTION SPRINKLER SYSTEM DESIGN CRITERIA

MARK	HAZARD CLASSIFICATION	SYSTEM TYPE
NO HATCH	LIGHT HAZARD	WET
	LIGHT HAZARD	PRE-ACTION
	ORDINARY HAZARD GROUP 2	DRY
	EXTRA HAZARD GROUP 2	WET

25 50

N

FIRST-FLOOR FIRE SUPPRESSION PLAN



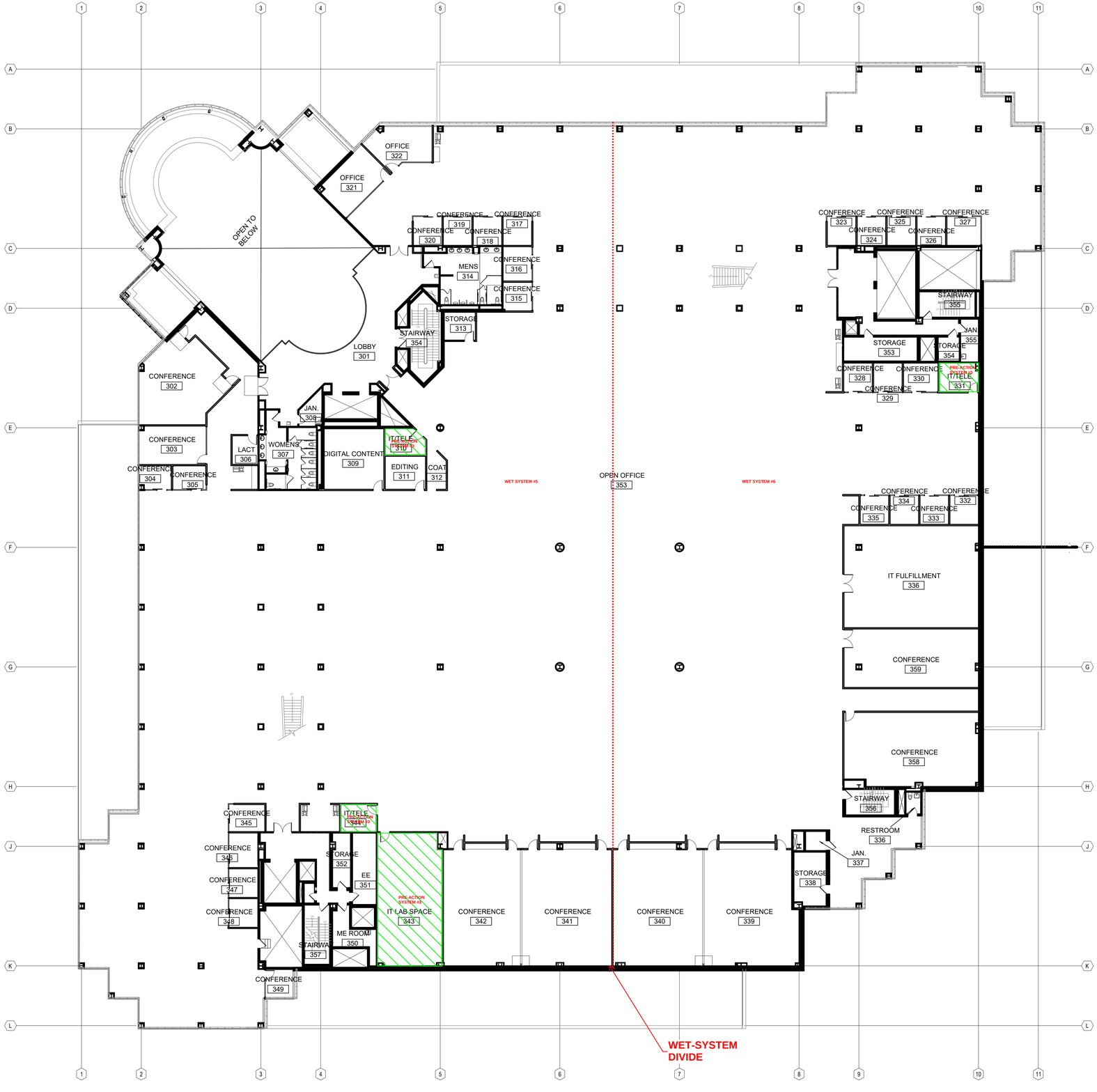
FIRE PROTECTION SPRINKLER SYSTEM DESIGN CRITERIA

MARK	HAZARD CLASSIFICATION	SYSTEM TYPE
NO HATCH	LIGHT HAZARD	WET
	LIGHT HAZARD	PRE-ACTION
	ORDINARY HAZARD GROUP 2	DRY
	EXTRA HAZARD GROUP 2	WET

25' 50'

N

SECOND-FLOOR FIRE SUPPRESSION PLAN



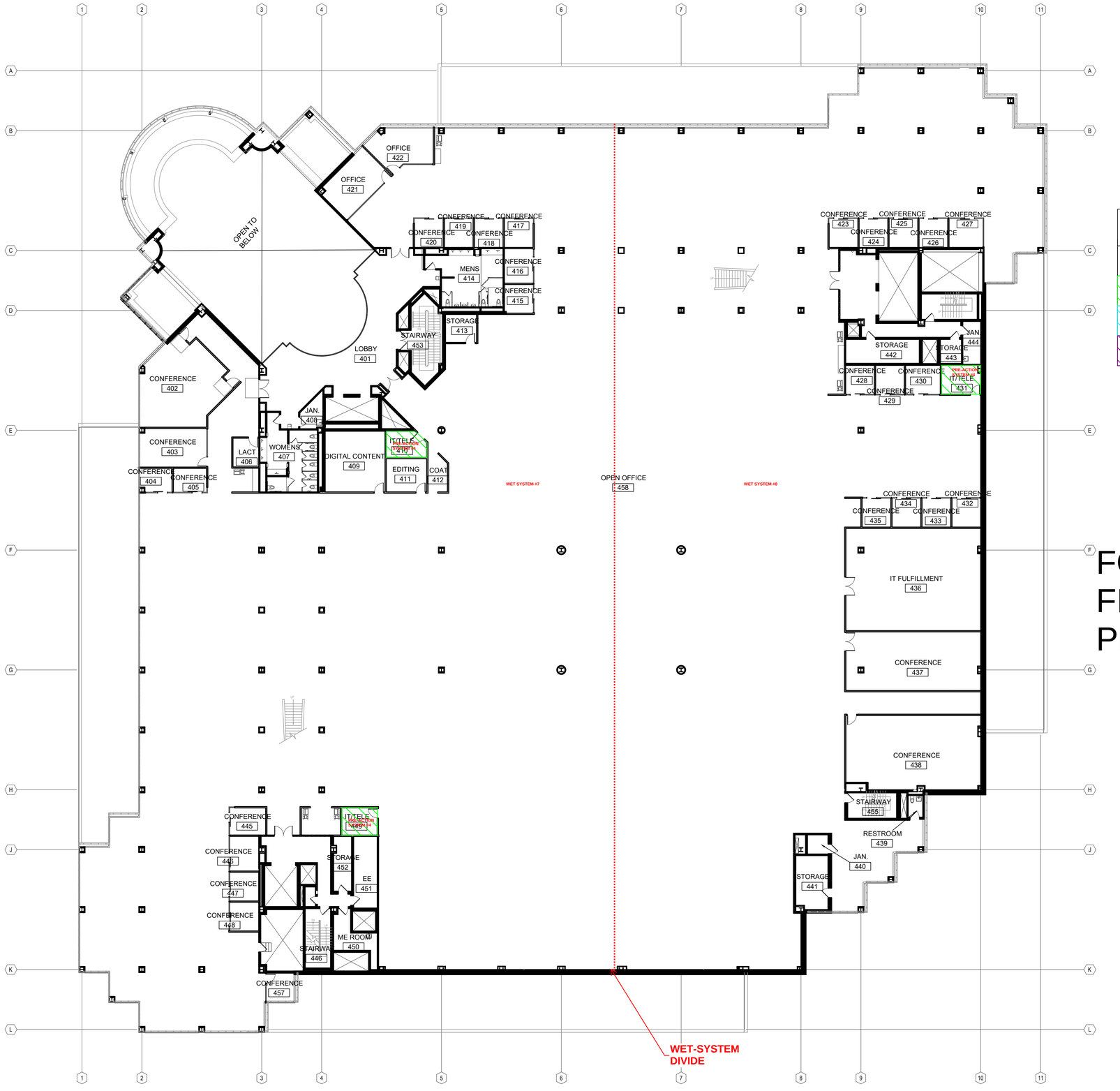
FIRE PROTECTION SPRINKLER SYSTEM DESIGN CRITERIA

MARK	HAZARD CLASSIFICATION	SYSTEM TYPE
NO HATCH	LIGHT HAZARD	WET
	LIGHT HAZARD	PRE-ACTION
	ORDINARY HAZARD GROUP 2	DRY
	EXTRA HAZARD GROUP 2	WET

25' 50'

N

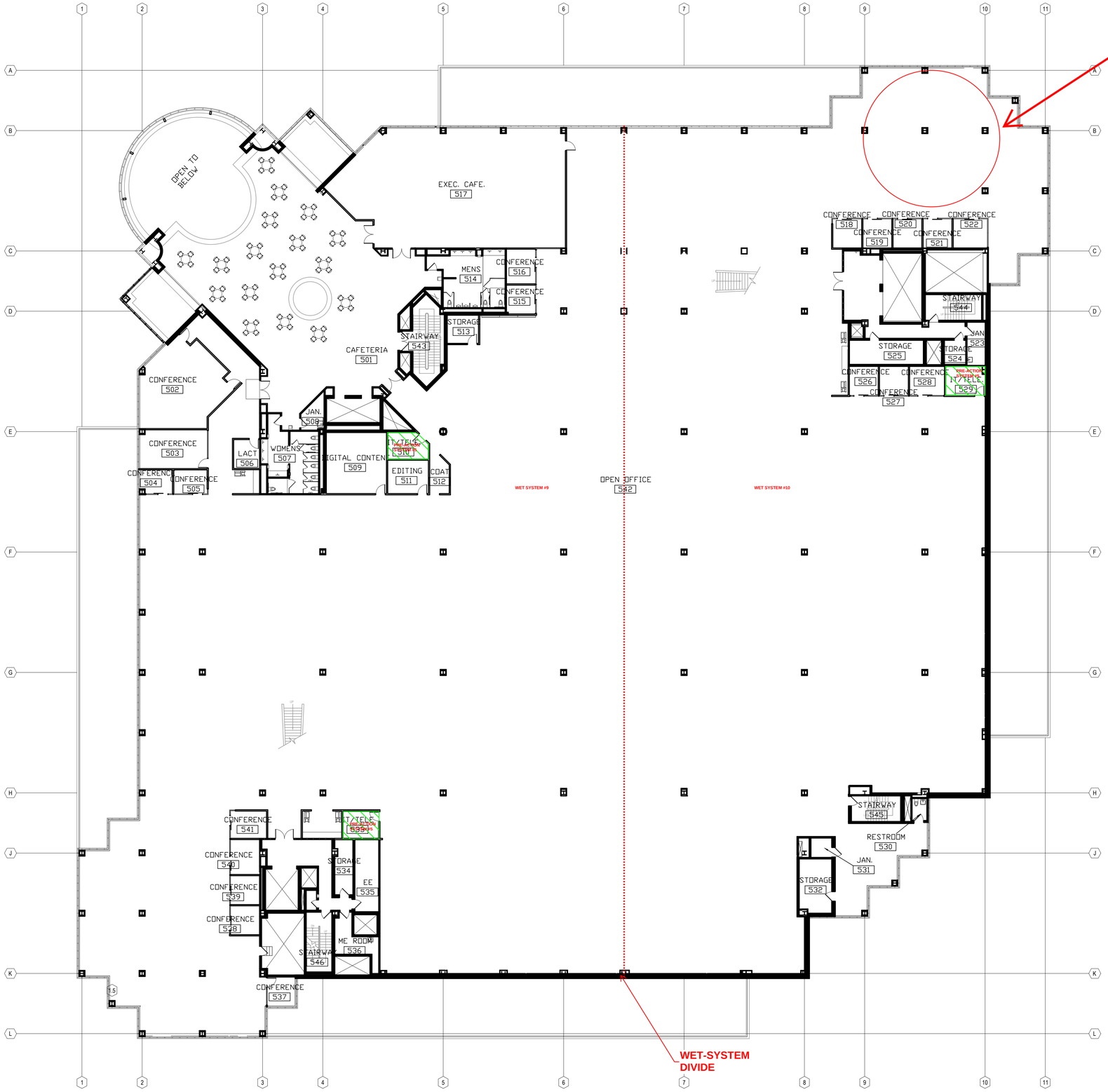
THIRD-FLOOR FIRE SUPPRESSION PLAN



FIRE PROTECTION SPRINKLER SYSTEM DESIGN CRITERIA

MARK	HAZARD CLASSIFICATION	SYSTEM TYPE
NO HATCH	LIGHT HAZARD	WET
	LIGHT HAZARD	PRE-ACTION
	ORDINARY HAZARD GROUP 2	DRY
	EXTRA HAZARD GROUP 2	WET

FOURTH-FLOOR FIRE SUPPRESSION PLAN



FIRE PROTECTION SPRINKLER SYSTEM DESIGN CRITERIA

MARK	HAZARD CLASSIFICATION	SYSTEM TYPE
NO HATCH	LIGHT HAZARD	WET
	LIGHT HAZARD	PRE-ACTION
	ORDINARY HAZARD GROUP 2	DRY
	EXTRA HAZARD GROUP 2	WET

25' 50'

N

FIFTH-FLOOR FIRE SUPPRESSION PLAN

Project FPE 596 - Culminating Experience
DCI Data Center
Subject Hydraulic Analysis
Date 8-May-17
Calc by Bryan Hathaway

Known and Assumptions

- The builiding will be fully sprinklered. The loading dock is protected by a dry-pipe system, the IT Spaces by dual interlock pre-action system with the remaining office space being protected by a wet-pipe system.
- Supply water is from the 24" domestic system via an eight-inch ductile iron pipe.
- Sprinkler systems will be designed in accordance with the limitations of NFPA 13.

Hydrant Flow Test

Compilation of the Hydrant Flow information resulted in the following data used for system design.

Date Performed	6/12/2015	
Static Pressure	89	psi
Static Flow	0	gpm
Residual Pressure	81	psi
Residual Flow	1,437	gpm

Estimated Supply Water Requirements

System Protection	System Protection Area Limitations (sq ft)	Code Reference
Light Hazard	52,000	NFPA 13 2010, para 8.2.1
Ordinary Hazard Group II	52,000	NFPA 13 2010, para 8.2.1
Extra Hazard Group II	40,000	NFPA 13 2010, para 8.2.1

Occupancy Classification	Design Density (gpm/sq ft)	Design Area (sq ft)	Hose Stream Allowance (gpm)	Code Reference
Light Hazard	0.10	1,500	100	NFPA 13 2010, para Figure 11.2.3.1.1
Ordinary Hazard Group II	0.20	1,500	250	NFPA 13 2010, para Figure 11.2.3.1.2
Extra Hazard Group II	0.40	2,500	500	NFPA 13 2010, para Figure 11.2.3.1.3

Wet-Pipe System Hydraulic Estimation

Remote Area # 1 Wet-Pipe System #2 Protecting Mattress Fab Room 130

Design Density (Extra Hazard Group II)	0.40	gpm / sq ft
Design Area	2,500	sq ft
Flow Required	1,000	gpm
15% Increase due to Flow Balancing	1,150	gpm
Hose Stream Allowance	500	gpm
Water Demand	1,650	gpm
Area of Coverage (NFPA 13 Table 8.6.2.2.1c)	100	sq ft
Design Density	0.40	gpm / sq ft
Minimum Head Flow	40	gpm
Minimum Head K-factor	11.2	
Sprinkler Head Pressure Requirement (7.0 psi Minimum)	13	psi

From Remote Area to Riser Room located in the southwest corner on the basement level

Project	FPE 596 - Culminating Experience
	DCI Data Center
Subject	Hydraulic Analysis
Date	8-May-17
Calc by	Bryan Hathaway

Flow Requirement for Remote Area	1,150	gpm
Sprinkler Head Elevation	29	ft aff
Bottom of Wet-pipe Riser Elevation	1.5	ft aff
Height Difference	27.5	ft
Pressure Requirement	11.90	psi
Linear Feet of pipe from Sprinkler Head to Base of Riser	475	ft
Estimated Fitting Equivalent Length (50%)	238	ft
Total Equivalent Piping from Sprinkler Head to Bottom of Riser	713	ft
6" Inside Pipe Diameter	6.065	in
C-factor Schedule 40 black Wet Pipe	120	
Pressure Loss Per Foot (Hazen-Williams)	0.046	psi / ft
Pressure Loss of pipe from Sprinkler Head to Bottom of Riser	32.46	psi
Velocity in Pipe	12.78	fps
Pressure loss through 6" Check Valve per NFPA 13	1.50	psi
Remote Area Summary for Wet-Pipe System		
Flow Requirement for Design Area	1,150	gpm
Pressure Requirement at Bottom of Riser	58.6	psi
External Hose Stream Requirement	500	gpm

Wet-Pipe System Hydraulic Estimation

Remote Area # 2 Wet-Pipe System #10 Protecting East Side of Level 5

Design Density (Light Hazard)	0.10	gpm / sq ft
Design Area	1,500	sq ft
Flow Required	150	gpm
15% Increase due to Flow Balancing	173	gpm
Hose Stream Allowance	100	gpm
Water Demand	273	gpm
Area of Coverage (NFPA 13 Table 8.6.2.2.1c)	100	sq ft
Design Density	0.10	gpm / sq ft
Minimum Head Flow	10	gpm
Minimum Head K-factor	5.6	
Sprinkler Head Pressure Requirement (7.0 psi Minimum)	7	psi

From Remote Area to Riser Room located in the southwest corner on the basement level

Flow Requirement for Remote Area	173	gpm
Sprinkler Head Elevation	71	ft aff
Bottom of Wet-pipe Riser Elevation	1.5	ft aff
Height Difference	69.5	ft
Pressure Requirement	30.09	psi

Project	FPE 596 - Culminating Experience
	DCI Data Center
Subject	Hydraulic Analysis
Date	8-May-17
Calc by	Bryan Hathaway

Linear Feet of pipe from Sprinkler Head to Base of Riser	750	ft
Estimated Fitting Equivalent Length (50%)	375	ft
Total Equivalent Piping from Sprinkler Head to Base of Riser	1125	ft
4" Inside Pipe Diameter	4.026	in
C-factor Schedule 40 black Wet Pipe	120	
Pressure Loss Per Foot (Hazen-Williams)	0.010	psi / ft
Pressure Loss of pipe from Sprinkler Head to Base of Riser	11.28	psi
Velocity in Pipe	4.35	fps
Pressure loss through 4" Check Valve per NFPA 13	1.50	psi
Remote Area Summary for Wet-Pipe System		
Flow Requirement for Design Area	173	gpm
Pressure Requirement at Bottom of Riser	49.9	psi
External Hose Stream Requirement	100	gpm

Pressure Loss From Bottom of Riser to Underground

Total Combined Flow	1,150	gpm
Linear Feet of 8" pipe to Fire Pump	25	ft
Estimated Fitting Equivalent Length (50%)	13	ft
Total Equivalent 8" Piping from Bottom of Riser to Underground	38	ft
10" Inside Pipe Diameter	7.981	in
C-factor Black Steel	120	
Pressure Loss Per Foot (Hazen-Williams)	0.012	psi / ft
Pressure Loss of pipe from 8" header to Fire Pump	0.4	psi
Velocity in Pipe	7.4	fps
Pressure Loss from Bottom of Riser to Underground	0.4	psi

Pressure Loss to Flow Hydrant (Underground)

Total Flow From Remote Area #1	1,150	gpm
Linear Feet of 8" DIP pipe from Riser to Hydrant	179	ft
Estimated Fitting Equivalent Length (50%)	90	ft
Total Equivalent 8" Piping from Riser to Hydrant	269	ft
8" Inside Pipe Diameter	8.39	in
C-factor Cement Lined Ductile Iron	140	
Pressure Loss Per Foot (Hazen-Williams)	0.007	psi / ft
Pressure Loss of pipe from Riser to Hydrant	1.9	psi
Velocity in Pipe	6.7	fps
Pressure Loss Underground	11.9	psi

Project	FPE 596 - Culminating Experience
	DCI Data Center
Subject	Hydraulic Analysis
Date	8-May-17
Calc by	Bryan Hathaway

Total Pressure

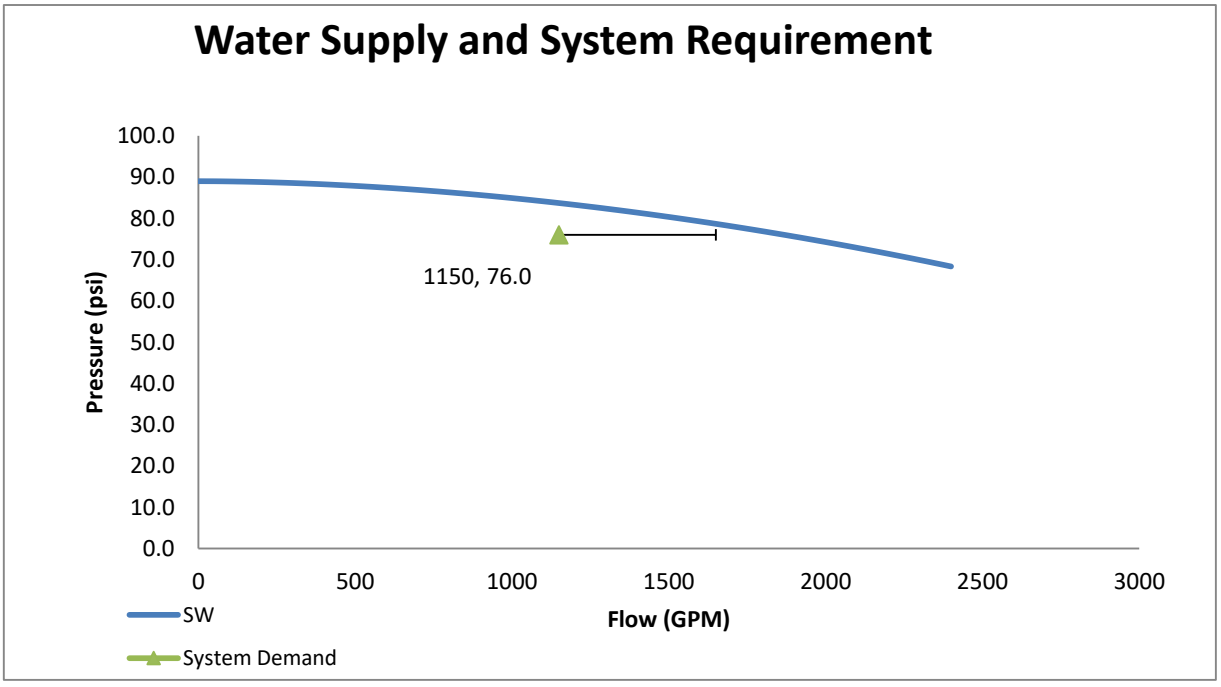
Total Flow From Remote Area #1	71	psi
Safety factor	5	psi
Pressure Loss from Riser to Hydrant	76.0	psi

Hydrant Data

Static Pressure	89.0	psi
Flow at Static Pressure	0	gpm
Residual Pressure	81.0	psi
Flow at Residual Pressure	1437	gpm
Design Area Flow	1150	gpm
Hydrant Flow	500	gpm
Total Estimated Flow	1650	gpm

Calculating the Residual Pressure at the Total Estimated Flow: (Q2/Q1)^1.85 = (S-R2) / (S-R1)

Static Pressure (S)	89.0	psi
Hydrant Flow Test Flow (Q1)	1437	gpm
Total Estimated Flow (Q2)	1650	gpm
Hydrant Flow Test Residual Pressure (R1)	81.0	psi
Residual Pressure at Total Estimated Flow (R2)	78.7	psi



APPENDIX C – FIRE ALARM ANALYSIS

FIRE ALARM SYSTEM LEGEND

FACU	FIRE ALARM CONTROL UNIT
NAC	NOTIFICATION CIRCUIT POWER BOOSTER, EXTENDER PANEL
	GROUND
SOV	SOLENOID VALVE (PROVIDED BY DIVISION 21)
BATT	SECONDARY POWER SUPPLY (BATTERY)
SS	SURGE SUPPRESSOR (TRANSIENT VOLTAGE SURGE SUPPRESSOR)
DACT	DIGITAL ALARM COMMUNICATOR TRANSMITTER
FAA	FIRE ALARM ANNUNCIATOR
DH	DOOR HOLD
PS	PRESSURE DETECTOR / SWITCH (PROVIDED BY DIVISION 21) H = HIGH L = LOW
F	MANUAL FIRE ALARM PULL STATION
VS	VALVE SUPERVISORY SWITCH (PROVIDED BY DIVISION 21)
WF	WATER FLOW DETECTOR / SWITCH (PROVIDED BY DIVISION 21)
C	HEAT DETECTOR F = FIXED TEMPERATURE
R	SMOKE DETECTOR / SENSOR FOR DUCT R = RETURN
SB	SMOKE DETECTOR P = PHOTOELECTRIC B = BEAM DETECTORS
RTS	REMOTE TEST STATION
	HORN / STROBE COMBINATION
	STROBE
	WALL MOUNT STROBE
IM	ISOLATION MODULE
AOM	ADDRESSABLE OUTPUT CONTROL MODULE
AIM	ADDRESSABLE INPUT MONITOR MODULE
RL	NON-ADDRESSABLE OUTPUT RELAY

AUDIBLE DESIGN CRITERIA:

1. PROVIDE AUDIBLE NOTIFICATION APPLIANCES THROUGHOUT THE BUILDING TO ACCOMPLISH THE FOLLOWING DESIGN CRITERIA WITH ALL DOORS, AND WINDOWS CLOSED. WHERE THIS DESIGN CRITERIA IS NOT ACCOMPLISHED DURING COMMISSIONING, PROVIDE ADDITIONAL DEVICES TO MEET THE MINIMUM DESIGN CRITERIA WITHOUT EXCEEDING THE LIMITATIONS OF THE FACU, NAC, ETC... (INCLUSIVE OF PRESCRIBED SAFETY FACTORS).

2. PROVIDE A MINIMUM SOUND POWER OF 70 DBA AND 15 DBA OVER THE AVERAGE AMBIENT SOUND LEVEL AT THE MOST REMOTE LOCATION WITHIN THE ROOM/AREA MEASURED AT 5 FT AFF. MEASURE THE SOUND POWER OFF THE TEMPORAL THREE TONE PATTERN. THE FOLLOWING CRITERIA WILL BE USED FOR REVIEW AND APPROVAL OF SHOP DRAWINGS.

   A. REDUCE THE SOUND POWER BY 6 DBA EACH TIME THE DISTANCE BETWEEN THE APPLIANCE AND THE LISTENER IS DOUBLED. STARTING DISTANCE IS PER MANUFACTURER'S DATASHEET, TYPICALLY 10 FT.

   B. REDUCE THE SOUND POWER IN ACCORDANCE WITH THE MANUFACTURER'S DATASHEET FOR SOUND POWER DISTRIBUTION NOT PERPENDICULAR TO THE FACE OF THE APPLIANCE. REFER TO MANUFACTURER'S TYPICAL SOUND OUTPUT DISTRIBUTION DIAGRAM.

   C. IN LIEU OF THE MANUFACTURER'S PUBLISHED DBA LOSS, ASSUME A MINIMUM 15 DBA LOSS THROUGH A STANDARD CLOSED DOOR.

VISUAL DESIGN CRITERIA:

1. PROVIDE VISUAL NOTIFICATION APPLIANCES IN PUBLIC AREAS AS REQUIRED TO ACHIEVE THE COVERAGE INDICATED.

2. SPACE STROBES IN ACCORDANCE THE CRITERIA OUTLINED IN NFPA 72, UNLESS OTHERWISE NOTED.]

GENERAL NOTES:

1. CONCEAL ALL CONDUITS IN WALLS OR ABOVE CEILINGS UNLESS OTHERWISE INDICATED. EXCEPTION: CONDUIT IS ALLOWED TO BE SURFACE MOUNTED ON WALLS AND CEILINGS IN UNFINISHED AREAS (E.G. MECHANICAL ROOM, ELECTRICAL ROOM, FIRE PROTECTION ROOM). WHERE A CONDUIT SUPPLIES A DEVICE NOT MOUNTED DIRECTLY ON THE WALL OR CEILING, ROUTE THE CONDUIT AS A SINGLE PENDENT DROP TO EACH DEVICE FROM THE CEILING SURFACE ABOVE. DO NOT TRAPEZE CONDUIT ACROSS AN OPEN SPACE.

2. PAINT ALL EXPOSED FIRE ALARM JUNCTION BOXES AND CONDUITS IN UNFINISHED AREAS RED, OR PROVIDED PRE-FINISHED MATERIALS FROM THE FACTORY. PAINT EXPOSED CONDUIT AND JUNCTION BOXES IN FINISHED AREAS TO MATCH ADJACENT SURFACES.

3. PROVIDE CONDUIT IN ACCORDANCE WITH THE REQUIREMENTS OF THE ELECTRICAL SPECIFICATIONS, UNLESS OTHERWISE NOTED. SUPPORT CONDUIT IN ACCORDANCE WITH THE NEC (E.G. MAXIMUM 10 FT SUPPORT INTERVALS AND 3 FT FROM A TERMINATION). TENSION ONLY HANGERS ARE NOT PERMITTED (E.G. BATWINGS). FLEXIBLE CONDUIT IS ONLY PERMITTED WHEN CONNECTING TO THE FOLLOWING DEVICES AND APPLIANCES. DEVICES LOCATED ON FIRE SUPPRESSION EQUIPMENT SUCH AS FLOW/PRESSURE SWITCHES, SOLENOIDS, AND TAMPER SWITCHES. DEVICES AND APPLIANCES LOCATED IN REMOVABLE CEILING TILES, OR WHERE SPECIFICALLY NOTED.

4. PROVIDE CONDUCTOR SIZING NOT LESS THAN 18 AWG. CONSISTENTLY COLOR COORDINATE ALL CONDUCTORS THROUGH THE SYSTEM IN RELATION TO DEVICES THEY FEED (E.G. SLC - BLACK/RED, STROBE - YELLOW/BLUE). PROVIDE ADDRESSABLE SLC CIRCUITS [AND SPEAKER CIRCUITS] WITH SHIELDED CONDUCTORS, WHERE THE SHIELDING IS GROUNDED AT ONE END. PROVIDE ALL CIRCUITS WITH LABELING AT THE POINT OF TERMINATION (E.G. SLC 1, NAC 8, IDC 4).

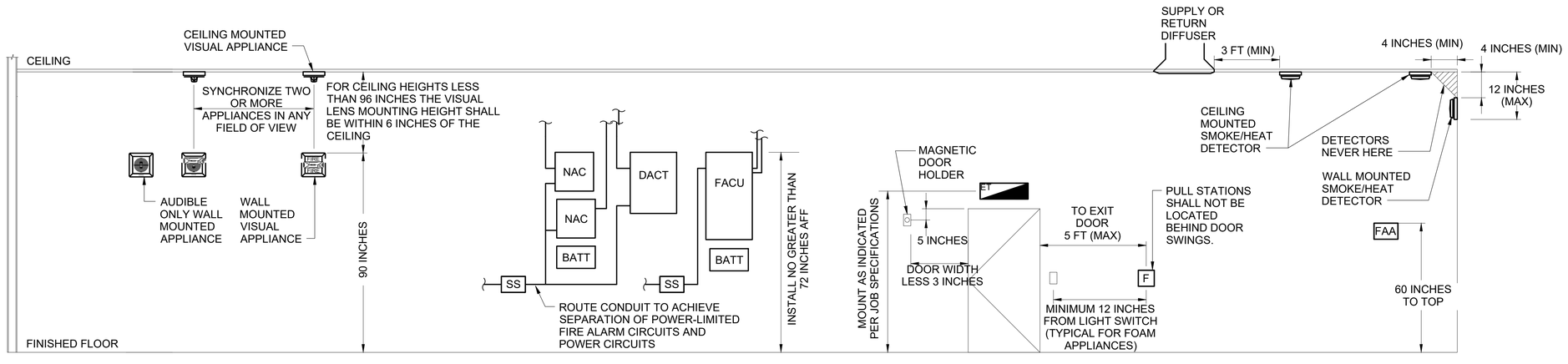
5. RUN CONDUCTORS FROM DEVICE TO DEVICE WITHOUT SPLICES. WIRE NUTS ARE PROHIBITED. UTILIZE TERMINAL STRIPS WHERE CONDUCTORS CANNOT BE DIRECTLY TERMINATED AT THE DEVICE (E.G. PIGTAILS OFF A HEAT DETECTOR).

6. DO NOT USE FIRE ALARM EQUIPMENT PANELS AS RACEWAY FOR ROUTING POWER WIRING OR LOW VOLTAGE WIRING. ONLY ROUTE WIRING TERMINATING WITHIN THE PANEL INTO THE PANEL. PROVIDE 1/4 INCH SEPARATION BETWEEN POWER-LIMITED FIRE ALARM CIRCUITS AND POWER CIRCUITS.

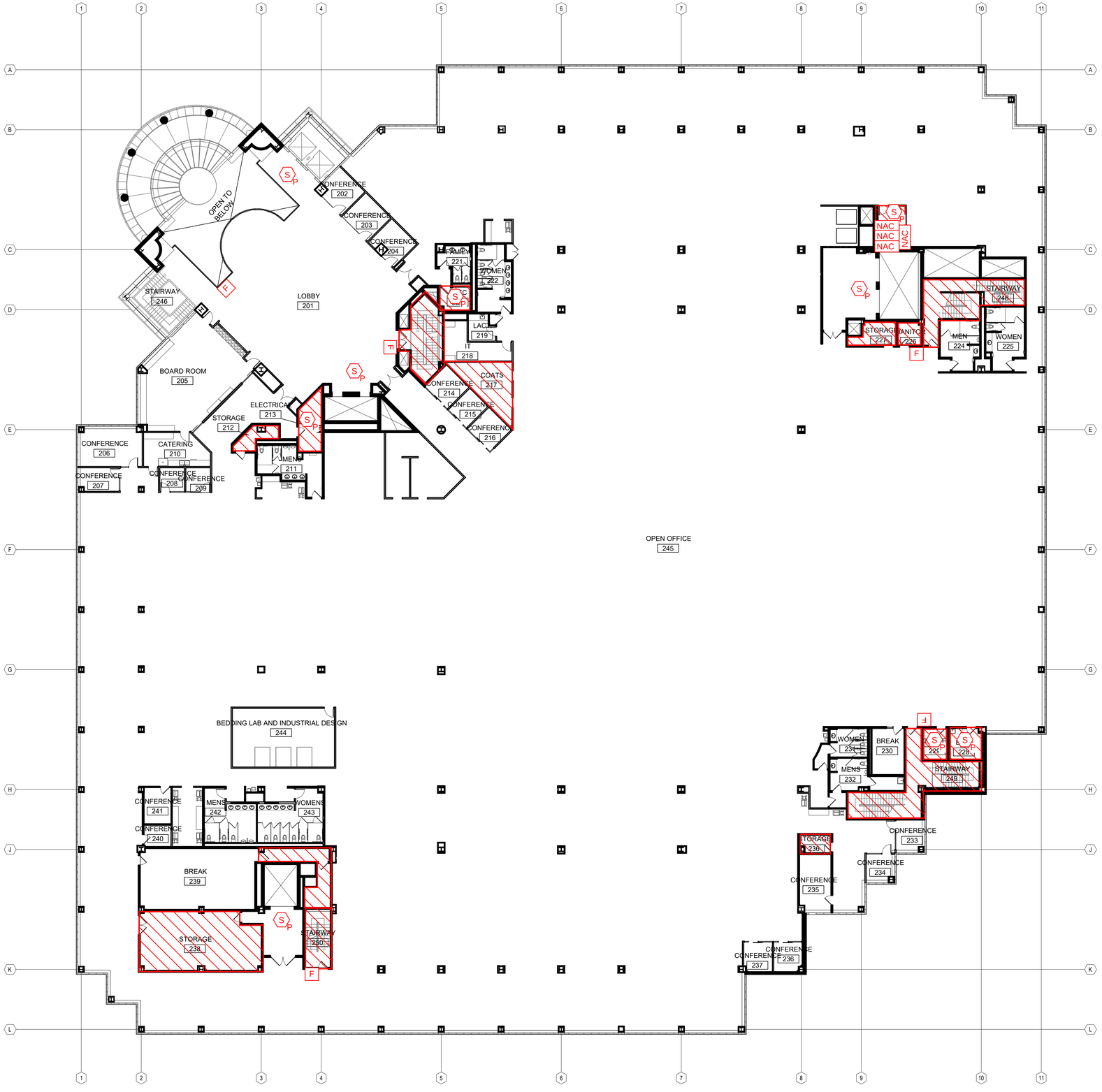
7. MOUNTING DEVICES IN THE FACU, INCLUDING ANY SUBPANELS (E.G. NAC.) WHICH ARE NOT UL LISTED AS PART OF THE UNIT IS PROHIBITED.

8. PROVIDE SURGE SUPPRESSORS TO PROTECT ALL POWER SUPPLY CIRCUITS TO THE FACU , INCLUDING ANY SUBPANELS (E.G. NAC.), AND ALL FIRE ALARM CIRCUITS LEAVING OR ENTERING THE BUILDING. DEVICES AND APPLIANCES MOUNTED DIRECTLY ON THE EXTERIOR OF THE BUILDING (E.G. WALL MOUNTED EXTERIOR SPEAKER) DO NOT REQUIRE SURGE SUPPRESSORS WHEN LIGHTING PROTECTION IS PROVIDED. MOUNT SURGE SUPPRESSORS IN A SEPARATE ENCLOSURE, UNLESS IT IS UL LISTED AND INSTALLED IN THE CONTROL UNIT BY THE FACTORY.

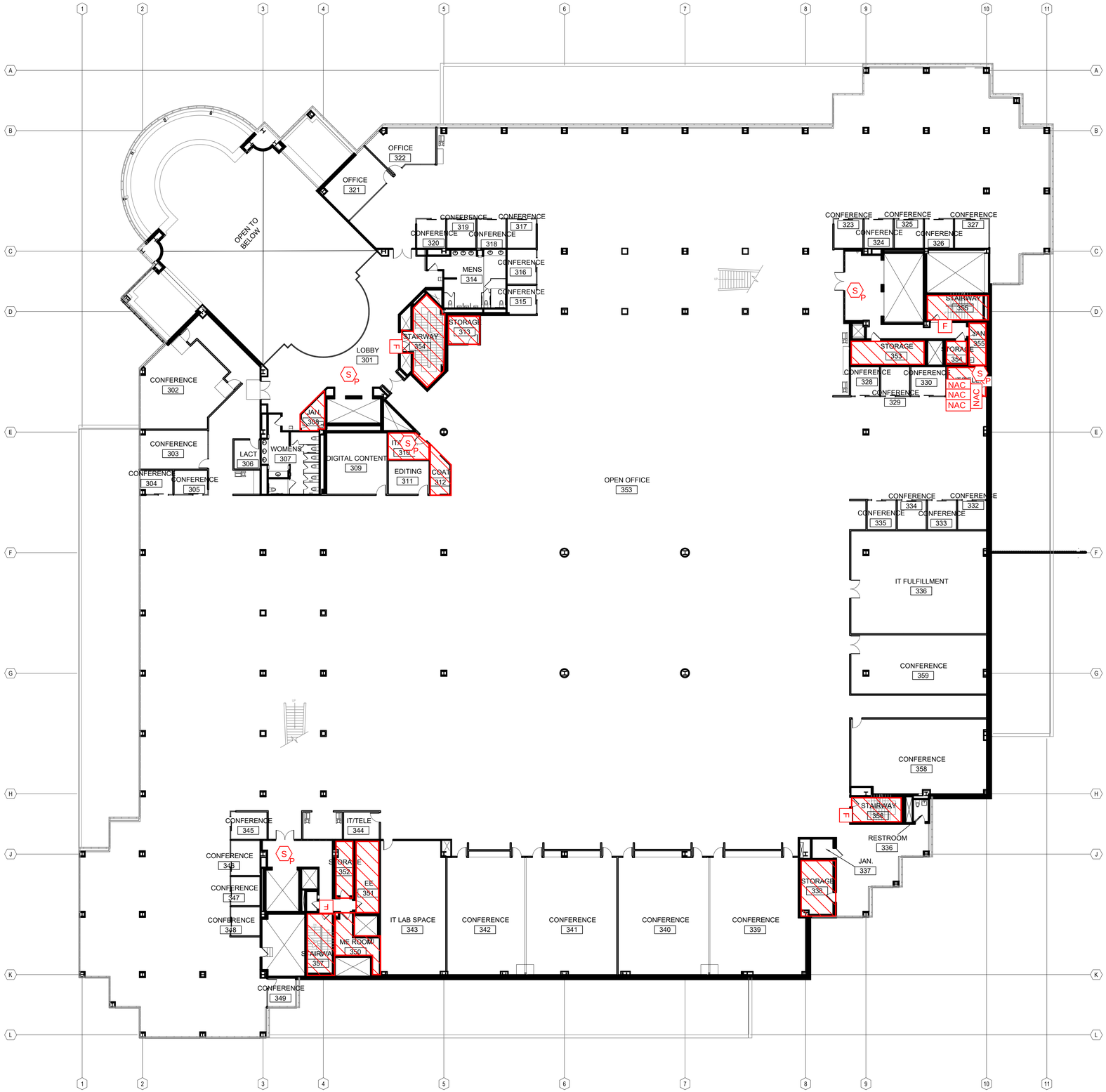
9. INSTALL FIRE ALARM BATTERIES IN THE ENCLOSURE OF THE DEVICE/UNIT IT SUPPORTS (E.G. FACU ENCLOSURE) OR IN AN INDEPENDENT DEDICATED ENCLOSURE.



FIRST-FLOOR FIRE ALARM PLAN



SECOND-FLOOR FIRE ALARM PLAN



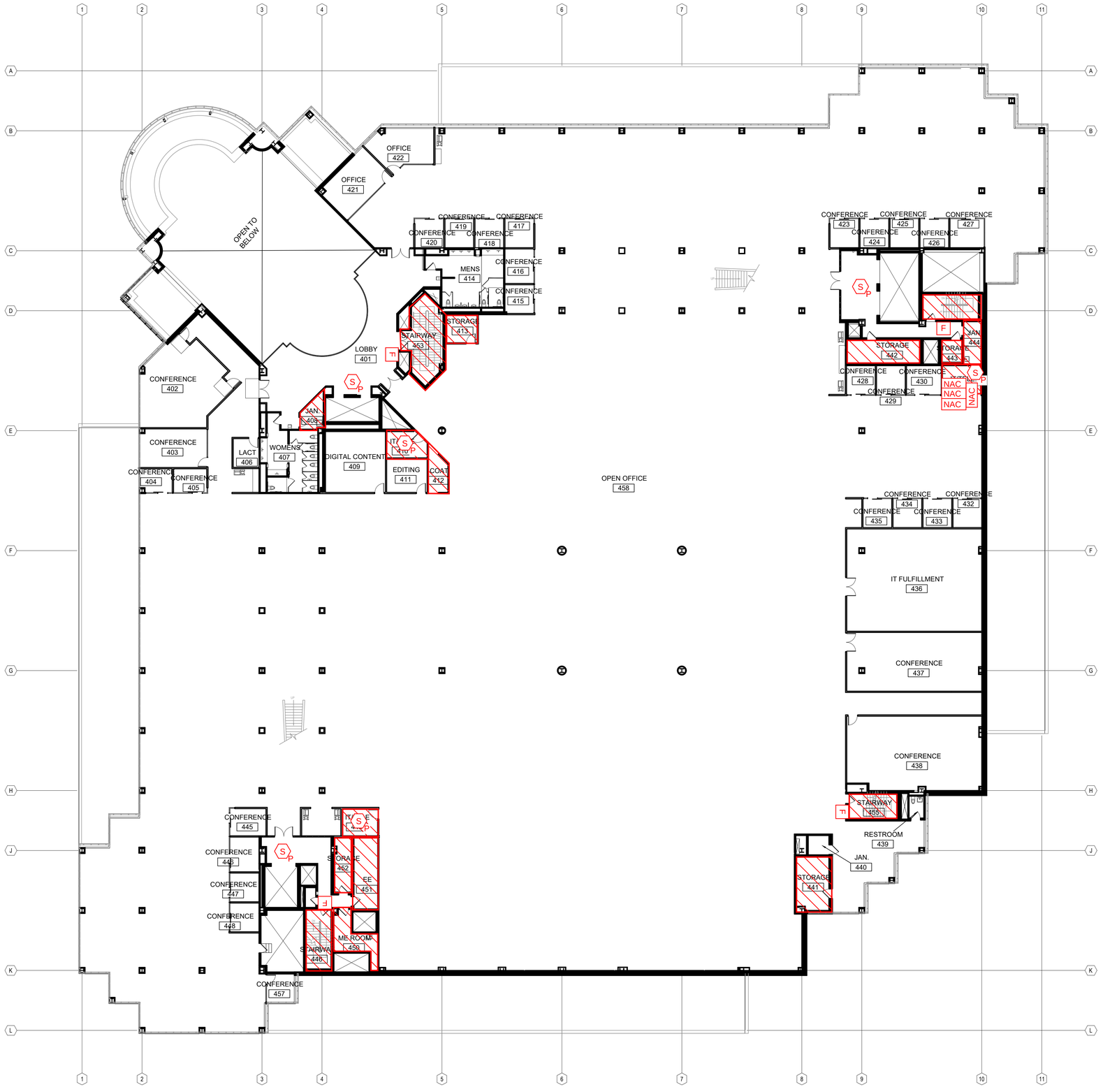
PROVIDE AUDIBLE AND VISUAL NOTIFICATION

PROVIDE AUDIBLE NOTIFICATION

25' 50'

N

THIRD-FLOOR FIRE ALARM PLAN



PROVIDE AUDIBLE AND VISUAL NOTIFICATION

PROVIDE AUDIBLE NOTIFICATION

FOURTH-FLOOR FIRE ALARM PLAN

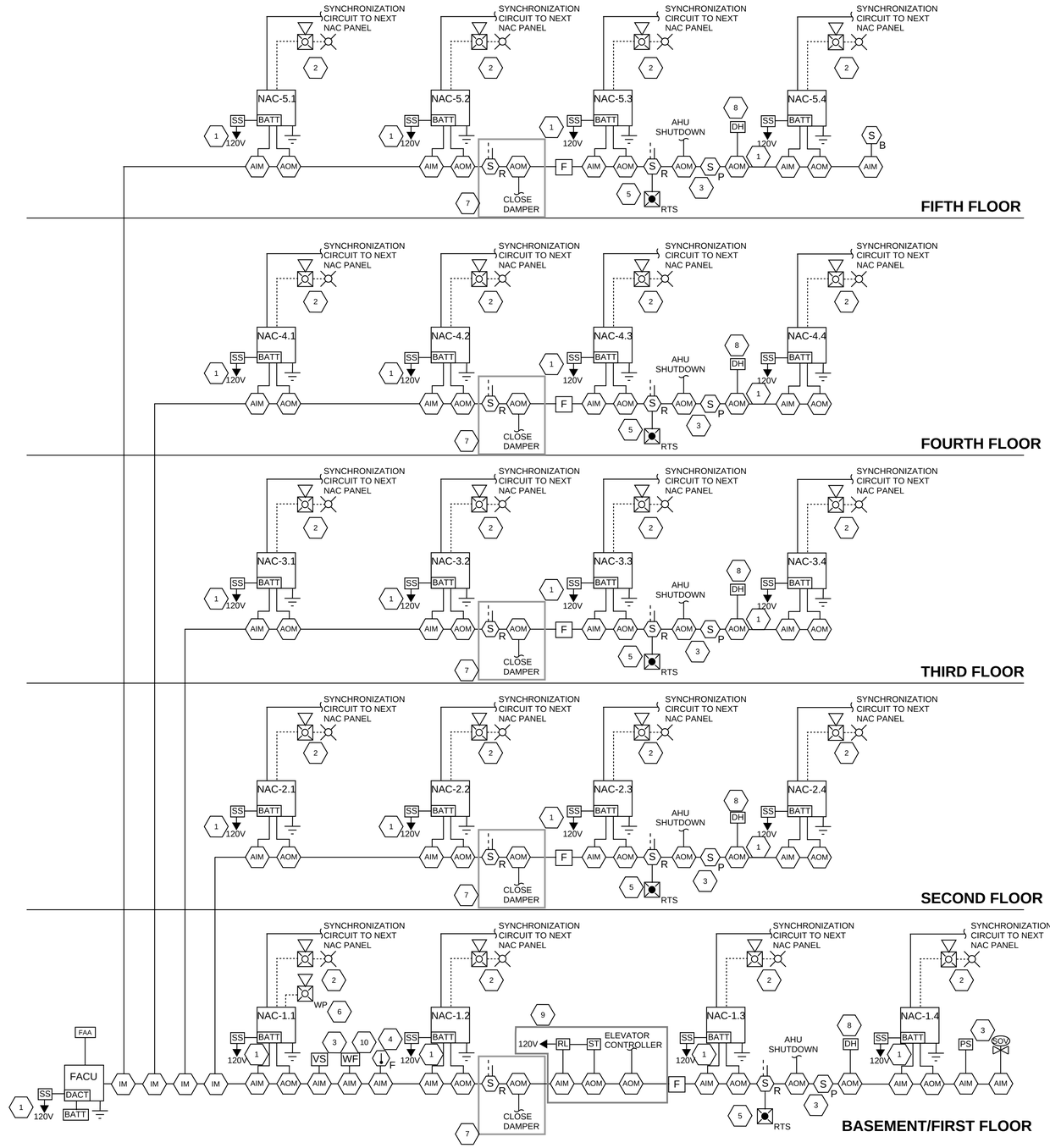
PROVIDE AUDIBLE AND VISUAL NOTIFICATION

PROVIDE AUDIBLE NOTIFICATION

25' 50'

N

FIFTH-FLOOR FIRE ALARM PLAN



FIRE ALARM ONE-LINE

1. LOCK, LABEL "FIRE ALARM", AND PAINT CIRCUIT BREAKER RED. PROVIDE A DEDICATED EMERGENCY PANEL FOR FIRE ALARM. SEE ELECTRICAL PLANS FOR ADDITIONAL INFORMATION.
2. QUANTITY AND LOCATION BY CONTRACTOR'S DESIGN TO MEET DESIGN CRITERIA.
3. REFER TO FIRE SUPPRESSION DRAWINGS FOR QUANTITY AND / OR LOCATIONS OF DEVICE(S).
4. REFER TO FIRE ALARM PLANS FOR QUANTITY AND / OR LOCATIONS OF DEVICE(S).
5. PROVIDE SUPPLY DUCT SMOKE DETECTORS FOR DIRECT SHUT DOWN FOR THE AHU'S GREATER THAN 2000 CFM.
6. EXTERIOR WP HORN STROBE OVER FDC.
7. FIRE DAMPERS TO SHUT DOWN AIRFLOW INTO THE ATRIUM.
8. DOOR HOLDS FOR DOORS LEADING TO ATRIUM.
9. SUPERVISE POWER TO ELEVATOR SHUNT
10. LOCATED IN ELEVATOR PIT

FIRE ALARM CONTROL UNIT (FACU) FUNCTIONAL MATRIX

	ANNUNCIATION AT LOCAL PANEL			NOTIFICATION					AUXILIARY FUNCTION									
ALARM CONDITIONS	AUDIO-VISUAL FIRE ALARM INDICATION BY DEVICE	AUDIO-VISUAL TROUBLE INDICATION BY DEVICE	AUDIO-VISUAL SUPERVISORY INDICATION BY DEVICE	FIRE ALARM SIGNAL TO FIRE DEPARTMENT	COMMON TROUBLE SIGNAL TO FIRE DEPARTMENT	COMMON SUPERVISORY SIGNAL TO FIRE DEPARTMENT	FIRE ALARM AUDIBLE NOTIFICATION	FIRE ALARM VISIBLE NOTIFICATION	SHUT-DOWN AIR HANDLING EQUIPMENT	SHUT-DOWN ASSOCIATED AIR HANDLING EQUIPMENT	CLOSE FIRE DOORS AND FIRE SHUTTERS	SHUT GAS VALVE	ELEVATOR RECALL TO PRIMARY RECALL FLOOR	ELEVATOR RECALL TO SECONDARY RECALL FLOOR	INITIATE ELEVATOR SHUNT TRIP (SUITABLE TIME DELAY REQUIRED)	ACTIVATE SMOKE EXHAUST SYSTEM	CLOSE DOOR HOLDS	RELEASE PRE-ACTION SPRINKLER SYSTEM
MANUAL FIRE ALARM STATIONS	X			X			X	X	X		X	X						
SMOKE DETECTOR OVER FACU AND NAC PANELS	X			X			X	X	X		X	X						
FLOW SWITCHES - WET-PIPE SYSTEM	X			X			X	X	X		X	X						
PRESSURE SWITCHES - PRE-ACTION SYSTEM	X			X			X	X	X		X	X						
HEAT DETECTOR - ELEVATOR PIT	X			X			X	X	X		X	X		X	X			
SMOKE DETECTION - ELEVATOR MAIN FLOOR LOBBY	X			X			X	X	X		X	X		X				
SMOKE DETECTION - ELEVATOR SECONDARY FLOOR LOBBY	X			X			X	X	X		X	X	X					
SMOKE DETECTION ASSOCIATED WITH PRE-ACTION SYSTEM	X			X			X	X	X		X	X	X					X
SMOKE DETECTION IN ATRIUM	X			X			X	X	X		X	X	X			X	X	
TROUBLE CONDITIONS																		
AC POWER FAILURE		X			X													
LOW BATTERY		X			X													
OPEN CIRCUIT FAULT		X			X													
GROUND FAULT		X			X													
NOTIFICATION APPLIANCE CIRCUIT SHORT		X			X													
COMPONENT COMMON TROUBLE		X			X													
COMMON TROUBLE (RSFACU)		X			X													
FIRE PUMP POWER/PHASE FAILURE		X			X													
FIRE PUMP PHASE REVERSAL		X			X													
SUPERVISORY CONDITIONS																		
COMPONENT COMMON SUPERVISORY			X			X												
IN-DUCT SMOKE DETECTORS			X	X		X	X	X		X								
GENERAL VALVE SUPERVISORY			X			X												

APPENDIX D – SMOKE EXHAUST CALCULATIONS

Known and Assumptions

- The design fire most closely resembles an **axisymmetric fire plume** per NFPA 92B.
- Ambient temperature is 72 degrees F
- The fire is assumed to start on the 2nd floor at the reception area furniture.
- The peak heat release rate is based on Figure 3-1.102 of the SFPE HB and additional assumptions which represents the fire orignating at a sofa and igniting an additional piece of furniture.

Atrium Geometry

Height to Atrium ceiling from top of fuel surface (H)	86	ft
Height of highest walking surface	56	ft
Target height from top of fuel surface to bottom of smoke layer (Z)	62	ft

Design Fire Properties

Fuel Source Peak Heat Release Rate (Q)	5000	kW
	4750	BTU/s
Convective Peak Heat Release Rate (Q_c)	3500	kW
	3325	BTU/s
Limiting Flame Height (Z_l)	13.65979	ft
Specific Heat of Plume Gases (C_p)	0.24	Btu/lb-°F

Mass Exhaust Rate

If… $Z > Z_l$, $m_p = (0.022Q_c^{1/3}Z^{5/3}) + 0.0042Q_c$

$Z = Z_l$, $m_p = 0.011Q_c$

$Z < Z_l$, $m_p = 0.0208Q_c^{3/5}Z$

Required Mass Flow Rate for Exhaust where Z > Zl (mp)	332.9	lbs/s

Smoke Layer Properties

Smoke Layer Temperature (T_s)	$T_s = T_a + Q_c/(m_pc)$	113.6	°F
Density of Smoke at Temperature T_s (p)	p = 0.075 x (528/(460 + Ts))	0.06904	lbs/ft^3

Required Smoke Exhaust Rate	**289,311**	**CFM**

Makeup Calculations

Makeup air (V_m) $V_m = 0.95 * V$	274,846	CFM
Area of makeup vents (A_m) $Am = V_m/U_m$	1,374	sq/ft
Makeup air (V_m)	274,846	CFM
Velocity limitation (U_m)	200	fpm

Number of Exhaust Inlets

Maximum mass rate of exhaust (V_{max}) $V_{max} = 452ad^{5/2}(T_s-T_o / T_o)^{1/2}$	440812	CFM
Temperature of smoke layer (T_s)	552.48	°R
Ambient temperature (T_o)	531.67	°R
Depth of smoke layer below bottom of exhaust inlet (d)	30	ft
Exhaust location factor (a)	1	

Known and Assumptions

- The design fire most closely resembles a **balcony spill** fire plume per NFPA 92B.
- Ambient temperature is 72 degrees F
- The fire is assumed to start on the 2nd floor at the reception area furniture
- The peak heat release rate is based on Figure 3-1.102 of the SFPE HB and additional assumptions which represents the fire orignating at a sofa and igniting an additional piece of furniture.

Atrium Geometry

Height to Atrium ceiling from top of fuel surface (H)		86	ft
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Design Fire Properties

Fuel Source Peak Heat Release Rate (Q)		5000	kW
		4750	BTU/s
Convective Peak Heat Release Rate (Q_c)		3500	kW
		3325	BTU/s
Specific Heat of Plume Gases (C_p)		0.24	Btu/lb-°F

Ventilation Calculations

Length of spill (W)	W=w+b	28.5	ft
Width of opening from area of origin (w)		25.5	ft
Distance from opening to balcony edge (b)		3	ft
Height of plume above balcony edge (z_b)		9	ft

Region 1: $z_b < 50$ ft (Hanbook of Smoke Control Engineering

For Region 1, mass flow plume is $m=0.12(QW^2)^{1/3}(z_b + 0.25H)$

Mass flow rate in plume (m)		381	lb/s
Heat release rate of fire (Q)		4750	BTU/s
Length of spill (W)		28.5	ft
Height of plume above balcony edge (z_b)		9	ft
Height of balcony above fuel (H)		45	ft

Smoke layer temperature

Average plume temperature (T_p) $T_p = T_o + (KQ_c)/(mc_p)$		108.35	°F
Ambient temperature (T_o)		72	°F
Convective heat release rate (Q_c)		3325	BTU/s
Specific Heat of Plume Gases (C_p)		0.24	Btu/lb-°F

Density of smoke

Density of smoke (p) $p = 144p_{atm} / R(T_p + 460)$		0.068	lb/ft^3
Atmospheric pressure (p_{atm})		14.257	lb/in^2
Gas constant (R)		53.34	
Average plume temperature (T_p)		108.35	°F

Smoke exhaust

Smoke exhaust (V) V = 60(m/p)		337674	cfm
Mass flow rate in plume (m)		381	lb/s
Density of smoke (p) $p = 144p_{atm} / R(T_p + 460)$		0.068	lb/ft^3

Required Smoke Exhaust Rate	**337,674**	**CFM**

Makeup Calculations

Makeup air (V_m) $V_m = 0.95 * V$	320,790	CFM
Area of makeup vents (A_m) $Am = V_m/U_m$	1,604	sq/ft
Makeup air (V_m)	320,790	CFM
Velocity limitation (U_m)	200	fpm

Number of Exhaust Inlets

Maximum mass rate of exhaust (V_{max}) $V_{max} = 452ad^{5/2}(T_s-T_o / T_o)^{1/2}$	411967	CFM
Temperature of smoke layer (T_s)	549.85	°R
Ambient temperature (T_o)	531.67	°R
Depth of smoke layer below bottom of exhaust inlet (d)	30	ft
Exhaust location factor (a)	1	

APPENDIX E - FDS CALCULATION

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    DENSITY=930.0/

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APPENDIX F – PATHFINDER CALCULATION

SUMMARYSUMMARY***SUMMARY***SUMMARY***SUMMARY***

Simulation: DCIB

Version: 2017.2.0301

Mode: Steering

Total Occupants: 6057

Completion Times for All Occupants (s):

Min:	1.0	"00227"
Max:	1146.3	"06405"
Average:	392.0	
StdDev:	281.0	

Completion Times by Behavior (s):

Behavior	Count	Min	Min_Name	Max	Max_Name	Avg	StdDev
Goto Any Exit	5922	1.0	"00227"	1146.3	"06405"	392.0	281.0
all behaviors	5922	1.0	"00227"	1146.3	"06405"	392.0	281.0

Completion Times by Profile (s):

Profile	Count	Min	Min_Name	Max	Max_Name	Avg	StdDev
Default	5922	1.0	"00227"	1146.3	"06405"	392.0	281.0
all profiles	5922	1.0	"00227"	1146.3	"06405"	392.0	281.0

Travel Distances for All Occupants (m):

Min:	0.6	"00227"
Max:	392.5	"05517"
Average:	102.1	
StdDev:	56.8	

Movement Distance by Behavior (m):

Behavior	Count	Min	Min_Name	Max	Max_Name	Avg	StdDev
Goto Any Exit	5922	0.6	"00227"	392.5	"05517"	102.1	56.8
all behaviors	5922	0.6	"00227"	392.5	"05517"	102.1	56.8

Movement Distance by Profile (m):

Profile	Count	Min	Min_Name	Max	Max_Name	Avg	StdDev
Default	5922	0.6	"00227"	392.5	"05517"	102.1	56.8
all profiles	5922	0.6	"00227"	392.5	"05517"	102.1	56.8

[Components] All: 716

[Components] Doors: 374

Triangles: 3642

Startup Time: 2.1s

CPU Time: 401.2s

Door Flow Rates:

Door	First_In (s)	Last_Out (s)	Total_Use (pers)	Flow_Avg (pers/s)
Door01	1.2	5.6	3	0.69
Door02	0.0	0.0	0	
Door03	2.9	14.9	8	0.66
Door05	1.1	15.0	16	1.15
Door06	1.8	1.8	1	
Door07	1.7	2.9	2	1.70
Door10	2.0	19.1	38	2.22
Door12	3.3	100.0	243	2.51
Door13	1.7	27.0	28	1.10
Door14	2.0	22.2	24	1.19

Door15	3.8	10.3	7	1.06
Door17	2.2	2.2	1	
Door18	1.2	1.2	1	
Door19	2.2	7.0	4	0.82
Door20	7.0	8.3	2	1.57
Door21	0.0	0.0	0	
Door22	0.0	0.0	0	
Door24	1.7	3.8	2	0.95
Door25	6.2	30.5	23	0.95
Door26	0.0	0.0	0	
Door27	1.0	18.3	13	0.75
Door28	3.0	13.0	5	0.50
Door29	5.1	11.4	5	0.79
Door35	6.2	6.2	1	
Door39	2.5	2.5	1	
Door41	3.1	155.2	175	1.15
Door42	2.9	2.9	1	
Door43	3.5	3.5	1	
Door44	3.8	8.2	3	0.68
Door45	2.8	2.8	1	
Door46	3.8	9.4	6	1.08
Door51	3.3	3.3	1	
Door52	1.7	3.1	2	1.36
Door53	2.1	11.2	15	1.65
Door54	3.8	6.5	3	1.11
Door55	5.6	9.1	2	0.57
Door56	5.0	27.9	23	1.01
Door58	3.7	42.1	35	0.91
Door59	0.8	8.5	5	0.65
Door60	0.0	0.0	0	

Door61	0.0	0.0	0	
Door62	4.5	29.7	19	0.75
Door63	3.4	3.4	1	
Door64	4.2	84.8	52	0.65
Door65	1.7	78.6	51	0.66
Door66	1.3	98.4	78	0.80
Door67	2.9	135.7	131	0.99
Door68	3.7	59.6	8	0.14
Door69	2.1	50.0	32	0.67
Door70	1.1	17.4	16	0.98
Door71	6.7	30.7	13	0.54
Door72	1.2	28.4	26	0.96
Door73	2.1	8.0	4	0.68
Door74	2.0	23.0	23	1.10
Door75	2.3	8.6	6	0.96
Door76	0.0	0.0	0	
Door77	4.8	9.7	2	0.41
Door78	4.1	4.1	1	
Door79	2.0	17.4	13	0.84
Door80	2.1	2.1	1	
Door81	1.8	2.9	2	1.78
Door82	3.3	4.5	2	1.57
Door83	3.9	8.0	4	0.99
Door84	2.5	2.5	1	
Door86	1.3	4.9	3	0.85
Door87	3.9	3.9	1	
Door88	3.1	9.6	6	0.92
Door89	1.3	26.8	22	0.86
Door90	2.8	43.0	78	1.94
Door91	2.2	56.9	45	0.82

Door93	1.8	1.8	1	
Door94	1.3	72.9	68	0.95
Door95	3.0	9.8	5	0.74
Door97	2.8	763.5	651	0.86
Door98	1.7	687.3	66	0.10
Door99	3.4	88.7	41	0.48
Door100	1.0	36.1	75	2.14
Door162	1.5	1.5	1	
Door164	1.8	248.1	371	1.51
Door165	0.0	0.0	0	
Stair10 door 1	19.5	1145.1	1013	0.90
Stair10 door 2	11.3	1128.9	1013	0.91
Door169	20.7	1146.3	1013	0.90
Door177	0.0	0.0	0	
Stair27 door 1	16.4	664.5	580	0.89
Stair27 door 2	19.9	668.0	580	0.89
Door182	21.3	669.4	580	0.89
Stair31 door 1	15.7	750.7	652	0.89
Stair31 door 2	10.8	745.8	652	0.89
Stair33 door 1	11.9	898.5	833	0.94
Stair33 door 2	18.8	908.4	833	0.94
Door183	20.5	910.6	833	0.94
Stair26 door 1	14.4	662.3	580	0.90
Stair26 door 2	8.5	656.4	580	0.90
Stair30 door 1	2.2	737.5	652	0.89
Stair30 door 2	6.0	741.3	652	0.89
Stair32 door 1	4.5	884.5	833	0.95
Stair32 door 2	9.0	893.4	833	0.94
Door101	1.5	74.6	6	0.08
Door102	1.5	176.6	9	0.05

Door103	2.1	207.8	214	1.04
Door104	6.4	196.3	11	0.06
Door105	2.6	9.3	6	0.90
Door106	2.7	2.7	1	
Door107	4.7	4.7	1	
Door108	3.4	7.5	4	0.96
Door109	0.9	219.5	18	0.08
Door110	2.6	59.7	4	0.07
Door111	2.8	2.8	1	
Door112	2.9	246.9	171	0.70
Door113	2.5	15.1	2	0.16
Door114	1.0	10.5	9	0.94
Door115	0.7	9.9	10	1.09
Door116	2.4	13.6	13	1.17
Door117	1.3	8.2	7	1.00
Door118	0.8	8.5	8	1.04
Door120	2.4	3.1	2	
Door121	7.8	12.3	4	0.88
Door122	1.5	1.5	1	
Door123	1.9	66.3	59	0.92
Door124	0.0	0.0	0	
Door125	0.0	0.0	0	
Door126	1.3	8.1	6	0.89
Door127	1.3	7.9	7	1.06
Door128	2.3	6.1	4	1.03
Door129	2.8	4.2	2	1.45
Door130	4.3	8.9	6	1.30
Door131	0.0	0.0	0	
Door132	1.5	58.5	10	0.18
Door133	1.9	5.4	4	1.15

Door134	1.3	9.1	8	1.02
Door135	1.3	101.1	22	0.22
Door136	2.0	128.6	113	0.89
Door137	3.0	138.4	114	0.84
Door138	16.4	98.7	5	0.06
Door139	3.3	59.0	9	0.16
Door140	1.5	1.5	1	
Door141	1.9	49.6	13	0.27
Door142	1.3	41.0	10	0.25
Door143	1.6	68.6	16	0.24
Door144	1.9	6.7	5	1.04
Door145	0.9	0.9	1	
Door146	4.2	4.2	1	
Door147	2.7	2.7	1	
Door148	1.4	5.2	3	0.78
Door153	2.0	577.9	52	0.09
Door154	1.2	285.3	146	0.51
Door155	1.8	175.0	323	1.87
Door156	3.4	552.8	115	0.21
Door158	1.7	14.0	13	1.06
Door159	2.4	18.4	16	1.00
Door160	1.6	10.5	10	1.12
Door161	1.6	372.6	324	0.87
Door171	77.8	111.7	7	0.21
Stair37 door 1	72.4	106.4	7	0.21
Stair37 door 2	76.1	110.0	7	0.21
Stair39 door 1	25.3	647.0	409	0.66
Stair39 door 2	31.7	653.4	409	0.66
Stair48 door 1	18.4	1068.1	799	0.76
Stair48 door 2	22.4	1078.8	799	0.76

Stair52 door 1	22.5	868.5	458	0.54
Stair52 door 2	18.9	862.6	458	0.54
Stair36 door 1	59.1	93.0	7	0.21
Stair36 door 2	64.4	98.3	7	0.21
Stair46 door 1	11.7	1029.1	799	0.79
Stair46 door 2	5.4	1020.5	799	0.79
Stair56 door 1	11.0	826.7	458	0.56
Stair56 door 2	7.5	812.2	458	0.57
Stair59 door 1	18.6	640.4	409	0.66
Stair59 door 2	15.1	636.8	409	0.66
Door184	2.3	600.0	22	0.04
Door186	1.4	1.4	1	
Door187	1.8	1.8	1	
Door188	2.9	2.9	1	
Door189	0.8	18.3	13	0.74
Door190	1.4	9.8	7	0.83
Door191	1.5	11.8	11	1.07
Door192	1.2	24.6	10	0.43
Door193	1.2	18.3	9	0.53
Door194	0.8	11.4	10	0.94
Door195	1.4	12.0	11	1.05
Door196	1.3	9.6	9	1.09
Door198	1.9	7.0	7	1.37
Door199	1.3	8.6	10	1.38
Door200	0.9	10.0	12	1.32
Door201	2.0	6.1	7	1.71
Door202	1.5	15.6	21	1.49
Door203	1.4	16.9	22	1.42
Door204	1.7	32.7	29	0.93
Door205	2.3	2.3	1	

Door206	2.3	2.3	1	
Door207	2.3	2.3	1	
Door208	4.6	22.8	19	1.04
Door209	1.5	23.2	20	0.92
Door210	0.9	16.6	14	0.89
Door211	1.5	19.3	17	0.96
Door212	1.8	24.4	20	0.88
Door213	1.8	18.8	18	1.06
Door214	3.6	21.5	19	1.07
Door215	2.3	15.5	13	0.98
Door216	4.6	4.6	1	
Door217	3.1	3.1	1	
Door218	3.5	3.5	1	
Door219	1.9	1.9	1	
Door220	1.1	7.0	7	1.18
Door221	0.7	12.0	11	0.98
Door222	0.9	14.3	12	0.90
Door223	1.4	16.9	15	0.97
Door224	0.8	20.5	10	0.51
Door225	12.7	105.1	58	0.63
Door227	1.0	5.5	5	1.11
Door228	1.7	78.4	8	0.10
Door229	0.9	125.5	33	0.26
Door230	1.6	28.5	25	0.93
Door231	1.8	42.4	46	1.13
Door232	2.3	2.3	1	
Door233	2.0	204.7	2	0.01
Door234	4.3	10.5	6	0.96
Door235	2.6	11.4	8	0.91
Door236	2.9	51.1	4	0.08

Door237	2.7	41.0	5	0.13
Door238	2.7	62.1	3	0.05
Door239	5.4	11.3	6	1.02
Door240	0.8	150.1	19	0.13
Door241	1.8	144.6	14	0.10
Door242	1.3	140.9	14	0.10
Door243	1.2	138.0	13	0.09
Door244	1.4	79.1	14	0.18
Door245	1.4	73.9	13	0.18
Door246	3.4	183.2	431	2.40
Door247	1.0	704.8	106	0.15
Door248	1.8	395.4	265	0.67
Door249	5.6	6.9	2	1.51
Door250	3.9	5.0	2	1.82
Door251	17.8	96.4	55	0.70
Door253	1.7	392.1	301	0.77
Door256	5.2	789.8	815	1.04
Stair57 door 1	12.0	1009.6	495	0.50
Stair57 door 2	15.5	1015.6	495	0.49
Stair60 door 1	13.2	634.9	409	0.66
Stair60 door 2	9.7	631.4	409	0.66
Stair62 door 1	11.1	86.9	62	0.82
Stair62 door 2	16.4	94.3	62	0.80
Stair65 door 1	18.1	809.8	445	0.56
Stair65 door 2	21.9	817.6	445	0.56
Stair58 door 1	6.1	992.2	495	0.50
Stair58 door 2	9.6	998.7	495	0.50
Stair61 door 1	7.5	629.2	409	0.66
Stair61 door 2	3.6	625.2	409	0.66
Stair64 door 1	3.9	73.2	62	0.89

Stair64 door 2	9.3	82.3	62	0.85
Stair66 door 1	27.7	827.3	446	0.56
Stair66 door 2	23.9	821.7	445	0.56
Door257	1.1	23.2	10	0.45
Door258	1.3	17.1	11	0.70
Door259	0.8	17.0	10	0.62
Door260	0.9	9.5	8	0.93
Door261	1.0	9.9	11	1.24
Door262	1.5	19.1	10	0.57
Door263	1.3	7.8	7	1.07
Door264	1.3	13.1	16	1.36
Door265	2.7	2.7	1	
Door267	1.9	1.9	1	
Door268	2.5	2.5	1	
Door269	2.3	805.0	22	0.03
Door270	4.5	936.1	313	0.34
Door271	1.4	10.0	10	1.17
Door272	0.8	5.9	7	1.36
Door273	1.6	8.0	8	1.25
Door274	1.5	9.4	10	1.27
Door275	1.1	32.5	78	2.48
Door276	1.8	132.7	109	0.83
Door277	1.5	117.4	23	0.20
Door278	0.0	0.0	0	
Door279	2.6	2.6	1	
Door280	2.7	2.7	1	
Door281	1.5	9.1	8	1.06
Door282	1.8	10.8	10	1.10
Door283	1.4	12.7	11	0.97
Door284	2.2	20.4	13	0.72

Door285	0.9	13.7	8	0.62
Door286	2.7	2.7	1	
Door287	1.9	62.6	2	0.03
Door288	4.7	4.7	1	
Door289	3.1	3.1	1	
Door290	2.7	2.7	1	
Door291	2.4	8.2	6	1.03
Door292	0.8	7.1	7	1.11
Door293	1.4	28.0	31	1.17
Door294	1.6	30.8	29	0.99
Door295	1.1	36.6	38	1.07
Door296	1.7	1.7	1	
Door299	3.3	32.5	8	0.27
Door300	2.5	33.7	3	0.10
Door301	2.5	2.5	1	
Door302	2.4	2.4	1	
Door303	1.4	298.6	53	0.18
Door304	1.1	259.8	45	0.17
Door305	1.0	214.3	36	0.17
Door306	1.3	165.9	30	0.18
Door307	1.3	100.7	28	0.28
Door308	1.5	95.5	30	0.32
Door309	1.6	867.7	1029	1.19
Door310	4.4	981.4	935	0.96
Door311	24.2	31.7	2	0.26
Door312	2.8	12.1	7	0.75
Door313	2.3	2.3	1	
Door314	1.0	23.8	3	0.13
Door315	3.4	11.2	7	0.90
Door316	1.4	860.7	1141	1.33

Stair67 door 1	15.7	968.5	353	0.37
Stair67 door 2	19.7	978.5	353	0.37
Stair69 door 1	19.4	623.1	179	0.30
Stair69 door 2	13.1	615.2	178	0.30
Stair72 door 1	21.0	292.9	14	0.05
Stair72 door 2	15.3	287.5	14	0.05
Stair74 door 1	16.2	845.9	655	0.79
Stair74 door 2	7.7	830.9	654	0.79
Stair68 door 1	6.4	873.9	353	0.41
Stair68 door 2	10.8	895.1	353	0.40
Stair71 door 1	11.4	613.3	178	0.30
Stair71 door 2	3.9	605.9	178	0.30
Stair73 door 1	6.9	279.1	14	0.05
Stair73 door 2	11.8	284.0	14	0.05
Stair75 door 1	1.0	799.5	654	0.82
Stair75 door 2	5.1	815.0	654	0.81
Door317	1.7	26.1	10	0.41
Door318	0.9	7.6	8	1.19
Door319	1.4	13.1	13	1.11
Door320	1.5	8.6	8	1.13
Door321	2.0	8.9	8	1.17
Door322	3.4	477.8	350	0.74
Door323	2.0	713.1	28	0.04
Door324	1.8	1.8	1	
Door325	1.8	1.8	1	
Door326	2.9	2.9	1	
Door327	1.3	9.2	9	1.14
Door328	0.8	12.7	6	0.50
Door329	1.5	13.8	11	0.89
Door330	1.9	1.9	1	

Door331	2.3	2.3	1	
Door332	1.8	1.8	1	
Door333	1.6	7.8	9	1.43
Door334	1.5	12.3	10	0.93
Door335	0.7	12.3	11	0.94
Door336	0.8	7.1	6	0.95
Door337	2.5	2.5	1	
Door338	0.0	0.0	0	
Door339	2.9	2.9	1	
Door340	2.7	2.7	1	
Door341	5.6	277.8	14	0.05
Door342	0.0	0.0	0	
Door343	32.7	268.9	12	0.05
Door344	2.2	8.0	7	1.21
Door345	1.2	7.0	8	1.36
Door346	1.0	63.1	8	0.13
Door347	0.7	216.9	29	0.13
Door348	1.7	35.7	37	1.09
Door349	2.2	26.9	24	0.97
Door350	2.7	2.7	1	
Door351	4.8	197.3	8	0.04
Door352	2.9	194.8	4	0.02
Door353	2.8	178.1	5	0.03
Door354	2.3	34.2	2	0.06
Door355	1.4	9.3	8	1.01
Door356	1.1	8.7	10	1.31
Door357	2.6	236.0	132	0.57
Door358	1.1	171.2	90	0.53
Door359	1.6	489.8	245	0.50
Door361	4.1	726.5	79	0.11

Door362	1.2	7.7	4	0.61
Door363	2.0	2.0	1	
Door364	1.8	529.5	448	0.85
Door365	2.1	10.4	6	0.73

Room Usage:

Room	First_In (s)	Last_Out (s)	Total_Use (pers)	
OFFICE 117	0.0	7.0	4	
BREAK ROOM 118	0.0	27.0	52	
OFFICE 120	0.0	0.0	0	
OFFICE 119	0.0	5.6	3	
OFFICE 124	0.0	14.9	8	
CONFERENCE ROOM 125	0.0	15.0	23	
WOMENS 126	0.0	1.8	1	
MENS 127	0.0	2.9	2	
JAN 122	0.0	2.2	1	
ELECT. 123	0.0	1.2	1	
Room23	0.0	0.0	0	
Room25	0.0	8.3	2	
MATTRESS FAB 130	0.0	19.1	40	
Room24	0.0	0.0	0	
LOADING DOCK 141	0.0	30.5	33	
STAIRWAY 161	0.0	18.3	13	
Room32	0.0	6.2	1	
Room33	0.0	2.5	1	
OFFICE 144	0.0	3.4	1	
OFFICE 143	0.0	84.8	52	
OPEN OFFICE 145	0.0	155.2	213	
STORAGE 156	0.0	8.2	4	

STORAGE 155	0.0	3.5	1	
STORAGE 154	0.0	2.9	1	
OFFICE 148	0.0	3.3	1	
OFFICE 147	0.0	3.1	2	
OFFICE 149	0.0	11.2	15	
LAB 153	0.0	9.4	6	
WOMENS 151	0.0	6.5	3	
Room45	0.0	9.1	2	
LAB 150	0.0	27.9	23	
Room47	0.0	248.1	403	
EE ROOM 146	0.0	59.6	8	
R&D 137	0.0	36.1	75	
CONFERENCE ROOM 136	0.0	17.4	16	
Room53	0.0	135.7	199	
ME ROOM 138	0.0	29.7	19	
OFFICE 140	0.0	8.5	5	
COMFORT	0.0	42.1	35	
Room58	0.0	56.9	123	
Room59	0.0	28.4	26	
OFFICE 134	0.0	8.0	4	
Room61	0.0	23.0	23	
Room62	0.0	8.6	6	
Room63	0.0	17.4	13	
Room64	0.0	9.7	2	
Room65	0.0	4.1	1	
Room66	0.0	4.5	2	
Room67	0.0	2.1	1	
Room68	0.0	2.9	2	
Room69	1.8	8.0	4	
Room70	0.0	2.5	1	

Room71		0.0	1.8	1
Room72		0.0	3.9	1
Room73		0.0	9.6	6
Room74		0.0	4.9	3
Room75		0.0	26.8	22
Room76		0.0	100.0	243
Room78		0.0	763.5	758
Room77		0.0	72.9	73
Room771		0.0	0.0	0
Room140		0.0	1.5	1
Room145		19.5	1146.3	1013
Stair10	11.3	1145.1	1013	
Room1421		0.0	0.0	0
Room142		0.0	0.0	0
Room157		0.0	0.0	0
Room160		18.8	910.6	833
Room162		19.9	669.4	580
Stair27	16.4	668.0	580	
Stair31	10.8	750.7	652	
Stair33	11.9	908.4	833	
Room153		9.0	898.5	833
Room161		14.4	664.5	580
Stair26	8.5	662.3	580	
Room163		6.0	745.8	652
Stair30	2.2	741.3	652	
Stair32	4.5	893.4	833	
Room100		0.0	8.2	7
Room101		0.0	8.5	8
Room102		0.0	7.9	7
Room103		0.0	8.1	6

Room104	0.0	6.1	4
Room105	0.0	4.2	2
Room106	0.0	8.9	6
Room107	0.0	66.3	59
Room108	0.0	0.0	0
Room109	0.0	0.0	0
Room110	0.0	12.3	4
Room111	0.0	3.1	3
Room113	0.0	0.0	0
Room114	0.0	9.1	8
Room115	0.0	101.1	22
Room116	0.0	58.5	10
Room118	0.0	5.4	4
Room119	0.0	138.4	114
Room120	16.4	98.7	5
Room121	0.0	1.5	1
Room122	0.0	59.0	9
Room123	0.0	577.9	196
Room124	0.0	49.6	13
Room125	0.0	41.0	10
Room126	0.0	68.6	16
Room127	0.0	0.9	1
Room128	0.0	6.7	5
Room129	0.0	2.7	1
Room130	0.0	5.2	3
Room131	0.0	4.2	1
Room132	0.0	14.0	13
Room133	0.0	18.4	16
Room134	0.0	10.5	10
Room135	0.0	0.0	0

Room137		0.0	884.5	1490
Room147		76.1	111.7	7
Room80		0.0	0.0	0
Room801		0.0	0.0	0
Room801		0.0	0.0	0
Room801		0.0	0.0	0
Room801		0.0	0.0	0
Room801		0.0	0.0	0
Room81		0.0	2.7	1
Room82		0.0	74.6	6
Room83		0.0	176.6	9
Room84		0.0	196.3	11
Room85		0.0	9.3	6
Room87		0.0	59.7	4
Room88		0.0	2.8	1
Room89		0.0	219.5	18
Room90		0.0	4.7	1
Room91		0.0	7.5	4
Room95		2.9	656.4	580
Room96		0.0	15.1	2
Room97		0.0	13.6	13
Room98		0.0	10.5	9
Room99		0.0	9.9	10
Stair37	72.4	110.0	7	
Stair39	25.3	653.4	409	
Room86		2.1	1128.9	1013
Stair48	18.4	1078.8	799	
Room80		0.0	552.8	1254
Stair52	18.9	868.5	458	
Room239		64.4	106.4	7

Stair36	59.1	98.3	7	
Room240		18.6	647.0	409
Room241		11.7	1068.1	799
Stair46	5.4	1029.1	799	
Stair56	7.5	826.7	458	
Room247		11.0	862.6	458
Stair59	15.1	640.4	409	
Room175		0.0	18.3	9
Room176		0.0	11.4	10
Room177		0.0	12.0	11
Room178		0.0	9.6	9
Room1641		0.0	0.0	0
Room190		0.0	2.3	1
Room191		0.0	2.3	1
Room193		0.0	23.2	39
Room194		0.0	19.3	31
Room195		0.0	21.5	32
Room196		0.0	24.4	38
Room197		0.0	0.0	0
Room203		0.0	4.6	1
Room204		0.0	3.5	1
Room206		0.0	7.0	7
Room208		0.0	14.3	12
Room209		0.0	12.0	11
Room210		0.0	20.5	10
Room226		0.0	11.3	6
Room235		0.0	6.9	2
Room238		16.4	96.4	62
Room227		0.0	73.9	13
Room172		0.0	2.9	1

Room174	0.0	24.6	10
Room171	0.0	11.8	11
Room170	0.0	9.8	7
Room169	0.0	18.3	13
Room225	0.0	62.1	3
Room221	0.0	51.1	4
Room214	0.0	78.4	8
Room213	0.0	5.5	5
Room184	0.0	10.0	12
Room183	0.0	8.6	10
Room182	0.0	7.0	7
Room185	0.0	6.1	7
Room186	0.0	15.6	21
Room187	0.0	16.9	22
Room217	0.0	2.3	1
Room1641	0.0	0.0	0
Room164	0.0	0.0	0
Room219	0.0	10.5	6
Room216	0.0	42.4	71
Room218	0.0	204.7	2
Room168	0.0	1.8	1
Room166	0.0	0.0	0
Room167	0.0	1.4	1
Room165	0.0	600.0	22
Room245	1.4	1020.5	799
Room215	0.0	125.5	33
Room255	5.2	812.2	859
Room222	0.0	41.0	5
Room220	0.0	11.4	8
Room236	0.0	5.0	2

Room228		0.0	79.1	14
Room229		0.0	138.0	13
Room232		0.0	150.1	19
Room231		0.0	144.6	14
Room230		0.0	140.9	14
Room234		1.0	789.8	815
Room207		0.0	16.9	15
Room211		3.1	105.1	58
Room205		0.0	1.9	1
Room202		0.0	3.1	1
Room192		0.0	2.3	1
Room188		0.0	32.7	29
Room164		0.0	704.8	1103
Stair57	12.0	1015.6	495	
Room329		13.2	636.8	409
Stair60	9.7	634.9	409	
Stair62	11.1	94.3	62	
Stair65	18.1	817.6	445	
Room327		9.6	1009.6	495
Stair58	6.1	998.7	495	
Room330		7.5	631.4	409
Stair61	3.6	629.2	409	
Room332		9.3	86.9	62
Stair64	3.9	82.3	62	
Room334		21.9	821.7	445
Stair66	23.9	827.3	446	
Room257		0.0	23.2	10
Room258		0.0	17.1	11
Room259		0.0	17.0	10
Room260		0.0	9.5	8

Room261	0.0	9.9	11
Room266	0.0	2.5	1
Room268	0.0	1.9	1
Room269	0.0	805.0	22
Room270	0.0	19.1	10
Room271	0.0	7.8	7
Room272	0.0	13.1	16
Room273	0.0	2.7	1
Room274	0.0	10.0	10
Room275	0.0	5.9	7
Room276	0.0	8.0	8
Room277	0.0	9.4	10
Room278	0.0	32.5	78
Room279	0.0	132.7	109
Room280	0.0	117.4	23
Room282	0.0	0.0	0
Room284	0.0	2.6	1
Room285	0.0	2.7	1
Room291	0.0	9.1	8
Room292	0.0	10.8	10
Room293	0.0	12.7	11
Room294	0.0	20.4	13
Room295	0.0	13.7	8
Room297	0.0	2.7	1
Room298	0.0	3.1	1
Room299	0.0	4.7	1
Room300	0.0	2.7	1
Room301	0.0	62.6	2
Room303	0.0	28.0	31
Room304	0.0	8.2	6

Room305		0.0	7.1	7
Room306		0.0	36.6	67
Room307		0.0	1.7	1
Room308		0.0	2.3	1
Room309		0.0	12.1	7
Room310		0.0	32.5	8
Room311		0.0	33.7	3
Room314		0.0	2.4	1
Room315		0.0	11.2	7
Room316		0.0	298.6	53
Room317		0.0	259.8	45
Room318		0.0	214.3	36
Room319		0.0	165.9	30
Room320		0.0	100.7	28
Room321		0.0	95.5	30
Room2561		0.0	0.0	0
Room312		0.0	2.5	1
Room3121		0.0	0.0	0
Room264		1.9	992.2	582
Room256		0.0	981.4	2670
Room325		0.0	860.7	1141
Room3251		0.0	0.0	0
Stair67	15.7	978.5	353	
Stair69	13.1	623.1	179	
Stair72	15.3	292.9	14	
Stair74	7.7	845.9	655	
Room390		10.8	968.5	353
Stair68	6.4	895.1	353	
Room391		11.4	615.2	178
Stair71	3.9	613.3	178	

Room393		11.8	287.5	14
Stair73	6.9	284.0	14	
Room394		5.1	830.9	654
Stair75	1.0	815.0	654	
Room339		0.0	26.1	10
Room340		0.0	7.6	8
Room341		0.0	13.1	13
Room342		0.0	8.6	8
Room343		0.0	8.9	8
Room344		0.0	13.8	11
Room345		0.0	12.7	6
Room346		0.0	9.2	9
Room347		0.0	2.9	1
Room348		0.0	713.1	28
Room349		0.0	1.8	1
Room350		0.0	1.8	1
Room351		1.8	873.9	353
Room353		0.0	1.8	1
Room354		0.0	2.3	1
Room355		0.0	1.9	1
Room356		0.0	7.8	9
Room357		0.0	12.3	10
Room358		0.0	12.3	11
Room359		0.0	7.1	6
Room361		0.0	8.0	7
Room362		5.6	279.1	14
Room367		0.0	0.0	0
Room368		0.0	2.5	1
Room369		0.0	2.9	1
Room370		0.0	0.0	0

Room371	0.0	2.7	1
Room3371	0.0	0.0	0
Room372	2.7	277.8	14
Room373	0.0	7.0	8
Room374	0.0	63.1	8
Room375	0.0	216.9	29
Room376	0.0	35.7	61
Room377	0.0	2.7	1
Room378	0.0	197.3	8
Room379	0.0	194.8	4
Room380	0.0	7.7	4
Room381	0.0	2.0	1
Room382	0.0	178.1	5
Room384	0.0	8.7	10
Room385	0.0	9.3	8
Room386	0.0	34.2	2
Room387	0.0	10.4	6
Room388	0.0	489.8	272
Room337	0.0	726.5	1082
Room389	0.0	799.5	757

APPENDIX G – SPECIFICATIONS

SECTION 283100 - FIRE ALARM SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and DIVISION 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. Furnish all labor, materials, and equipment for a fully operational fire alarm system in full compliance with the applicable NFPA standards and all other codes, regulations and laws applicable to the work, and in full compliance with the intent of the plans and specifications, including all work inferable from same.

B. Section includes:

1. Fire alarm control unit (FACU).
2. Remote notification appliance circuit (NAC) power supply (NAC panel).
3. Initiating devices.
4. Notification appliances.
5. Input and output modules.
6. System accessories.
7. Wiring and connections.
8. Raceway.
9. Supervising station monitoring.
10. Remote annunciator.
11. Surge protective devices.
12. System programming.
13. System testing.

C. Pay for all necessary construction permits related to the fire alarm system.

1.03 REFERENCES:

A. Applicable Codes and Standards (latest edition or as adopted by local jurisdiction):

1. 2015 MBC (Minnesota Building Code) with State and local amendments.
2. 2015 MFC (Minnesota Fire Code) with State and local amendments.
3. Local Codes including local policies, interpretation, and standards.
4. Americans with Disabilities Act (ADA).
5. FM Global (FM):
    a. FM Approvals - Approval Guide.
6. NFPA (National Fire Protection Association) - Latest edition or as adopted by local jurisdiction:
    a. NFPA 13 - Standard for the Installation of Sprinkler Systems.
    b. NFPA 70 - National Electrical Code (NEC).
    c. NFPA 72 - National Fire Alarm and Signaling Code (2016 for submittal requirements only).
7. Underwriters Laboratories (UL): Comply with provisions of UL safety standards pertaining to fire alarm systems; provide products and components which are UL-listed and labeled.
    a. Fire Protection equipment directory.
8. International Code Council (ICC)
    a. International Mechanical Code (IMC) with state and local amendments.
9. American Society of Mechanical Engineers (ASME)

a. ASME A17-1 Safety Code for Elevator and Escalators.

10. American Petroleum Institute (API)
    a. API RP 2001 – Fire Protection in Refineries

1.04 DEFINITIONS:

A. References to the Fire Protection Engineer in this SECTION shall mean:
B. References to the Fire Alarm Technician in this SECTION shall mean:
   1. A qualified fire protection technician certified at Level IV with the National Institute for Certification in Engineering Technologies (NICET) in Fire Alarm Systems.
C. References to the Fire Alarm Installer in this SECTION shall mean:
   1. A qualified fire protection technician certified at Level II with the National Institute for Certification in Engineering Technologies (NICET) in Fire Alarm Systems.
D. References to the Manufacturer's Authorized Representative in this SECTION shall mean:
   1. A qualified fire protection technician certified at Level III with the National Institute for Certification in Engineering Technologies (NICET) in Fire Alarm Systems, trained and authorized by the fire alarm equipment manufacturer on the installation, programming and testing of their equipment.
E. References to the Fire Alarm Control Unit in this section shall mean:
   1. A control unit performing the combined functions of both a fire alarm control unit and releasing service fire alarm control unit.

1.05 PERFORMANCE REQUIREMENTS:

A. The system shall be a complete, supervised, noncoded, analog/addressable, fire alarm system with horn/strobe occupant notification conforming to NFPA 72.
B. Provide fire alarm system suitable for type of occupancy as defined by the locally adopted building code and as approved by local authority having jurisdiction (AHJ).
C. Fire alarm system design shall be approved by Engineer and authorities having jurisdiction.

1.06 ACTION SUBMITTALS:

A. Shop Drawings: Prepare working plans, material cut sheets, and calculations for the complete fire alarm system in accordance with the documentation requirements of NFPA 72, 2016. Shop drawing submittals shall include, but not be limited to, the following:
   1. Employ the services of a Fire Alarm Technician to prepare, sign and certify the fire alarm system shop drawings and calculations for submittal.
   2. Drawings showing equipment/device locations, conduit sizes, logic diagrams, and point-to-point field wiring diagrams of the entire fire alarm system.
   3. Name of protected premises, owner, and occupant (where applicable), name of installer or contractor, location of protected premises, device legend and date of issue and any revisions.
   4. Battery calculations and voltage drop calculations.
   5. Interface of fire safety functions, and programming sequence of operations.
   6. Scaled floor plan drawings which include floor identification, point of compass, graphic scale, all walls and doors, point-to-point connections, circuit identification, all partitions extending to within 10 percent of the ceiling height (where applicable), room occupancy descriptions, fire alarm device/component locations, device settings or ratings (candela or wattage), locations of fire alarm primary power connection(s), locations of monitor/control interfaces to other systems, conduit routing, riser locations, type and number of fire alarm system components/devices identified to each circuit, type and quantity of conductors and conduit (if used) for each circuit, information regarding types

of construction to verify correct device location, location of all supply and return air diffusers (where automatic detection is used), details of ceiling height, and type of construction.

7. Shop drawing plans shall be drawn at a minimum scale of 1/8" = 1'-0".
8. Fire alarm riser diagrams which include the general arrangement of the system in building cross-section, number of risers, type, number and identification of circuits in each riser, and type and number of fire alarm system components/devices on each circuit, type and quantity of conductors and conduit (if used) for each circuit.
9. Provide fire stopping details for penetration through fire and smoke walls, barriers, and partitions. Include UL System numbers for each detail.
10. Control unit wiring diagrams for all control equipment (i.e., equipment listed as either a control unit or control unit accessory), power supplies, and battery chargers, and which also includes identification of the control equipment depicted, all field wiring terminals and terminal identification, all circuits connected to field wiring terminals and circuit identification, all indicators and manual controls including the full text of all labels, all field connections to supervising station signaling equipment, and fire safety control interfaces.
11. Information on conductors, terminations, and raceway to be used.
12. The shop drawings, including resubmittals, shall be submitted as a complete submittal package including, but not limited to, shop drawings/working plans, annotated cut sheets, and calculations. Partial submittals and submittals not fully complying with the requirements and recommended practices of NFPA 72 and this specification will be returned disapproved without review.
13. Material cut sheets shall be annotated to indicate the exact model, configuration, finishes, and other options that will be provided. Submit device power requirements. Cut sheets with multiple models, configurations and options that are not annotated will not be accepted. Outdated or poorly reproduced cut sheets will not be accepted.
14. Shop drawings shall be wholly generated and coordinated by the Fire Alarm Contractor. Partial or complete reproductions of the Engineer's drawings will not be accepted.
15. Shop drawings resubmittals shall be accompanied by a response letter addressing each comment in the Engineer's review of the shop drawings. Changes to the working plans shall be clouded to indicate the revised area and annotated to indicate the revision number and revision date.
16. Submit shop drawings, cut sheets, and calculations to the City of Minneapolis for review.

B. Submit a fire alarm system acceptance test procedure detailing the procedures to be followed for testing of the control equipment, remote monitoring, wiring systems, devices, accessories and notification appliances. Identify each piece of control equipment, device, appliance and circuit to be tested. Describe the test procedure for each item. Identify all equipment and personnel required for the testing.
   1. Test procedures are to be written to minimally disrupt facility operations (minimize activation of evacuation notification appliances, AHU shutdown, etc.) in support of testing requirements.

C. The Fire Alarm Contractor assumes sole responsibility for purchasing equipment or beginning installation before all approvals are obtained. No change orders will be awarded due to purchasing equipment or beginning installation prior to obtaining approvals.

1.07 INFORMATION SUBMITTALS

A. Contractor qualifications: The Fire Alarm Contractor shall be a qualified Fire Alarm Contractor, licensed and regularly engaged in the installation of fire alarm systems of similar

size and complexity. Submit license information and proof of successful completion of three projects of similar size and scope.

B. Designer qualifications:
   1. Submit qualifications of Fire Alarm Technician.
   2. Submit qualifications of Fire Alarm Installer.
   3. Submit qualifications of Manufacturer's Authorized Representative.

1.08 CLOSEOUT SUBMITTALS

A. Provide documentation in accordance with the documentation requirements of NFPA 72. Include as-built drawings, material cut sheets, calculations, and a copy of the site-specific software.
B. Submit all field test data per NFPA 72 and specifications.
   1. Submit NFPA 72 System Record of Completion and applicable Supplementary Records of Completion.
   2. Submit NFPA 72 System Record of Inspection and Testing and applicable Supplementary Records of Inspection and Testing.
C. Submit complete warranty information.

1.09 QUALITY ASSURANCE

A. Design and install fire alarm systems in accordance with the applicable NFPA standards, locally adopted building code, fire code and other local policies, interpretations and standards as listed in Part 1 References.
   1. If there is a conflict between the reference codes or standards and this SECTION, it is the Contractor's responsibility to notify the Engineer in writing. The most stringent requirement, as determined by the Engineer shall apply.
B. Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the appendices of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears.
C. Installer Qualifications:
   1. The Fire Alarm Contractor for the fire alarm installation shall be a qualified Fire Alarm Contractor, regularly engaged in the installation of fire alarm systems for a minimum of 5 years with required state and local licenses.
   2. The Fire Alarm Contractor's responsibilities include designing, fabricating, installing and programming the fire alarm system and providing professional design and engineering services needed to assume engineering responsibility.
      a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports shall be by a qualified Fire Alarm Technician.
      b. The Contractor shall maintain a qualified Fire Alarm Installer on-site during installation.
      c. The Contractor shall maintain a qualified Fire Alarm Technician on-site during testing and commissioning.
D. Manufacturer's Representative: Provide the services of a certified representative or technician trained by the manufacturer of the system, experienced in the installation and operation of the type of system provided. The technician shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system. The technician shall provide the required instruction to the Owner's personnel in the system operation, maintenance and programming.

PART 2 - PRODUCTS

2.01 GENERAL:

A. All equipment shall be Listed by Underwriter's Laboratories and included in the latest edition of the U.L. Fire Protection Equipment directory or Approved by FM Global and listed in the FM Approvals - Approval Guide.

B. All materials shall be approved by FM Global and listed in the FM Approvals - Approval Guide.

C. All components provided shall be listed for use with the selected system.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 FIRE ALARM AND DETECTION SYSTEMS:

A. General: Provide a complete analog/addressable fire alarm system and products of types, sizes, and capacities indicated, which comply with manufacturer's standard design, materials, components; constructed in accordance with published product information and as required for complete installation. Provide fire alarm and detection systems for applications indicated.

B. The fire alarm system shall provide operation of detection devices, alarm notification, local annunciation, auxiliary control functions and monitoring and releasing of fire suppression systems.

C. System Wiring and Supervision:
   1. Provide Class B notification appliance circuits (NAC).
   2. Provide Class B signaling line circuit (SLC).

D. Power Supplies: Provide system for operation on 120Vac power supply from the building electrical system. Fire alarm systems shall be power limited, operating on 24 VDC.
   1. Provide battery back-up as secondary power supply. Provide back-up battery and battery charger each with 20% spare capacity for future use. Design battery back-up to take over supply to system instantaneously. Provide battery with adequate capacity to be capable of operation of system for[the greater of the following]:
      a. 24 hours under normal supervisory (nonalarm) conditions and then for 5 minutes under alarm conditions.
      b. 60 minutes under full connected load.
   2. Battery capacity requirement shall be met regardless of whether an emergency power generator is provided as part of the project.
   3. The battery charger shall completely recharge batteries within 48 hours.

E. Spare circuit capacity:
   1. Do not load notification appliance circuits (horn/strobe) beyond 80 percent of their current and voltage capacity.
   2. Provide 2 spare notification appliance circuits.
   3. Provide 25 spare addresses.

F. Required System Features:
   1. Refer to the functional matrix on the drawings.
   2. Fan shut down relays.
   3. Magnetic door release 24Vdc.
   4. Start-up of smoke exhaust fans.
   5. Alarm initiation from sprinkler flow switches.
   6. Alarm initiation from smoke detectors, heat detectors, and manual pull stations.
   7. Supervisory indications from sprinkler valve tamper switches and supervisory switches.
   8. Supervisory indication from duct smoke detectors.

9. Provide detection and release for the preaction system(s).
10. Equip and wire system so that in addition to energizing fire alarm audible notification appliances, the system will also activate the following:
    a. Exterior flashing red lights.
    b. Interior flashing strobe lights.
11. Occupant notification with audible and visual occupant notification appliances.
12. Audible and visual notification at sprinkler system fire department connection.
13. Provide fan control switches at console in ME Room for control of building HVAC units, and smoke exhaust fan controls.

G. Wiring System Materials: .
1. Provide wire and cable in accordance with requirements of NFPA 70 and the FACU manufacturer.
2. Minimum conductor size shall be 16 AWG.
3. Provide shielded conductors for SLC's where recommended by the manufacturer or otherwise required due to other building systems or construction. Communications issue resulting from interference will be considered a deficient installation to be corrected at no additional cost.
4. Provide shielded conductors for SLC's.
5. Conductors shall be solid except those used in circuits requiring shielding.
6. Provide conductors which are listed and approved for fire alarm usage.
7. Conduit shall be electrical metallic tubing (EMT) or rigid metal conduit (RMC).
8. Minimum conduit size shall be ¾ inch.
9. All conduit shall be factory finished red. Conduit that cannot be concealed and is exposed in finished areas shall be painted to match the surrounding finishes.
10. Fittings and seals shall be metallic suitable for use with the conduit type.
11. Terminal Boxes and Floor Terminal Panels: Provide fire alarm junction boxes and floor terminal panels that are painted with red enamel. Label boxes as required by the AHJ and specifications. Provide each box with suitable number of terminals and of proper size to hold wiring both for immediate floor and floors above.
12. Wiring connections shall be made at screw terminals at individual devices or using terminal strips. Wire nuts, spring loaded connectors, and similar devices are not permitted.

H. Fire Alarm Control Equipment (FACU and NAC panels):
1. Provide FACU enclosures for housing devices and circuits necessary to perform required functions to service test points and to service trouble-signal points. Control panels shall comply with UL 864. Cabinet shall be lockable steel cabinet.
2. Provide notification appliance circuit (NAC) extender panels as required by Contractor's design. NAC panels shall be by the same manufacturer as the FACU.
3. Provide minimum 6 keys to Owner.
4. Design devices to be modular, plug-in.
5. Provide control panel for operation on 120Vac supply and for 24Vdc (power limited) system operation with integral battery standby power source.
6. Provide integral DACT to transmit signal to supervising station via two phone lines.
7. A fire alarm signal shall activate notification appliances throughout the building. Audible devices shall produce a three-pulse temporal pattern in accordance with NFPA 72. Visual devices shall operate in accordance with NFPA 72.
8. System shall be listed for releasing service. Coordinate with DIVISION 21 for a compatible solenoid that is cross-listed with the FACU.
9. Capable of alarm verification and positive alarm sequence.

10. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.
    a. Mounting: Surface.

I. Initiating Devices
1. All alarm initiating devices shall be assigned a unique address which is not assigned by their position in the circuit. The system shall allow the future addition of additional addressable initiating devices by tee-tapping into any point in the circuit.
2. Addressable initiating devices shall prohibit the insertion of non-addressable devices.
3. Addressable Manual Fire Alarm Pull Stations: Provide manufacturer's standard construction, red enclosure, manual fire alarm pull station with the following features.
    a. Surface mounted in unfinished areas and outdoors.
    b. Outdoor units and units located in wet indoor locations shall be weatherproof.
    c. Semi-flush mounted in finished areas.
    d. Addressable.
    e. Non-break glass operation.
    f. Annunciator contacts; (N.O.).
    g. Double action.
    h. Key operated to reset.
        (1) Reset key must be the same as the FACU key.
    i. Unit includes integral sounder.
4. Addressable Automatic Heat Detectors shall comply with UL 521:
    a. Addressable Fixed temperature, 24Vdc, spot type, restorable, 175ºF.
5. Automatic Smoke Detectors: Provide manufacturer's standard construction automatic smoke detectors of the following types.
    a. Addressable Photoelectric, 24Vdc, spot types, restorable, with pulsed infrared LED light source for operation on voltage indicated. Design detector for mounting on interchangeable type base. Nominal sensitivity shall be 2.5%-3.5% per foot obscuration when tested per UL 268. Self-restoring detector which does not require resetting. Provide flashing LED indicator for normal operation which changes to steady on alarm condition. Detector shall comply with UL 268.
    b. Addressable In-duct photoelectric type, 24Vdc, with integral and remote test-reset-off keyed switch and remote LED alarm light. Provide sampling tubes of design and dimension as recommended by the manufacturer for the specific duct size where it is applied. Detector shall comply with UL 268A. Provide integral fan shutdown relay. A trouble signal shall occur when the cover is removed.
    c. Projected beam type, 24Vdc, with field adjustable sensitivity. Provide with contacts for trouble and alarm conditions. Minimum detection range shall be as required to operate correctly with the detector locations shown on the drawings. Detector shall comply with UL 268.

J. Notification Appliances
1. Horns: Provide manufacturer's standard construction, 24Vdc, fire alarm horn with following features.
    a. Coded
    b. Surface mounted (with grille) in unfinished areas and outdoors. (Outdoor units shall be weatherproof).
    c. Semi-flush mounted.
    d. Flush mounted.
    e. White base lettered "FIRE" in 1-inch high, red letters.
    f. Electronic Tone. Electromechanical designs are not acceptable.

2. Visual Alarm Strobes: Strobe shall comply with UL 1971 except as noted otherwise. Provide manufacturer's standard construction alarm lights with the following features.
   a. Clear lens, white base lettered "FIRE" in 1-inch high, red letters.
   b. 24Vdc Xenon or LED strobe.
   c. Flash intensity, rate and duration shall comply with NFPA 72.

K. System Accessories
1. Test Chart Instructions: Provide fire alarm system test instructions chart mounted in a polycarbonate enclosed frame assembly on control cabinet hinged door.
2. Addressable Input Modules (AIMs):
   a. Same manufacture as the FACU.
   b. Input modules shall include an LED that changes states to indicate an alarm or supervisory condition. Module LED's shall be visible without removal of covers.
   c. Dual monitor modules and monitor modules with multiple addresses and a single LED indicator are not acceptable. Multi-address modules with LED indicators for each input and address are acceptable when mounted in cabinet with all LED's visible without removing cover.
3. Addressable Output Modules (AOMs):
   a. Same manufacture as the FACU.
   b. Output modules shall include an LED that changes states to indicate an activated condition. Module LED's shall be visible without removal of covers.
   c. Modules and monitor modules with multiple addresses and a single LED indicator are not acceptable. Multi-address modules with LED indicators for each output and address are acceptable when mounted in cabinet with all LED's visible without removing cover.
4. SLC Loop Isolation Modules:
   a. Manufacturer's standard product.
   b. Isolates loop when short circuits are detected.
   c. Provide in electrical box or enclosure.
5. Addressable Releasing Modules:
   a. Same manufacture as the FACU.
   b. Releasing modules shall include an LED that changes states to indicate an activated condition. Module LED's shall be visible without removal of covers.
   c. Releasing modules shall be compatible and listed for use with the fire suppression system solenoid or releasing device and system released.
6. Maintenance Disconnect:
   a. Provide key operated disconnect switch in circuit to the preaction solenoid. Operation of the key switch shall create a supervisory condition.
7. Surge Protective Devices:
   a. Transient Voltage Surge Suppressors (TVSS) for use on AC power to FACU and NACS.
      (1) Series Connected
      (2) UL 1449 4th Edition, UL 1283
   b. For use on NAC, SLC and dialer circuits
      (1) UL 497A/497B
8. Magnetic Door Holders: Holding force of 15 pounds (minimum) at 85% rated voltage and 50 pounds (maximum) at 110% voltage. Provide manufacturer's standard construction magnetic door holder with the following features.
   a. 24Vac
   b. Single door.

c. Surface mounted.
d. The magnetic door holders are not powered when the fire alarm control is being powered by batteries.

9. Remote Annunciator: Provide (manufacturer's standard construction) annunciator that indicates the type of alarm (manual pull station, low pressure, heat detector, smoke detector, water flow, valve tamper and trouble) and of the following type.
   a. Graphic back lighted annunciator with building floor plan or map. Plan shall clearly indicate zone number and zone boundaries. Provide LED for each type of alarm in each zone. Type of alarm: manual pull station, low pressure, heat detector, smoke detector, water flow, valve tamper trouble. Ventilation controls, emergency power status, emergency power controls (ON/OFF), applicable fire pump status, and applicable fire pump trouble. Minimum zone size shall be three square inches. Provide "You Are Here" designation. Orient graphic plan to be in agreement with "You Are Here" in regard to left and right. Red LED for alarm, amber LED for trouble, and green LED for power on.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine areas and conditions under which fire alarm systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 DELIVERY, STORAGE, AND HANDLING:

A. Handle fire alarm equipment carefully to prevent damage, breaking, and scoring. Do not install damaged equipment or components; replace with new.
B. Store fire alarm equipment in a clean, dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

3.03 GENERAL:

A. Furnish and install a complete and fully operational fire alarm system as described herein and as shown on the drawings.
B. Equipment shall be installed and wired in accordance with this specification, project drawings and approved shop drawings.
C. Provide all new wiring, conduit, junction boxes and outlet boxes required for the system, including connections to initiating, indicating and control devices furnished by others. Connections to other systems shall be done by the suppliers of those systems.
D. The Fire Alarm Installer shall oversee the fire alarm installation and shall be on site during all fire alarm system work.

3.04 INSTALLATION OF BASIC WIRING SYSTEM MATERIALS:

A. Install all wiring in conduit or raceways.
   1. Cables may be installed without conduit in areas not subject to mechanical damage and where not otherwise required to be installed in conduit by the NEC. Wiring shall be installed above suspended ceilings or above the bottom of the structure in areas with exposed structure.
      a. Support wiring in strict accordance with the NEC. Wiring shall be installed neatly, at right angles to the building structure. Support wiring from the building structure or from independent support wires. Wiring may not be supported by the ceiling support wires or ceiling grid when installed above a suspended ceiling.

b. Spacing of wiring supports shall not exceed those allowed by NFPA 70 for NM cable or the manufacturer's recommended support spacing, whichever is less.

2. Reuse of the existing conduit is acceptable but is at the risk of the fire alarm contractor. Label and paint any reused conduit according to new requirements. All conductors must be new.

B. Support conduit in accordance with the NEC.
   1. Tension only hangers are not permitted (for example, batwings).
   2. Flexible conduit is permitted only where connecting to devices and appliances located on fire suppression equipment such as flow and tampers switches, solenoids, etc.; devices and appliances located in removable ceiling tiles; and where specifically indicated on the drawings.

C. Fire alarm cabling installed in spaces above ceilings or below raised floors must be plenum rated.

D. Where possible, install wires and cables without splices. Make connections and splices at terminal strips in terminal boxes, cabinets or at equipment terminals. Wire nuts are prohibited.

E. Ground one end of shielding on circuits with shielded conductors.

F. Raceway shall only enter the bottom of fire equipment panels.

G. Firestop all penetrations through smoke and fire barriers.

3.05 INSTALLATION OF FIRE ALARM SYSTEMS:

A. Install fire alarm system as indicated, in accordance with equipment manufacturer's written instructions and complying with applicable portions of the NEC.

B. Manual Pull Stations:
   1. Install fire alarm manual pull stations 48 inches above finished floor (top of device).

C. Smoke Detectors:
   1. Smoke detectors shall not be installed until just prior to system testing when the site is free from abnormal dust and dirty conditions. If it is necessary to install smoke detectors prior to this time, they shall be protected from entry of dust and dirt with manufacturer supplied covers until the site is clean and free from construction dust and debris.
   2. Locate and space smoke detectors in accordance with NFPA 72.
   3. The FACU shall be programmed to release the preaction sprinkler system on activation of any two smoke detectors in the preaction sprinkler system zone.
      a. Not less than two smoke detectors shall be installed in each room or area where cross zoned smoke detection is required.
   4. Spot type area smoke detectors shall not be installed in direct air flow and shall not be installed closer than 3 ft. from an air supply diffuser.
   5. Install ceiling mounted smoke detectors not less than 4 inches from a side wall to the near edge. Install detectors located on the wall at least 4 inches, but not more than 12 inches, below the ceiling.

D. Addressable Modules
   1. Install modules in backbox or manufacturer provided enclosure with LED visible without cover removal.

E. Duct Smoke Detectors:
   1. Duct mounted smoke detectors shall be installed in the ductwork between six and ten duct equivalent diameters of straight, uninterrupted ductwork from a bend or opening. Coordinate installation with Contractor.

F. Projected Beam Smoke Detectors:
   1. Install projected beam smoke detectors in accordance with NFPA 72 and the manufacturer's published recommendations.

a. Located transmitters and reflectors as indicated on the plans to the extent possible. Field coordinate exact locations.
b. Calibrate and align detectors for proper operation.
c. Provide power and monitoring of trouble and alarm conditions.

G. Alarm Notification Appliances:
1. Install notification appliances as indicated on the drawings, spaced in accordance with NFPA 72.
2. Install wall mounted audible alarms not less than 90 inches above finished floor nor less than 6 inches below ceiling.
3. Install wall mounted visual alarm strobes with the entire lens between 80 and 96 inches above finished floor.
4. Mount appliances at uniform heights.
5. Fire alarm notification appliances shall be installed flush mounted or semi-flush mounted. Appliances may be surface mounted in unfinished areas. Surface installation shall be with a factory provided back box. Flush and semi-flush installation shall mount to standard electrical hardware requiring no additional trim plate or adapter. The aesthetic appearance shall not have any mounting holes or screw heads visible when the installation is completed.
6. Outdoor notification appliances shall be NEMA 4X, IP56 rated and shall be installed with suitable weatherproof back box, seals and gaskets.
7. Install audible notification appliance as required to meet the intelligibility requirements specified.

H. Wiring: Wiring of fire alarm system is work of this Section but is not specifically detailed on drawings.
1. Complete wiring in accordance with the NEC and the manufacturer's requirements. Consistently color code wiring throughout the system and install per manufacturer's point-to-point wiring diagram. Determine exact number of wires for each fire area zone from number and types of devices installed. Connect each device with sufficient wiring to complete its intended operation.
2. Size all raceway per the NEC.
3. All fire alarm circuits shall be supervised. Provide end-of-line resistors where required to supervise conventional device circuits, power circuits, releasing circuits, etc. This includes the wiring between fire alarm devices and auxiliary devices such as air handling units.
4. Install devices and appliances using power supplies, circuits and wire sizes to alleviate voltage drops which would make devices operate below the voltage limits for which they are designed. Calculate voltage drops taking into account the maximum ambient temperatures anticipated before wire and equipment is installed.
a. Perform voltage drop calculations for notification appliance circuits using a starting voltage of 20.4 VDC. Provide a minimum of 16 VDC at all notification appliances.
5. Boxes for magnetic door holders shall be securely mounted to withstand a minimum of 80 pounds of pulling force.
6. Provide SLC loop isolators as required to limit the number of devices lost due to a single fault to not more than a single zone or floor or as indicated on the drawings.
7. Program the system to function properly and according to the operational matrix indicated on the drawings.
8. Where allowed by the AHJ, program all smoke detectors for 30 second alarm verification.
9. Locate addressable devices only in conditioned spaces.

10. Ground surge protection devices in accordance with the manufacturer's recommendations.
11. Coordinate with Division 21 regarding location of heat detectors with respect to sprinklers to comply with NFPA 13, NFPA 72 and ASME A17-1.
12. Coordinate with Division 21 for location and quantity of fire sprinkler and fire suppression system monitoring. Each sprinkler supervisory switch must have a separate address.
13. Coordinate with Division 23 for location and quantity of air handling units requiring duct smoke detectors. Provide, install and wire detector for shutdown of air handling equipment.
14. Externally label all panels (FACU, NAC-1, etc.) to match fire alarm as-built plans.
15. Identify all conductors with permanent markings at each device and panel.

I. Provide all modules and install all wiring and make final connections to equipment interfaced, controlled, or monitored by the fire alarm system. Provide modules and supervised power for interface with mechanical air handling units and dampers for automatic control of HVAC systems, fire suppression (releasing) control panels, elevators, and other systems as indicated on the drawings.
   1. Install modules a maximum of 3 feet from the controlled or monitored circuit or device. All relay contacts shall be Form C to permit interface with open and closed circuit systems. Install all relays in properly sized equipment enclosures.
   2. Wiring between the fire alarm module and elevator system is by Division 14.
   3. 120 VAC power for shunt trip control and connections between fire alarm equipment and the shunt trip breaker is by Division 26.

3.06 INSTALLATION OF BASIC IDENTIFICATION:

A. All junction, terminal and pulling box covers shall be factory finished or painted red and shall be identified in a permanent and legible manner to indicate the zone and circuit that it contains.
   1. Hand lettering and adhesive backed stick-on lettering such as Dymo or Kroy tape are not acceptable.

B. All detection and terminal devices shall be identified in a permanent and legible manner to indicate the device zone and address keyed to the posted operations and maintenance instructions. Hand lettering and adhesive backed stick-on lettering such as Dymo or Kroy tape are not acceptable. Use labels such as:
   1. SD## (smoke detector)
   2. HD## (heat detector)
   3. DSD## (duct smoke detector)
   4. MM## (monitor module)
   5. CM## (control module)
   6. RM## (relay module)

C. All notification appliances shall be identified in a permanent and legible manner to indicate the device number keyed to the posted operations and maintenance instructions. Hand lettering and adhesive backed stick-on lettering such as Dymo or Kroy tape are not acceptable. Use labels such as:
   1. HS## (horn/strobe)
   2. H## (horn)
   3. S# (strobe)

D. All system controls and equipment including remote power supplies and amplifiers shall be permanently labeled with red plastic labels with engraved white letters.

E. All wiring shall be labeled.

1. SLC wiring shall be labeled using the following format:
   a. Input (from previous device on SLC): "SLC from SD##" or "SLC from FACU"
   b. Output (to next device on SLC): "SLC to SD##" or "SLC to FACU"
2. NAC wiring shall be labeled using the following format:
   a. Input (from previous device on NAC): "NAC from HS##", "NAC from RPS#"
   b. Output (to next device on NAC): "NAC to HS##" or "NAC to RPS1"

F. Label each fire alarm control unit, power supply and other equipment provided with 120VAC power with the panel location, number and circuit number powering the equipment.

G. Label batteries with the date of installation.

3.07 FIELD QUALITY CONTROL AND TESTING:

A. Connection and Supervision: Make connections to panel and perform all testing under the supervision of the Manufacturer's Authorized Representative.

B. Protect fire alarm devices during construction. Replace any unprotected smoke detectors.

C. All wiring shall test free from open conductors, shorts and/or crosses between conductors, and grounded conductors.

3.08 TESTING:

A. The Manufacturer's Authorized Representative shall perform all testing.

B. Participate in pre-testing between sub-contractors for any and all building systems with interface with the building fire alarm system.

C. Provide all materials, equipment and labor for testing. This includes specialized equipment such as manometers and intelligibility meters.

D. System Test and Approval:
   1. Prior to final acceptance of system, the Manufacturer's Authorized Representative shall test the system per NFPA 72 requirements. Test each manual, automatic, sensing, detecting, and alarm device.
      a. All resettable smoke detection devices shall be tested with "canned smoke."
      b. Duct smoke detector testing shall include verifying pressure differential with a manometer or as recommended by the manufacturer.
      c. All water flow devices shall be tested with actual water flow.
      d. All pressure switches shall be tested by actual pressure conditions.
      e. All resettable thermal sensors shall be tested with heat, and non-resettable thermal sensors shall be tested by short-circuiting each end-of-line device's contacts.
      f. Test all HVAC, elevator, door, exhaust fan, and annunciator interfaces for proper operation.
      g. Correct any deficiencies prior to final acceptance testing. Submit written notification to the Engineer that the system has been pre-tested all deficiencies corrected.
   2. In presence of the Authority Having Jurisdiction, and Engineer's representative, the Manufacturer's Authorized Representative shall perform acceptance testing in accordance with NFPA 72. Test each manual, automatic, sensing, detecting, and alarm device in accordance with NFPA 72.
   3. After being signed by the Authority Having Jurisdiction, submit a copy of test results to the Engineer, Owner, and Owner's insurance carrier, and the Authority Having Jurisdiction. Provide a copy of the inspection record at the fire alarm control panel.
   4. The Manufacturer's Authorized Representative shall provide 8 hours of on-site training of the Owner's personnel on procedures related to start-up, shutdown, operation, troubleshooting, servicing, adjusting and preventative maintenance for the system.

Provide Owner with 10 days advance notice of training. Coordinate training with Division 14, Division 21, Division 23, and Division 26.

3.09 MAINTENANCE

A. The equipment supplier shall maintain a local service organization which is available to perform testing, inspection, repair and maintenance service on the system.

3.10 SPARE PARTS:

A. Provide a list of manufacturer suggest spare parts and accessories for maintenance of the system. Including suggested quantities and unit prices.

B. Provide spare parts for the fire alarm system.
   1. General: All spare parts shall be directly interchangeable with the corresponding components of the installed systems.
   2. All spare parts shall be suitably packaged and identified by nameplate, stamping, or tagging.
   3. The following spare parts and accessories shall be included:
      a. Provide 5 spare smoke detector[s].
      b. Provide 5 spare heat detector[s].
   4. Furnish a list of all other spare parts and accessories which the manufacturer recommends to be stocked for maintenance of the system.

C. Keys and locks for all equipment shall be identical where possible. Not less than 6 keys for each type required shall be provided. Keys shall be identified by an appropriate number stamped on the key or on a metal tag attached thereto. If required, a key numbering chart shall be provided in each operations and maintenance manual furnished.

END OF SECTION 283100

SECTION 211313 - AUTOMATIC SPRINKLER SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

1.02 SUMMARY:

A. Furnish all labor, materials, and equipment for fully operating fire protection systems in full compliance with the applicable NFPA standards and all other codes, regulations and laws applicable to the work, and in full compliance with the intent of the plans and specifications, including all work inferable from same.

B. Section Includes:

1. Connect to flanged connection on the water service piping inside the building as provided under DIVISION 22.
2. Wet sprinkler systems throughout heated areas of the building.
3. Dry pipe sprinkler systems in unheated areas of the building and where indicated on the drawings.
4. Pre-action sprinkler systems where indicated on the drawings.
5. Pipes, fittings, couplings and specialties.
6. Fire-protection valves.
7. Fire-department connections.
8. Sprinklers.
9. Monitoring and Alarm devices.
10. Pressure gauges.
11. Inspector’s test valves and piping.
12. Drain valves and piping.
13. System testing.

C. Pay for all necessary construction permits related to the fire sprinkler system.

1.03 REFERENCES:

A. Applicable Codes and Standards (latest edition or as adopted by local jurisdiction):

1. 2015 MBC (Minnesota Building Code) with State and local amendments.
2. 2015 MFC (Minnesota Fire Code) with State and local amendments.
3. Local Codes including local policies, interpretation, and standards.
4. American Welding Society (AWS).
    a. AWS B2.1 - Specification for Welding Procedure and Performance Qualification.
    b. AWS D10.12 - Guide for Welding Mild Steel Pipe.
5. ASME International (ASME):
    a. ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications".
    b. ASME B1.20.1 - Pipe Threads, General Purpose (Inch).
    c. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.
    d. ASME B16.3 - Malleable Iron Threaded Fittings.
    e. ASME B16.4 - Gray Iron Threaded Fittings.
    f. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Inch Standard.
    g. ASME B16.9 - Factory-Made Wrought Buttwelding Fittings.
    h. ASME B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges.

i. ASME B18.2.1 - Square and Hex Bolts and Screws, Inch Series.
j. ASME B31.9 - Building Services Piping.

6. ASTM International (ASTM).
   a. ASTM A47 - Specification for Ferritic Malleable Iron Castings.
   b. ASTM A53 - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. ASTM A135 - Specification for Electric-Resistance-Welded Steel Pipe.
   d. ASTM A234 - Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
   e. ASTM A536 - Specification for Ductile Iron Castings.
   f. ASTM A674 - Standard Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids.
   g. ASTM A795 - Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use.
   h. ASTM A865 - Specification for Threaded Couplings, Steel, Black or Zinc-Coated (Galvanized) Welded or Seamless, for Use in Steel Pipe Joints.
7. FM Global (FM):
   a. FM Approvals - Approval Guide.
8. NFPA (National Fire Protection Association) - Latest edition or as adopted by local jurisdiction:
   a. NFPA 13 – Standard for the Installation of Sprinkler Systems.
   b. NFPA 14 – Standard for the Installation of Standpipe and Hose Systems.
   c. NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
   d. NFPA 70 - National Electrical Code.
   e. NFPA 72 – National Fire Alarm and Signaling Code.
   f. NFPA 1963 – Standard for Fire Hose Connections (2014).
9. Underwriters Laboratories Inc. (UL):
   a. Fire Protection Equipment Directory.

1.04 PERFORMANCE REQUIREMENTS:

A. Sprinkler system design shall be approved by Engineer and Authorities Having Jurisdiction (AHJ).
   1. See plans for sprinkler system design criteria.

1.05 ACTION SUBMITTALS:

A. Submit Shop Drawings: Include working plans, product data sheets and hydraulic calculations. Prepare working plans, product data sheets, and hydraulic calculations for the complete sprinkler system in accordance with NFPA 13.
   1. Employ the services of a Fire Protection Technician certified at Level III in Water Based System Layout through the National Institute of Certification in Engineering Technologies (NICET). The Fire Protection Technician shall prepare the sprinkler system shop drawings and hydraulic calculations for submittal.
   2. Employ the services of a Fire Protection Technician to prepare, sign and certify the sprinkler system shop drawings and hydraulic calculations for submittal.
   3. The shop drawings, including resubmittals, shall be submitted as a complete submittal package including, but not limited to, shop drawings/working plans, annotated cut sheets,

and hydraulic calculations. Partial submittals and submittals not fully complying with the requirements and recommended practices of NFPA 13 and this SECTION will be returned disapproved without review.

4. Shop drawing plans shall be drawn at a minimum scale of 1/8" = 1'-0".
5. Product data sheets shall be included for all materials used. Product data sheets shall be annotated to indicate the exact model, size, finishes, and other options that will be provided. Data sheets with multiple models, options and sizes that are not annotated will not be accepted. Outdated or poorly reproduced cut sheets will not be accepted.
6. Provide fire stopping details, with UL system numbers, for penetration through fire and smoke walls, barriers, and partitions.
7. Coordinate with other Contractors to provide data sheets and details for items that may not be included in the Fire Protection Contractor's contract but are necessary for review of the shop drawings. This includes water service piping into the building, backflow preventers located outside the building, new underground piping, etc.
8. Shop drawings shall be wholly generated and coordinated by the Fire Protection Contractor. Partial or complete reproductions of the Engineer's drawings will not be accepted.
9. Shop drawing resubmittals shall be accompanied by a response letter addressing each comment in the Engineer's review of the shop drawings. Changes to the working plans shall be clouded to indicate the revised area and annotated to indicate the revision number and revision date.
10. Submit shop drawings and hydraulic calculations to the City of Minneapolis for review.

B. The Fire Protection Contractor assumes sole responsibility for purchasing equipment or beginning installation before all approvals are obtained. No change orders will be awarded due to purchasing equipment or beginning installation prior to obtaining approvals.

1.06 INFORMATION SUBMITTALS:

A. Contractor qualifications: The Fire Protection Contractor shall be a qualified Fire Protection Contractor, licensed and regularly engaged in the installation of automatic fire sprinkler systems of similar size and complexity.
   1. Submit Contractor qualifications and license information.
   2. Submit proof of successful completion of three projects of similar size and scope.

B. Designer qualifications:
   1. Submit qualifications of Fire Protection Technician.

C. Submit test certificates for flushing of underground prior to making connection to building sprinkler systems.

1.07 CLOSEOUT SUBMITTALS:

A. Submit Operation and Maintenance Data: Submit operations and maintenance manuals in accordance. In addition to items specified in DIVISION 01, provide as-built drawings, material cut sheets, hydraulic calculations and one copy of NFPA 25.
   1. Include operation and maintenance data for valves and specialties in the operations and maintenance manuals.

B. Submit completed Contractor's Material and Test Certificate for Aboveground Piping in accordance with NFPA 13.

C. Submit documentation of training.

D. Submit complete warranty information.

1.08 QUALITY ASSURANCE:

A. Sprinkler systems shall be designed and installed in accordance with the applicable NFPA standards, locally adopted building code, fire code and other local policies, interpretations and standards as listed in Part 1 References.
   1. If there is a conflict between the reference codes or standards and this SECTION, it is the Contractor's responsibility to notify the Engineer in writing. The most stringent requirement, as determined by the Engineer shall apply.

B. Compliance with referenced NFPA standards is mandatory. This includes advisory provisions listed in the annexes of such standards, as though the word "shall" had been substituted for the word "should" wherever it appears.

C. The Contractor's responsibilities include designing, fabricating, and installing the sprinkler systems and providing professional design and engineering services needed to assume engineering responsibility.

D. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.09 WARRANTY

A. Warrant all equipment and materials for a minimum of one-year from the date of substantial completion.

PART 2 - PRODUCTS

2.01 GENERAL:

A. Unless otherwise noted, all materials shall be:
   1. Listed by Underwriter's Laboratories and included in the latest edition of the U.L. Fire Protection Equipment directory or Approved by FM Global and listed in the FM Global Approval Guide.

B. All sprinkler system components shall be rated for 175 psig minimum working pressure.

2.02 STEEL PIPE AND FITTINGS:

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. Schedule 40, Galvanized and Black Steel Pipe: ASTM A53, ASTM A795. Pipe ends may be factory or field formed to match joining method.

C. Schedule 10, Galvanized and Black Steel Pipe: ASTM A135 or ASTM A795, Schedule 10 in NPS 5and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 12. Pipe ends may be factory or field formed to match joining method.

D. Galvanized and Uncoated, Steel Couplings: ASTM A865, threaded.

E. Galvanized and Uncoated, Cast-Iron Threaded Fittings: ASME B16.4, Class 125, 175 psig rated.

F. Galvanized and Uncoated, Malleable Iron Threaded Fittings: ASME B16.3, Class 150, 300 psigrated, standard pattern.

G. Malleable-Iron Unions: ASME B16.39.

H. Cast-Iron Flanges: ASME 16.1, Class 125, 200 psig rated.

I. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

J. Steel Welding Fittings: ASTM A234 and ASME B16.9.

K. Grooved-Couplings and Fittings:
   1. Factory Painted, Grooved-End Fittings for Steel Piping: ASTM A47, malleable-iron casting or ASTM A536, ductile-iron casting; with dimensions matching steel pipe.
   2. Factory Painted Grooved-End-Pipe Couplings for Steel Piping: AWWA C606, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.
   3. Gaskets for use on dry pipe and pre-action systems shall be equal to Victaulic 'Flush Seal' UL listed for dry-pipe service. Gaskets shall be lubricated in accordance with manufacturer's recommendations for dry pipe sprinkler system gaskets.
   4. Reducing couplings are not acceptable. Tapered reducing fittings shall be used.

L. Provide shop welded piping, fittings and flanges where welded connections are used.

M. Push on, plain end, "roust-a-bout" type and fittings using set screws are not acceptable.

N. Split flanges and flange adapters are not acceptable.

O. Install fittings manufactured with outlets the same size as the piping to be installed in the fittings. Bushings are not acceptable.

P. Threaded pipe couplings with continuous threads through the coupling are not acceptable.

Q. 1/2-inch extension couplings shall not be used at sprinkler connections.

2.03 PIPING JOINING MATERIALS:

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.
   1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.04 LISTED FIRE-PROTECTION VALVES:

A. Indicating Ball Valves:
   1. Valves NPS 1-1/2 and Smaller: Bronze body with threaded ends.
   2. Valves NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
   3. Valves NPS 3: Ductile-iron body with grooved ends.
   4. Required Options: Provide with visual indicating device and integral supervisory switch.

B. Bronze Check Valves:
   1. Pressure Rating: 175 psig minimum.
   2. Sizes: NPS 1-1/2 and smaller.
   3. Standard: MSS SP-80
   4. Type: Swing check with renewable disc and seat.
   5. Body Material: Bronze.
   6. End Connections: Threaded.

C. Iron Check Valves:
   1. Pressure Rating: 175 psig minimum.
   2. Type: Swing check with renewable disc and seat.
   3. Body Material: Cast iron or ductile iron.
   4. End Connections: Flanged or grooved.

D. Bronze OS&Y Gate Valves:

1. Pressure Rating: 175 psig.
2. Sizes: NPS 2 and smaller.
3. Body Material: Bronze.
4. End Connections: Threaded.

E. Iron OS&Y Gate Valves:
1. Pressure Rating: 250 psigminimum.
2. Type: Resilient wedge OS&Y gate valve.
3. Body Material: Cast or ductile iron. Fusion bonded epoxy coating inside and out.
4. Wedge material: EPDM encapsulated cast or ductile iron.
5. End Connections: Flanged or grooved.
6. Accessories: Pre-grooved stem for mounting tamper switch.

F. Indicating-Type Butterfly Valves:
1. Pressure Rating: 175 psig minimum.
2. Valve Type: Butterfly.
3. Body Material: Epoxy coated ductile iron.
4. Disc material: EPDM encapsulated ductile iron.
5. End Connections: Flanged or grooved.
6. Required options: Provide with visual indicating device and integral supervisory switch with two single-pole, double-throw circuits.

2.05 TRIM AND DRAIN VALVES:

A. Angle Valves:
1. Type: Screw in bonnet angle valve with integral seat and renewable disc.
2. Body Material: Bronze or Brass.

B. Ball Valves:
1. Type: Full port ball valve with blowout-proof stem.
2. Body Material: Bronze or Brass.

C. Globe Valves:
1. Type: Screw in bonnet globe valve with integral seat and renewable disc.
2. Body Material: Bronze or Brass.

2.06 SPECIALTY VALVES:

A. General Requirements:
1. Body Material: Cast or ductile iron.
2. Size: Same as connected piping.

B. Alarm Valves:
1. Design: For horizontal or vertical installation.
2. Include trim set required for correct operation including bypass, drain, water flow alarm pressure switch, pressure gauges,[retarding chamber,][water motor gong,] and alarm line with strainer.
3. End Connections: Flanged or Grooved.

C. Dry Pipe Valves:
1. Pressure Rating: 250 psig minimum.
2. Include UL 1486 / FM 1031 quick-opening devices when required by design.
3. Include trim set required for correct operation including air supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.

4. End Connections: Flanged or Grooved.

D. Automatic (Ball Drip) Drain Valves:
   1. Pressure Rating: 175 psig minimum.
   2. Type: Automatic draining, ball check.
   3. Materials: Bronze body with stainless steel or brass ball check.
   4. End Connections: Threaded.

2.07 DOUBLE INTERLOCK PRE-ACTION SYSTEMS:

A. Double interlock pre-action system with deluge valve controlled by an electric release system and pneumatic system pressure. Deluge valve will open only when both the pressure in the sprinkler system is lost and the electric detection system operates. If the detection system operates due to fire, damage, or malfunction, the valve will not open. If the sprinkler piping is damaged or sprinkler is broken or fused, the valve will not open. The operation of both a sprinkler and the detection system is required before the valve will open allowing water to enter the piping system.

B. Provide preaction valve assemblies where shown on drawings to serve preaction sprinkler systems. Preaction valve assembly shall include all components required for correct operation.

C. In addition to the water supply control valve, provide a supervised test valve in riser piping above deluge valve.

D. System air supply trim.
   1. The air pressure switch shall monitor high and low air pressure conditions.
   2. Provide a separate air maintenance device for each preaction valve.

E. Release trim.
   1. A detection system and solenoid valve shall serve as the electrical interlock.
      a. The solenoid valve shall be listed for releasing service with the releasing panel.
   2. A pneumatic actuator shall serve as the mechanical interlock. The low air pressure switch does not serve as a system interlock.
   3. Provide a system manual release valve on the preaction trim.

F. Preaction valve trim shall be galvanized, brass or bronze.

2.08 DRY SPRINKLER VALVE ASSEMBLY:

A. Provide dry valve assembly where shown on drawings to serve dry pipe sprinkler system. Dry valve assembly shall include all components required for correct operation.

B. System air supply trim.
   1. The air pressure switch shall monitor high and low air pressure conditions.
   2. Provide a separate air maintenance device for each dry pipe valve.
   3. Provide a quick opening device when required by system design.

C. Dry pipe valve trim shall be brass, bronze, or galvanized.

2.09 AIR SUPPLY COMPONENTS:

A. Air-Pressure Maintenance Device:
   1. Type: Automatic device to maintain minimum air pressure in piping.
   2. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure switch, strainer, outlet pressure adjustable from 5 to 50-psig, and 175-psigmaximum inlet pressure.

3. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator, strainer, outlet pressure adjustable from 5 to 50-psig, and 175-psig maximum inlet pressure.

B. Air Compressor:
1. Standard UL 2125.
2. Type: Oil Less, Tank mounted.
3. Air compressors shall be capable of filling the largest system in less than 30 minutes.
4. Power: 120-V ac, 60 Hz, single phase.
5. Provide motor starter and disconnect.
a. Provide with means to secure in the on position.
6. Provide magnetic starter for 3 phase units and motors greater than 1 HP.

C. Desiccant Air Dryers
1. Type: Manual desiccant air dryer with silica gel desiccant to produce dew points to -40 degrees F. Desiccant shall be replaceable when saturated and shall indicate a saturated condition by a change in color.
2. Provide additional dryers piped in parallel for each 275 gallons of system volume.

D. Install a coalescing filter prior to the desiccant dryer. to remove oil vapor from the air before the air enters the desiccant.

2.10 FIRE-DEPARTMENT CONNECTIONS:

A. Flush-Type, Fire-Department Connection:
1. Type: Flush, for wall mounting.
2. Pressure Rating: 175 psig minimum.
3. Body Material: Corrosion-resistant metal.
4. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
5. Caps: Brass, lugged type, with gasket and chain.
6. Escutcheon Plate: Rectangular, brass, wall type.
7. Outlet: With pipe threads.
8. Outlet Size: NPS 4.
9. Number of Inlets: Two.
10. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."
11. Finish: Polished chrome plated.

2.11 BACKFLOW PREVENTER:

A. Double Check Valve Assembly
1. Type: Double Check Valve
2. Operation: Continuous-pressure applications unless otherwise indicated.
3. Body Material: Stainless steel or epoxy coated steel.
4. End Connections: Flanged.
5. Accessories:
a. OS&Y gate valves with flanged ends on inlet and outlet.

2.12 BACKFLOW PREVENTER TEST CONNECTION:

A. Flush-Type, Outlet:
1. Type: Flush, for wall mounting.

2. Pressure Rating: 175 psig minimum.
3. Body Material: Corrosion-resistant metal.
4. Outlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples and brass lugged swivel connections. Provide without drop clappers.
5. Caps: Brass, lugged type, with gasket and chain.
6. Escutcheon Plate: Rectangular, brass, wall type.
7. Outlet: With pipe threads.
8. Number of Outlets: Two.
9. Escutcheon Plate Marking: Similar to "BACKFLOW TEST"
10. Finish: Polished chrome plated.
11. Inlet Size: NPS 4.

2.13 SPRINKLER SPECIALTY PIPE FITTINGS:

A. Mechanical tee and cross fittings are not acceptable.
B. Branch Outlet Fittings:
   1. Pressure Rating: 175 psig minimum.
   2. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
   3. Type: Mechanical-tee and -cross fittings.
   4. Configurations: Bolted split case body wrapping completely around the pipe. Saddle type fittings utilizing a single strap, snap-on, and strapless type fittings are not acceptable.
   5. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
   6. Branch Outlets: Grooved or threaded.
C. Inspector's Test Assemblies:
   1. Pressure Rating: 175 psig minimum.
   2. Body Material: Brass or bronze housing with orifice, sight glass, integral test valve and pressure relief valve factory set to 175 psi.
   3. Size: Same as connected piping.
   4. Inlet and Outlet: Threaded.
   5. Individual components may be used in place of a listed assembly. This must include a test valve, sectional or main drain valve, sight glass, smooth bore corrosion-resistant orifice and pressure relief valve piped to drain.
D. Flexible, Sprinkler Hose Fittings:
   1. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
   2. Type: Flexible hose for connection to sprinkler, and with mounting block for connection to ductwork.
   3. Pressure Rating: 175 psig minimum.
   4. Size: Same as connected piping, for sprinkler.
   5. Where supplying dry sidewall sprinklers, provide assembly UL Listed or FM Approved for use with dry horizontal sidewall sprinklers.

2.14 SPRINKLERS:

A. General Requirements:
   1. Pressure Rating for Automatic Sprinklers: 175 psig minimum.
B. Quick Response Sprinklers:

1. General Requirements:
   a. Temperature Rating: As required by NFPA 13.
   b. K factor: As required by the design.
2. Quick Response Recessed Pendent:
   a. Type: Recessed quick response pendent sprinkler with adjustable two-piece escutcheon.
   b. Finish: Sprinkler and escutcheon finish shall be white.
3. Quick Response Upright:
   a. Type: Quick response upright sprinkler.
   b. Finish: White finish in finished areas. Rough brass finish in unfinished areas without suspended ceilings and beneath ductwork and ceiling mounted equipment.

C. Standard Response Sprinklers:
1. General Requirements:
   a. Temperature Rating: As required by NFPA 13.
   b. K factor: As required by the design.
2. Standard Response Recessed Pendent:
   a. Type: Recessed standard response pendent sprinkler with adjustable two-piece escutcheon.
   b. Finish: Sprinkler and escutcheon finish shall be white.
3. Standard Response Upright:
   a. Type: Standard response upright sprinkler.
   b. Finish: White finish in finished areas. Rough brass finish in unfinished areas without suspended ceilings and beneath ductwork and ceiling mounted equipment.

D. Extended coverage upright and pendent type sprinklers are not acceptable.
E. Sprinkler cabinet per NFPA 13 with sprinklers and a wrench for each type of sprinkler.
F. Second cabinet with a sprinkler escutcheon for each sprinkler that is stored in the sprinkler cabinet.
G. Sprinkler Guards:
1. Guards shall be listed with the sprinkler they are installed on.
2. Type: Wire cage with fastening device for attaching to sprinkler piping.

2.15 ALARM AND SUPERVISORY DEVICES:

A. Alarm and supervisory device types shall match piping and equipment connections.
B. Water-Flow Alarm Horn/Strobe:
1. Type: Electrically operated, 120V ac alarm horn/strobe.

C. Water-Flow Indicators:
1. Water-Flow Detector: Electrically supervised.
2. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard from 0-90 seconds to prevent false signals and tamperproof cover.
   a. Flow switches supervising piping supplying elevator machine room sprinklers shall not include a retard function.
3. Option: Provide with contacts to send supervisory signal if cover is removed.
4. Type: Paddle operated.
5. Pressure Rating: 250 psig.
6. Design Installation: Horizontal or vertical.

D. Dry and Pre-action Sprinkler System Water-Flow Indicators:

1. Water-Flow Detector: Electrically supervised.
2. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with tamperproof cover.
3. Option: Provide with contacts to send supervisory signal if cover is removed.
4. Type: Pressure operated.
5. Pressure Rating: 300 psig.
6. Design Installation: Horizontal or vertical.

E. Dry and Preaction Sprinkler System High/Low Air Pressure Indicators:
1. Air Pressure Detector: Electrically supervised.
2. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; field-adjustable pressure settings, complete with tamperproof cover.
3. Option: Provide with contacts to send supervisory signal if cover is removed.
4. Type: Pressure operated.
5. Pressure Rating: 300 psig.
6. Design: Signals an increase or decrease in sprinkler system air pressure.

F. Valve Supervisory Switches:
1. Type: Standard OS&Y type switch. Electrically supervised. Plug type switches are not allowed except where specifically indicated.
2. Components: Single-pole, double-throw switch with normally closed contacts. Provide with tamperproof cover.
3. Option: Provide with contacts to send supervisory signal if cover is removed.
4. Design: Signals that controlled valve is in other than fully open position.

2.16 PRESSURE GAUGES:

A. Dial Size: 3-1/2- to 4-1/2-inch diameter.
B. Water Pressure Gauge Range: 0 to 300 psig with “Water” label on dial face.
C. Air Pressure Gauge Range: 0 to 80 psig retard to 250 psig with “Air” label on dial face.

2.17 AUTOMATIC AIR VENTS:

A. Type: Automatic air vent piped to exterior, or interior drain in a visible location.
B. Options: Provide without electronic monitoring.
C. Alternate: Models with a secondary valve that automatically closes in case of air vent failure and with a visual indicator visible from the floor are acceptable and are not required to be piped to drain.

2.18 SUPPORTS, ANCHORS AND SEALS:

A. Hangers and Supports:
1. Hangers and hanger assemblies shall be UL listed or FM Approved for use in fire protection systems.
2. Hangers and supports shall be galvanized.

B. Pipe Stands:
1. Type: Adjustable Pipe Saddle Support with U-bolt and Pipe Stanchion similar to Anvil Figure 265 Adjustable Pipe Saddle Support with U-bolt and Anvil Figure 63 Type T Pipe Stanchion.
2. Stanchion diameter shall be per manufacturer’s published recommendations but not less than 2” diameter.

3. Base plate size shall be per manufacturer's published recommendations with holes for bolting to floor slab.
4. Saddle shall include U-bolt or pipe clamp.
5. Pipe stands and bases shall be galvanized.

C. Sleeves and Seals:
1. Pipe sleeves through floor slabs, concrete, masonry or brick partition walls, fire barriers, fire walls and exterior building walls above and below grade shall be Schedule 40 black or galvanized steel pipe, fabricated of new material, cut square and reamed.
2. Where piping passes through sleeves in floor slabs on grade or through building walls below grade, provide a modular mechanical seal, equal to Link-Seal, as manufactured by Pipeline Seal & Insulator, Inc.

PART 3 - EXECUTION

3.01 DESIGN CRITERIA:

A. Design and hydraulically calculate the piping systems including the locations of all valves, devices and sprinklers. Design sprinkler systems based on the hazard of the occupancy as determined by the most stringent requirements of State and Local Building and Fire Codes, NFPA 13, and the Contract Documents.

B. Sprinkler systems shown on the drawings are based on hydraulic design method. Contractor may redesign the branch piping system to coordinate with other mechanical and electrical ductwork and piping systems and the structural constraints of the building. Pipe sizes shown on the drawings are minimums and may be upsized where indicated by the Contractor's hydraulic calculations. Design of sprinkler system shall be based on the hazard of the occupancy as determined by the most stringent requirements of State and Local Building and Fire Codes, NFPA 13, and the Contract Documents.

C. Water supply flow test information on the plans is for bid purposes only. Perform a new water flow test at the location of the building to verify the available water supply prior to design and installation of the sprinkler system. Perform the flow test in accordance with NFPA 291 and NFPA 13. Submit new hydrant flow test with shop drawings. Flow test information shall include date, time, witness, location of flow and pressure hydrant, static and residual pressures, pitot pressures, hydrant coefficients, residual flow rates and hydrant elevations relative to the building floor. Include a site plan with water main locations, static and residual hydrant location, and hydrant and ground floor building elevations.

D. The Fire Protection Contractor shall include an additional safety factor of 10 psi in their bid to account for possible drop in water pressure from the information provided in the bid documents. No additional costs will be awarded for a drop in water pressure from the flow test information in bid documents and the flow test performed by the Fire Protection Contractor for hydraulic design of the sprinkler system. This additional safety factor, above what is required in other paragraphs of this specification, is not required to be included in the final hydraulic calculations.

E. The velocity of water in the piping system shall not exceed 32feet per second.

F. Provide a margin of safety for all hydraulically calculated sprinkler systems of 5 psi or 10 percent (whichever is larger), including losses through water-service piping, valves, and backflow preventers.

G. The hydraulic remote area may be reduced when quick response sprinklers are installed per NFPA 13. The reduction only applies to light and ordinary hazard wet sprinkler systems.

H. The hydraulic remote area for dry pipe and preaction sprinkler systems shall be increased by 30 percent without revising the density.

3.02 PREPARATION OF PIPING:

A. Ream pipe ends to remove burrs. Make joints smooth and unobstructed inside. Remove any obstructions or debris inside piping, blowing it out with compressed air or otherwise cleaning it internally immediately prior to assembly.

B. Pipe shall be delivered with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

3.03 PIPING INSTALLATION:

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
   1. Deviations from approved working plans for piping require written approval from Engineer.

B. Coordinate fire protection installation with mechanical components including ductwork and piping, electrical systems and components, and all other building systems, as well as structural and architectural drawings.

C. Comply with requirements for installation of sprinkler piping in NFPA 13.

D. Install sprinkler piping with drains for complete system drainage.

E. Install chrome plated escutcheons on all exposed pipes passing through walls, floors and ceilings.

F. Install automatic air vents at the high point of each wet sprinkler system to automatically vent air from the sprinkler system piping. Install a ball valve in the piping prior to each automatic air vent. Air vents with a visual indicator shall be installed such that they are visible from the floor. They shall not be in installed above ceilings, ductwork or other equipment.

G. Install a flanged connection, grooved connection or union on both sides of all equipment. Unions shall only be used on NPS 1 threaded piping.

H. Flexible sprinkler hose fittings shall be installed in accordance with the manufacturers published recommendations including limitations on bend radius required by the listing, approval and hydraulic calculations.

3.04 PIPING SUPPORT:

A. Point Loads on the building structure due to sprinkler piping may not exceed 300 lb. on any single structural member except where indicated otherwise on the drawings.

B. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

C. Pipe stands shall be securely fastened to the floor slab with 1/2 inch concrete anchors.

D. Threaded rod used to support piping shall not be formed or bent. Threaded rod shall not be used in the horizontal position to support vertical loading or as a pipe stand or column.

E. Sprinkler risers in stairs or other accessible locations shall be provided with supports to prevent lateral movement at the top and bottom of the riser.

F. Shear loads on the building structure due to sprinkler piping bracing may not exceed 500 lb. on any single structural member except where indicated otherwise on the drawings.

3.05 JOINT CONSTRUCTION:

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install a union adjacent to each valve in NPS 1 threaded piping. Install a grooved coupling or flange adjacent to each valve in threaded piping NPS 1-1/4 and larger.

C. Install flanges or grooved couplings on valves, apparatus, and equipment having grooved or flanged connections.

D. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream pipe ends to remove burrs and restore full inside diameter prior to threading. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
   3. When externally galvanized piping is threaded, coat exposed threads with a cold galvanizing, zinc coating.

F. Welded Joints: Construct joints according to NFPA 13, using qualified processes and welding operators that meet or exceed the requirements of AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, and ASME *Boiler and Pressure Vessel Code*, Section IX, "Welding and Brazing Qualifications".
   1. Shop weld pipe joints where welded piping is indicated.
   2. Do not use welded joints for galvanized-steel pipe.

G. Grooved joints:
   1. All grooved couplings and fittings in a system shall be manufactured by the same manufacturer. Mixing of grooved couplings and fittings by different manufacturers or different designs of the same manufacturer is not acceptable.
   2. Grooved couplings on mains shall be rigid type couplings except where flexible couplings are required by NFPA 13.
   3. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
   4. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
   5. [Dry pipe][, preaction][and deluge] sprinkler piping shall not be roll-grooved.

H. Piping upstream of the riser check valve or alarm check valve shall not be grooved.

I. Flat circular washers shall be provided under all bolt heads and nuts. Washers are not required on listed assemblies such as grooved couplings except where washers are part of the listed assembly.

3.06 PENETRATIONS, SLEEVES AND SEALS:

A. Openings for penetrations in walls and floors shall be made using a hole saw or core drill.

B. Install sleeves for piping passing through penetrations in all walls and floors.

C. Install sleeves for piping passing through penetrations in floors, concrete and masonry partitions and walls, fire barriers and fire walls.

1. Sleeves are not required for core-drilled holes except where required by a UL through-penetration firestop system.

D. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Sleeves are not required for core-drilled holes.
   2. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   3. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   4. Using grout, seal the space outside of sleeves in slabs and walls.

E. Install sleeves for pipes passing through interior partitions.
   1. Sleeves are not required for core drilled holes or holes made using a hole saw.
   2. Cut sleeves to length for mounting flush with both surfaces.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   4. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

F. Fire-Barrier and Fire Wall Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with a UL listed firestop system.
   1. Label all penetrations to indicate UL system number and additional information.

3.07 VALVE AND SPECIALTIES INSTALLATION:

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and Authorities Having Jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water supply connection. Install pressure gauges on both sides of check valves and backflow preventers.
   1. Install backflow preventers with bottom of the backflow preventer not more than 24 inches above finished floor.

D. Install riser check valves in each wet sprinkler system riser. Install pressure gauges on both sides of the riser check valve.

E. Install pressure gauges on riser or feed main and at each sprinkler test connection. Include pressure gauges with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they will not be subject to freezing.

F. Normally closed valves required to be electronically supervised shall be butterfly valves designed and factory wired with a supervisory switch to supervise the valve in the closed position.

G. Valves shall be installed in accessible locations not more than 7’-0” above finished floor.

H. Where auxiliary drains discharge to a location other than the exterior of the building, the drain valve shall be located within sight of the drain piping discharge.

I. Provide a minimum of 3 feet of clearance in front of all equipment and 6 inches behind the equipment.

3.08 INSPECTOR'S TEST CONNECTION:

A. For each sprinkler system and for each waterflow alarm device, where multiple devices occur, furnish and install an inspector's test assembly. Pipe discharge from this assembly, to building exterior or as shown on drawings. Provide splash block at building exterior.
B. Furnish and install an inspector's test connection on the remote branch line of each sprinkler system where required by the local Authority Having Jurisdiction.

3.09 SUPERVISORY SWITCHES, LOCKS AND SEALS:

A. Furnish and install a supervisory switch on each shutoff valve in the fire protection piping system to indicate when valve is not fully open.
B. In addition to the supervisory valve switches provided on each sprinkler system valve, the valves shall be locked or secured in the open position. All valve locks shall be keyed the same.
C. Normally closed OS&Y valve shall be supervised with plug type supervisory switches.
D. Provide seals on all trim valves that would adversely affect the operation of the systems or cause or prevent activation of alarm signals.

3.10 FLOW SWITCHES:

A. Furnish and install a flow switch for each system. Set retard on flow switches to 60 seconds or as required by local Authorities Having Jurisdiction.
    1. Flow switches on piping supplying elevator machine room sprinklers shall not be provided with retard.
B. Flow switches installed in horizontal piping shall be installed on the top of the piping.

3.11 PRESSURE SWITCHES:

A. Furnish and install supervisory pressure switches to monitor both the high and low air pressure on dry pipe and pre-action system piping.
B. Furnish and install a pressure switch on the dry pipe and pre-action valve trim to indicate a water flow condition upon actuation of the system.

3.12 DRY PIPE SYSTEMS:

A. Dry pipe system piping shall pitch toward a drain. Install condensate drum drip drains at all low points. Locate drum drips in a warm location. Review the location of the condensate drum drip drains with the Architect and Engineer prior to pipe fabrication and installation.
B. Dry pipe system valve, valve trim, and air supply shall be installed in complete accordance with the manufacturer's requirements and recommendations.
C. Install a desiccant dryer system for each air compressor serving dry pipe valves. Where multiple dryers are required the units shall be piped in parallel so that air flow is divided into the multiple units.
D. Sprinklers on dry pipe systems shall be upright or dry pendents. Where dry pipe sprinkler system piping is located in a heated space, standard pendent sprinklers on return bends may be used.
E. Sprinklers on dry pipe system shall be standard response.
F. Delivery of water from the dry pipe valve to the system test connection starting at normal air pressure shall not exceed 60 seconds regardless of system volume.
G. Seal or lock air compressor disconnect switches in the on position.

3.13 PREACTION SYSTEMS:

A. Preaction system piping shall pitch toward a drain. Install condensate drum drip drains at all low points. Review the location of the condensate drum drip drains with the Architect and Engineer prior to pipe fabrication and installation.
B. Preaction system valve, valve trim, and air supply shall be installed in complete accordance with the manufacturer's requirements and recommendations.
C. Install a desiccant dryer system for each air compressor serving dry pipe valves. Where multiple dryers are required the units shall be piped in parallel so that air flow is divided into the multiple units.
D. Sprinklers on preaction systems shall be upright or dry pendents. Where preaction sprinkler system piping is located in a heated space, standard pendent sprinklers on return bends may be used.
E. Sprinklers on pre-action system shall be standard response.
F. Seal or lock air compressor disconnect switches in the on position.

3.14 SPRINKLER INSTALLATION:

A. Coordinate location of sprinklers with reflected ceiling plans on Architectural drawings. Sprinklers shall be located in the center of the ceiling tiles, or with 24 inch x 48 inch ceiling panels, center sprinklers on the 24 inch dimension.
B. Sprinklers are to be located symmetrically with the column lines of the building.
C. Sprinklers in gypsum board or plaster ceilings are to be specifically located as required by the architect to coordinate with lighting, diffusers, speakers, detectors and architectural elements in the ceiling. Review the location of sprinklers in gypsum board or plaster ceilings with the architect prior to piping fabrication and installation.
D. Install sprinklers in accordance with NFPA 13 requirements regarding obstructions to sprinkler discharge. In addition, the "three times rule" of NFPA 13 shall be applied to all obstructions including non-structural elements in all occupancy classifications including light and ordinary hazard.
E. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
F. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.
G. Provide guards on sprinklers where sprinklers are within 7'-0" of floor or in any location where sprinklers might be subject to mechanical damage.
H. Provide extra sprinklers of each style, enclosed in sprinkler cabinet, and one sprinkler wrench for each type. The number of extra sprinklers to be supplied is to be determined according to NFPA 13. Cabinet shall be mounted where directed by Owner.

3.15 FIRE PROTECTION OF ELECTRICAL COMMUNICATIONS AND IT ROOMS:

A. Provide a complete fire protection system in electrical switchgear rooms, panel rooms, small electrical closets and communications rooms per NFPA 13.
B. Do not install sprinkler piping directly above electrical equipment, communications equipment or motor control centers.
C. Sprinkler piping serving electrical and communications rooms shall serve those areas only. Sprinkler piping serving other areas may not pass through electrical and communications rooms.

D. Provide heavy gauge galvanized steel hoods and shields (or stainless steel) that are shop fabricated for electrical rooms and communications rooms to protect the electrical equipment from water spray where a sprinkler system is installed. Drainage from these hoods shall be directed to floor drains.

3.16 ELEVATOR SHAFTS AND EQUIPMENT ROOMS:

A. Hydraulic Elevators:
   1. Elevator Hoistway: No sprinklers.
   2. Elevator Pit: Provide sidewall sprinklers with sprinkler guards in the elevator pit not more than 24 inches above the pit floor. Provide a supervised control valve in piping supplying the elevator pit.
   3. Machine Room: Provide sprinklers with sprinkler guards in elevator machine rooms. Provide a control valve assembly including a supervised control valve, check valve, water flow switch and test and drain valve in piping supplying the elevator machine room. Pipe discharge of test and drain to building exterior unless otherwise indicated on the drawings. Locate control valve assembly outside and adjacent to the machine room. Actuation of the flow switch shall shunt trip power to the elevator served by that machine room. The flow switch shall have no time delay.

3.17 FIRE-DEPARTMENT CONNECTION INSTALLATION:

A. Install flush wall-type, fire-department connections.
B. Install check valve(s), located in a heated area, in the piping between the fire-department connection and sprinkler systems.
C. Install automatic (ball drip) drain valve at each check valve for fire-department connection to drain piping between fire-department connection and check valve. Pipe drain to floor drain or to outside building.
D. Piping between fire-department connections and check valves shall be galvanized.

3.18 CENTRAL DRAIN RISER:

A. Pipe discharge from 2 inch central drain riser to the exterior of the building or, where noted on the drawings.
B. Furnish and install a 2-1/2 inch tee with swivel connection equal to Potter-Roemer Model 5912 located approximately 3’-0” above the finished floor on the 3 inch drain risers at locations where a 2-1/2 inch pressure regulating fire department valve is installed.

3.19 ELECTRICAL CONNECTIONS:

A. Wiring for sprinkler system supervision and power to air compressors will be provided under DIVISION 16 and DIVISION 28. Coordinate location of these devices with the Fire Alarm and Electrical Contractors.
B. Furnish and install all electric wiring, conduit, accessory devices and make final control connections to maintenance air compressor as required, from the adjacent junction box provided under DIVISION 26. All wiring shall be installed in compliance with DIVISION 26 and NFPA 70.

3.20 FIELD QUALITY CONTROL:

A. Maintain a record set of drawings at the job site.
B. Participate in pre-testing between contractors to verify interface and function of all related building systems.

3.21 CLEANING:

A. Clean dirt and debris from sprinklers.
B. Remove and replace sprinklers with paint other than factory finish.

3.22 TESTING:

A. The Contractor shall engage a factory-authorized service representative to perform all testing and inspections.
    1. Perform tests required by NFPA 13. Submit test reports to Engineer. Provide copy of all test certificates in Owner's operation and maintenance manual.
    2. Hydrostatic testing shall include the piping between the fire department connection and the sprinkler systems.
    3. Repair system and perform test or inspection again following failure of any test or inspection.
    4. All tests shall be witnessed by the Authority Having Jurisdiction and Engineer.
    5. Pre-test all systems prior to request for witness by the Authority Having Jurisdiction and Engineer.
    6. Coordinate with underground utilities contractor for flushing of underground and water service mains in accordance with NFPA 13, "Systems Acceptance" Chapter and NFPA 24.
B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
C. Prepare test and inspection reports.
    1. Include NFPA 13, Contractor's Material and Test Certificate for Aboveground Piping.
    2. Include NFPA 13, Contractor's Material and Test Certificate for Underground Piping.

3.23 DEMONSTRATION AND DOCUMENTATION:

A. Upon completion of the fire protection systems including testing, the Contractor shall furnish the Owner a letter stating the sprinkler systems have been installed and tested in accordance with NFPA 13 and this specification. The letter shall be accompanied by the NFPA 13 Contractor's Material and Test Certificate for Underground Piping and the NFPA 13 Contractor's Material and Test Certificate for Aboveground Piping.
    1. This letter shall be signed and certified by the Fire Protection Technician responsible for design of the sprinkler system.
B. Operational Instruction: Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain the sprinkler systems and specialty valves.
C. Provide shop drawings, material cut-sheets, hydraulic calculations, and a copy of NFPA 25 in the sprinkler system operation and maintenance manuals.

3.24 PIPING SCHEDULE:

A. Use pipe types and joining methods complying with Part 2.
B. Standard pressure, wet-pipe sprinkler system piping shall be one of the following:
    1. Schedule 40, black-steel pipe with threaded ends; threaded fittings; and threaded joints.
    2. Schedule 40, black-steel pipe with cut-or roll-grooved ends; grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
    3. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
    4. Schedule 40, black-steel pipe with flanged ends; flanged fitting; and flanged joints.

5. Schedule 10, black-steel pipe with roll-grooved ends; grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
6. Schedule 10, black-steel pipe with plain ends; steel welding fittings; and welded joints.
7. Schedule 10, black-steel pipe with flanged ends; flanged fitting; and flanged joints.

C. Standard pressure, dry pipe sprinkler system piping shall be one of the following:
1. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, threaded fittings; and threaded joints.
2. Schedule 40, galvanized-steel pipe with roll-grooved ends; galvanized, grooved-end fittings for steel piping; galvanized grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 10, galvanized-steel pipe with roll-grooved ends; galvanized, grooved-end fittings for steel piping; galvanized, grooved-end-pipe couplings for steel piping; and grooved joints.

D. Standard pressure, pre-action sprinkler system piping shall be one of the following:
1. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, threaded fittings; and threaded joints.
2. Schedule 40, galvanized-steel pipe with roll-grooved ends; galvanized, grooved-end fittings for steel piping; galvanized grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 10, galvanized-steel pipe with roll-grooved ends; galvanized, grooved-end fittings for steel piping; galvanized, grooved-end-pipe couplings for steel piping; and grooved joints.

E. Drain piping extending through the exterior wall shall be galvanized with galvanized fittings.

F. Fire department connection piping extending through the exterior wall shall be galvanized.

G. Piping between Fire-Department Connections and Check Valves: Galvanized, Schedule 40 steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

H. Sprinkler system piping installed outdoors or in damp or humid areas shall be galvanized with galvanized fittings and couplings.

I. Sprinkler system piping installed outdoors or in damp or humid areas shall be painted.

J. Piping below the alarm valve or riser check valve shall be flanged or welded.

3.25 SPRINKLER SCHEDULE:

A. Use sprinkler types in subparagraphs below for the following applications:
1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Recessed pendent sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.
1. Recessed Sprinklers: White, with bright chrome escutcheon.
2. Upright Sprinklers: White in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211313