**CALIFORNIA POLYTECHNIC STATE UNIVERSITY-SAN LUIS OBISPO/FIRE PROTECTION ENGINEERING DEPARTMENT**

**FPE 596**

*Culminating Experience in Fire Protection Engineering*

*Fire and Life Safety Report*

***Orfalea College of Business***


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**Statement of Disclaimer**

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Keywords: Life Safety Code, Performance Based Design, ASET, Fire Dynamic Simulator (FDS), RSET.

**Executive Summary:**

A comprehensive fire and life safety analysis was performed on the Orfalea College of Business. The report covers the prescriptive analysis of the building and the performance-based design analysis. The prescriptive analysis includes assessment of the relevant codes for egress system, water-based suppression system, alarm and detection system, and structural fire protection. The egress analysis under the Life Safety Code 2015 found the building meets the requirements of occupant load to exceed exit capacity, number of exits and its location, travel distances. Four rooms on the second floor that have not met the common path of travel distances limits were discussed in detail in this report. In addition, two locations where exits signs should have been located were investigated in this report. The water-based suppression system was analyzed, and an automatic fire sprinkler system was designed according to NFPA 13. The fire alarm and detection system throughout the building was reviewed. The notification device in Room 300 does not meet required candela rating. The smoke management system analysis indicates door magnetic holder for the exit enclosure on the third floor does not work properly. The analysis of the structural fire protection demonstrates that the building is in accordance to the requirements of the IBC 2015 for Type I-B construction.

A performance based analysis of the Orfalea College of Business was performed to evaluate a design fire scenario. The fire scenario was modeled using Fire Dynamic Simulator (FDS), Pyrosim and Pathfinder. The tenability results of the simulation are compared to the established tenability criteria to determine the available safe egress time (ASET) for the scenario. Then, (ASET) is compared to the required safe egress time (RSET). The fire scenario evaluated an upholstered three seat sofa in a break room on the fourth floor. The required safe egress time (RSET) was calculated as 249 seconds and the available safe egress time (ASET) was determined to be 42 seconds when the visibility tenability criterion was exceeded.

As part of the evaluation process, there are additional recommendations in the report including exit sings locations on the third floor, obstructions in the corridor on the fourth floor, smoke detection system and notification appliances coverage, and several other recommendations are discussed in more detail in the report.

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# 1. Scope of Report

This Fire and Life Safety report will describe in detail the required and provided fire and life safety features of the Orfalea College of Business. The features discussed will include the egress system, fire suppression system, fire alarm and detection system, and the structural fire protection. Following the discussion of these prescriptive features, a performance-based analysis involving potential fire scenario will be presented. A summary of both the prescriptive and performance-based analyses, and their findings, will conclude this report.

The intended function of this report is to provide the owner, the Authority Having Jurisdiction (AHJ), and the fire department with a resource outlining the design of the fire and life safety systems in the Orfalea College of Business Building. The building will be analyzed in accordance with the following:

- NFPA 101, "Life and Safety Code".
- IBC, "The International Building Code".
- NPFA 13, "Standard for the Installation of Sprinkler Systems".
- NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems"
- NFPA 72, "National Fire Alarm and Signaling Code"

# 2. Building Overview


***Figure 1****. Map picture for the business building*

The Orfalea College of Business Building is a building inside the campus of California Polytechnic State University in San Luis Obispo, located at the west end of the campus (as shown in Figure 1). The building was approved in 1989 and completed in 1992 under "the Uniform Building Code - 1985 edition" with a total area of 115,854 ft$^2$. The frontage to the actual street is very limited; the access road is College road and is on the south side of the building. The building was constructed adjacent to an existing building called the Education Building "Building 2".


***Figure 2****. View for the Building 3 and Building 2*

Figure 2, shows a top view layout of the two buildings, the Orfalea College of Business consists of: the quarter circle on the right, the leg attached to its left and the circle above. The circular area on the down left is the lecture hall known as "Silo". Two levels of the Education Building connect to the second and third levels of the Orfalea College of Business Building. In addition, the building utilizes an open air design with a court yard in between the two buildings (as shown in Figure 3), interconnecting open walkway (as shown in Figure 4) and an open stairway on the second floor.

***Figure 3****. Courtyard between two buildings*

***Figure 4***. *Open walkway connects two buildings*

The building consists of four floors (each at an average of 10 feet in height and 12 feet floor to floor). The first floor of the building consists of classrooms and offices, with a direct access to either courtyard or public way. The second floor is used mainly for classrooms and computer labs for the students. The quarter circle part of the third floor used for classrooms and students reading rooms, while the leg part of the floor completely used for faculty offices. The fourth floor is entirely used for faculty offices.

The separated large lecture hall “Silo” has 12 seating rows and two exits. This space is used for lectures, welcoming international students, and guest speaker events. Figures 5 and 6 show pictures of the “Silo” from outside and inside, respectively.


***Figure 5***. *Outside view for Silo*


***Figure 6***. *Inside view for Silo*

The construction materials are structural steel and concrete blocks. The Orfalea College of Business was constructed to meet a fire rating of two hours for the structural frame, shaft enclosures, and floors. The roof is rated at one hour. These rating meet the Type II Fire Resistant rating under the 1985 Uniform Building Code.

Initial installation included a Simplex Fire Alarm. Later, to establish a single and uniform system throughout the Cal Poly campus, a Notifier Alarm System was installed. The fire alarm and detection system was not designed to provide complete coverage throughout the building. The selected coverage for detection included corridors and mechanical rooms. Upgraded fire alarm and detection system was added to the building in 2016 to include more spaces to the coverage. The building was designed and constructed without fire sprinklers system. The next part will include a discussion of occupancy classification for the building, and analysis for means of egress.

# 3. Egress Analysis

## 3.1 Occupancy Classification

Generally, the building is used for more than one purpose, however, the main use is for offices. Other spaces are used as classrooms, computer labs, and administrative spaces. The first floor is mainly used for lecture rooms, with a few number of offices. The second floor is used for lecture rooms, computer labs, conference rooms and a large student area space called "Student Success Center". Also, the building has some small storage areas as well as mechanical and electrical rooms. However, the third and fourth floors, which have the largest number of spaces, are used for faculty and administration offices. Table 1, shows number of spaces different use in floors.

**Table 1** *Classification of uses for spaces in the building floors.*

| Floor | Offices | Classrooms | Conference Rooms | Computer Labs | Other Uses |
|---|---|---|---|---|---|
| First | 13 | 5 | N/A | N/A | 8 |
| Second | 4 | 8 | 2 | N/A | 5 |
| Third | 40 | 2 | N/A | 4 | 7 |
| Fourth | 62 | N/A | N/A | N/A | 6 |

Figures 7,8,9 and 10 show pictures from inside the building for different uses of the spaces.

***Figure** 7. Computer lab*

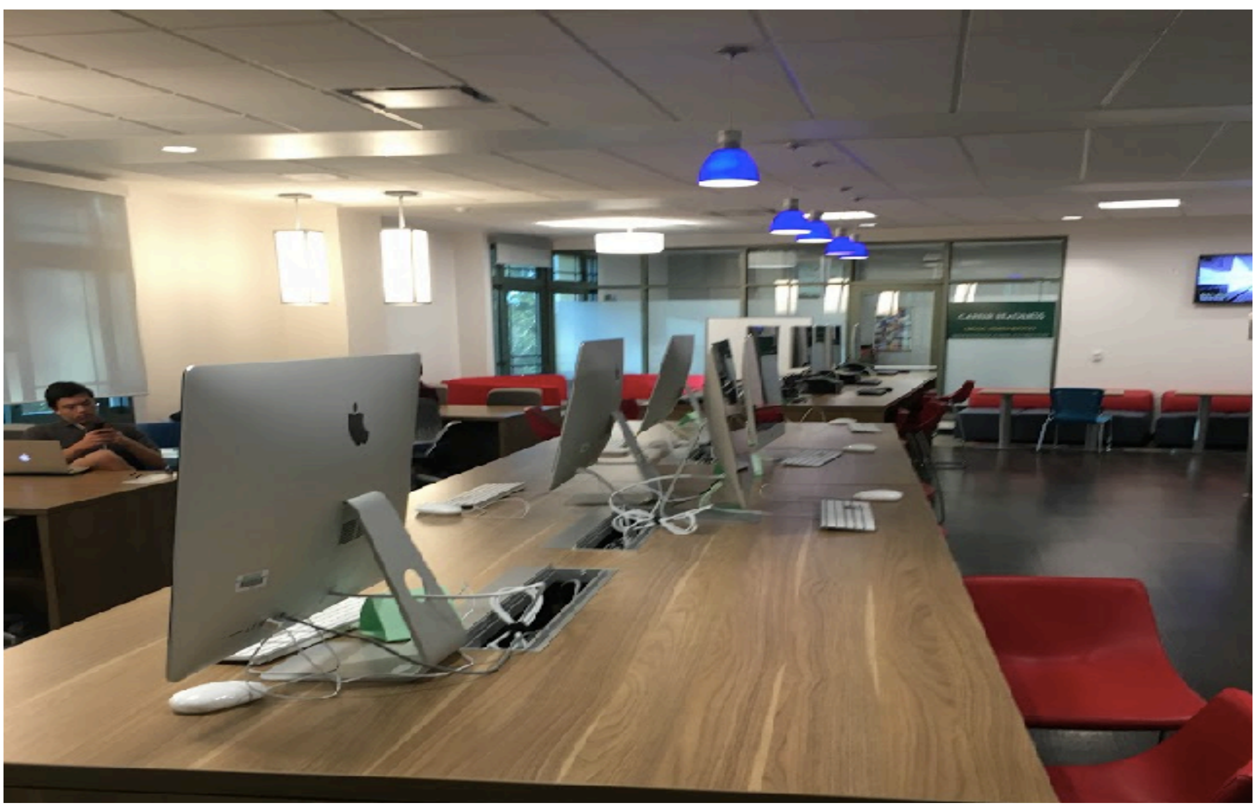


***Figure 8**. Students area*

***Figure 9***. *Classroom in the Business building*

***Figure 10***. *Conference room in the Business building*

The business building on the Cal Poly campus was clearly designed and built to give safe access to exits for all occupants in the building. The egress capacity exceeds the occupancy load according to the LSC 2015. Table 2, shows total areas for each occupancy in the Orfalea College of Business Building, followed by Figures 11,12,13 and 14 show the color coded occupancy classification for each area within the building.

***Table 2*** *Areas for each occupancy in $ft^2$*

| | Business | Assembly | Storage | Mechanical/Electrical |
|---|---|---|---|---|
| First | 2828 | 5139 | 403 | 1972 |
| Second | 1400 | 6551 | 20 | 251 |
| Third | 14791 | 1021 | 264 | 825 |
| Fourth | 9487 | 0 | 53 | 407 |
| Silo | 0 | 2616 | 0 | 0 |
| Total | 28506 | 15327 | 740 | 3455 |


***Figure 11*** *First  floor color-coded occupancy classifications*

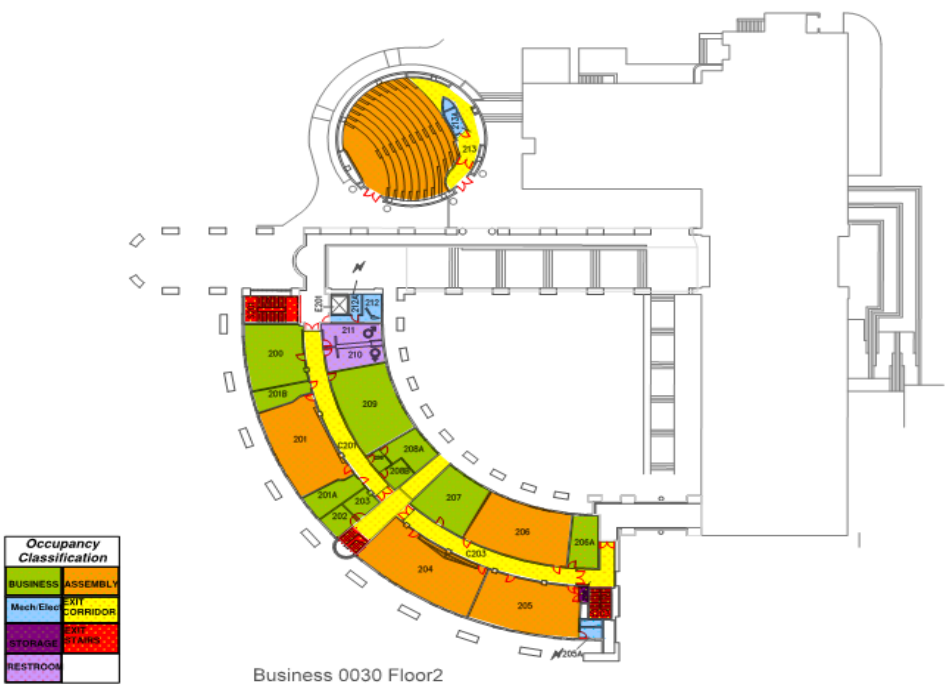



***Figure 12*** *Second  floor color-coded occupancy classifications*

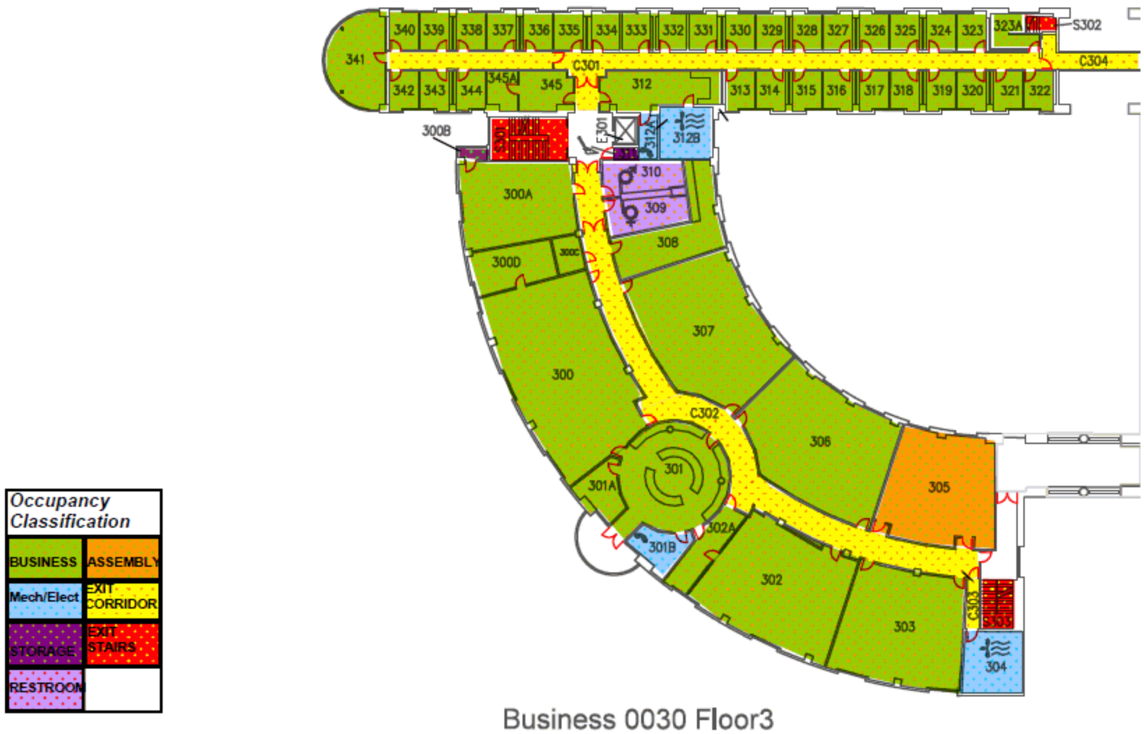



***Figure 13*** *Third floor color-coded occupancy classifications*

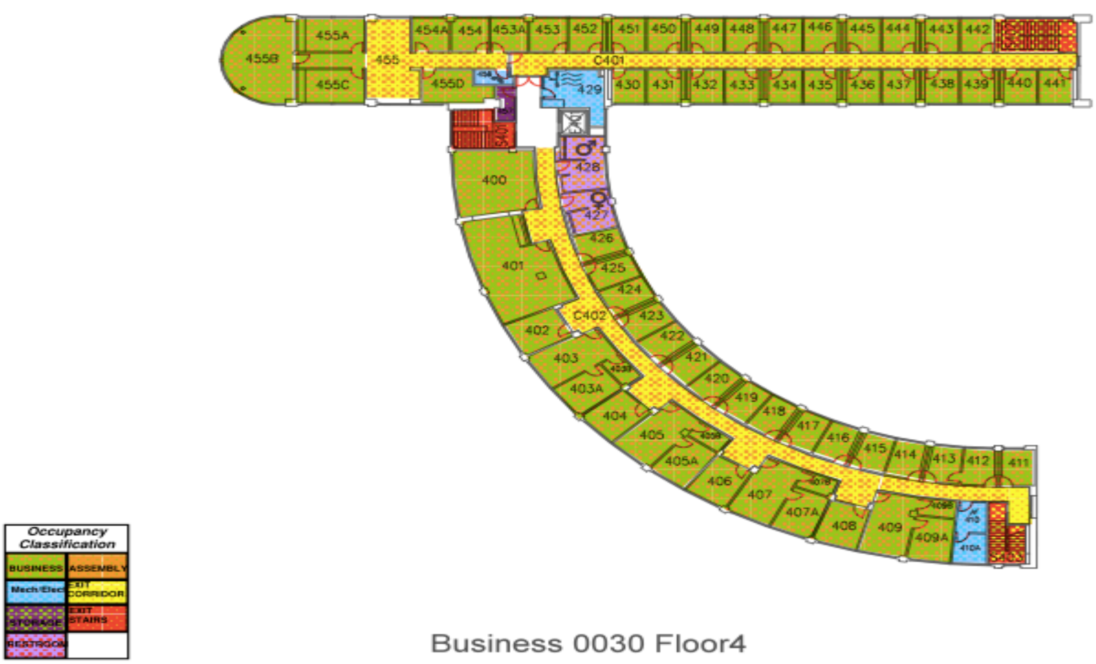



***Figure 14*** *Fourth floor color-coded occupancy classifications*

## 3.2 Occupant Load

The occupant load of the building was calculated using the occupant load factors that are provided in Table 7.3.1.2 of LSC 2015, as well as by knowing the area of each space. The area of each space was divided by the occupant load factor to determine the number of occupants.

$$Occupant\ Load = \frac{Area\ of\ Room(\ ft^2)}{Occupant\ Load\ Factor\ (ft^2\ per\ occupant)}$$

The total occupant of each floor and the subsequent total occupant load of the building can be calculated by adding the occupant load of each room. Table 3 shows the occupant load calculated for each floor in the Orfalea College of Business Building.

***Table 3*** *Occupant load for each floor*

| Floor | Occupant Load |
|---|---|
| First | 165 |
| Second | 410 |
| Third | 393 |
| Fourth | 153 |
| Silo | 230 |
| Total | 1,315 |

The calculated occupant load for each space in the building is provided in Appendix A.

## 3.3 Exit Capacity

As per requirements of the LSC 2015, the exit capacity should follow this formula;

$$Exit\ Capacity > Occupant\ Load$$

According to LSC 2015, Table 7.4.1.2, the number of means of egress provided should match the following table:

***Table 4*** *Occupant load and number of required exits*

| Occupant load served | Number of exits required |
|---|---|
| < 50 (typical but varies) | 1 |
| < 500 | 2 |
| 501-1000 | 3 |
| >1000 | 4 |

In the business building, the space with the highest number of occupants that has only one mean of egress is Room 209 on the second floor (as shown in Figure 15).

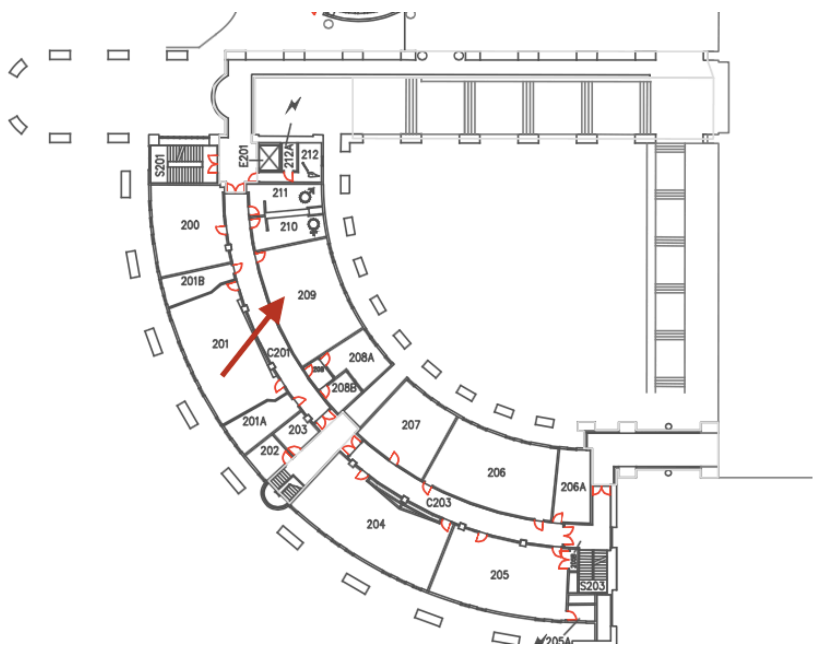



**Figure 15** Room with highest occupant's number with one exit

The occupant load for this room is 47 persons; and, to calculate the egress capacity three factors are needed:

- Occupant Load
- Door Width
- Capacity Factor

The occupant load for the room is 47 persons, and the door width is 36”. Based on LSC 2015, the capacity factor is 0.2 inch/person.

The doorway capacity can be calculated using the following formula:

$$Doorway\ capacity = door\ width/\ capacity\ factor$$

So, the doorway capacity= 36”/0.2 = 180, which is sufficient and meet the requirements of Life Safety Code, 2015.

The area with the highest number of occupants is clearly the outside large circular lecture hall called the Silo. This room has 230 occupants, and is provided with two exits. One exit is on the first floor that discharges to public way and the other exit is on the second floor where it discharges to either open walkway to building 2 or to public way in the opposite side (as shown in Figure 16).

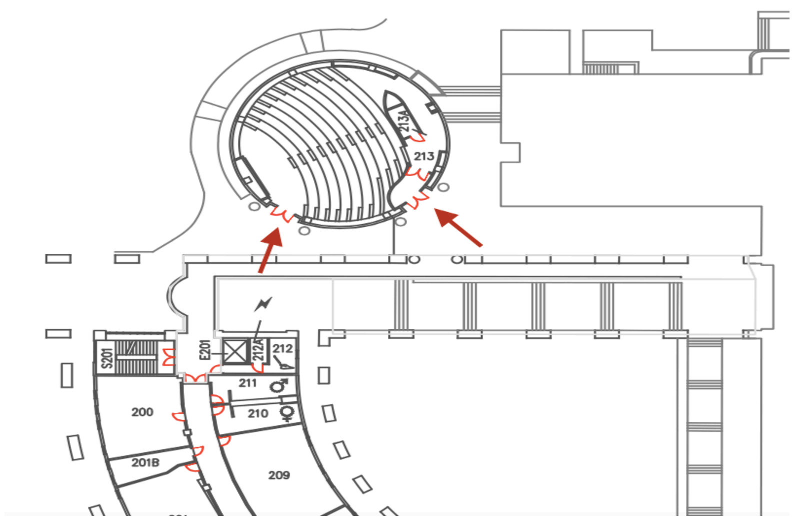



***Figure 16*** *Means of egress on the second floor*

By using the same process that was used to calculate the exit capacity for Room 209, the exit capacity for the Silo can be calculated. The door width is 72” for both exits, and based on the LSC 2015, the capacity factor is 0.2 inch/person; the exit capacity is calculated to be 360 persons for each exit. The capacity is clearly sufficient according to Table 7.4.1.2 of LSC 2015. These two example were provided for the room with highest occupant load and served by only one exit and highest occupant load with more than one exit to clarify that all other rooms are matching the LSC 2015 requirements.

In terms of exit capacity for each floor, the same criteria are followed. Table 7.3.3.1 of the LSC 2015 is used for the calculation.

*Table 7.3.3.1 Capacity Factors*

| Area | Stairways (width per person) | | Level Components and Ramps (width per person) | |
|---|---|---|---|---|
| | in. | mm | in. | mm |
| Board and care | 0.4 | 10 | 0.2 | 5 |
| Health care, sprinklered | 0.3 | 7.6 | 0.2 | 5 |
| Health care, nonsprinklered | 0.6 | 15 | 0.5 | 13 |
| High hazard contents | 0.7 | 18 | 0.4 | 10 |
| All others | 0.3 | 7.6 | 0.2 | 5 |

The Orfalea College of Business building has different widths at different locations. The calculation used the capacity factors represented in Table 7.3.3.1 of LSC 2015. The main exit stairway located in the middle of the building has a width of 65”, which provides an exit for 216 persons. The two stairways located northeast and southeast of the building have a width of 56” so it serves 186 persons. The open stairway located in the middle of the second floor serves 106 persons.

Also, for the corridors, the same procedure is followed by dividing the width of the corridor over the capacity factor. The corridor on the third floor that serves the horizontal exit has a width of 38”, and based on the LSC 2015, the capacity factor is 0.2; so, the capacity = 38”/0.2= 190 persons. For the corridor that serves classrooms, the width is 72”, and based on the LSC 2015, the capacity factor is 0.2, so the exit capacity = 72”/0.2= 360 persons. The building meets and even exceeds the requirements of LSC 2015. Table 5 summarizes the occupant load and exit capacity for each floor and shows LSC 2015 compliance.

*Table 5 Exit capacity for each floor*

| Floor | Occupant Load | Exit Capacity | Code Compliance |
|---|---|---|---|
| First | 165 | - | - |
| Second | 410 | 503 | Exceeded |
| Third | 393 | 577 | Exceeded |
| Fourth | 153 | 577 | Exceeded |
| Silo | 230 | 720 | Exceeded |

## 3.4 Means of Egress

The first floor is at ground level and all of the rooms discharge into either the courtyard that is located in the center of Building 2 and business building or public ways. All rooms on the first floor have a sufficient exit capacity in accordance to the LSC 2015. The second floor (as shown in Figure 17) has two enclosure stairways located in the northwest and southeast of the floor and an open stairway in the middle of the floor (as shown in Figure 18). In addition, there are two open walkways connecting this floor to the adjacent education building.

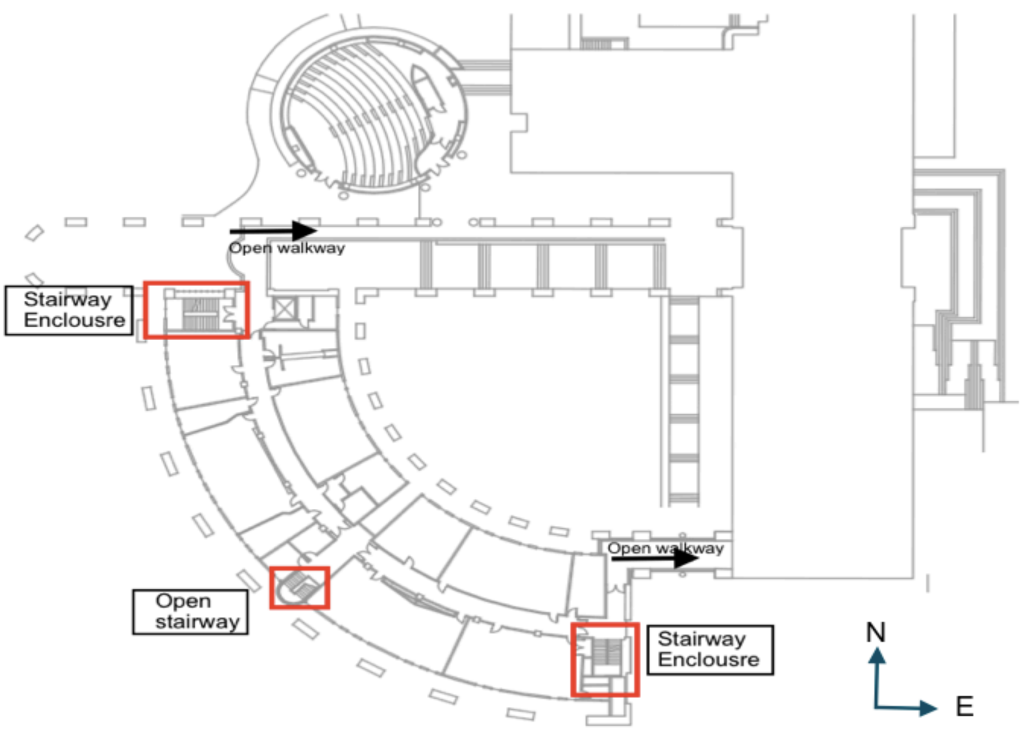



***Figure 17** Means of Egress on The Second Floor*

***Figure 18*** *Open Stairway on The Second Floor*

The third floor has two exit enclosures, the main stairway exit enclosure and the exit enclosure for the stairway that located on the southeast of the floor. In addition, the third floor has a horizontal exit takes to the adjacent education building (as shown in Figures 19 and 20), this horizontal exit gives the ability for people who are coming from the fourth floor through the northeast enclosure to discharge directly to education building or to access the corridor of third floor in the same building. The third floor has an open walkway connected to the Education building.

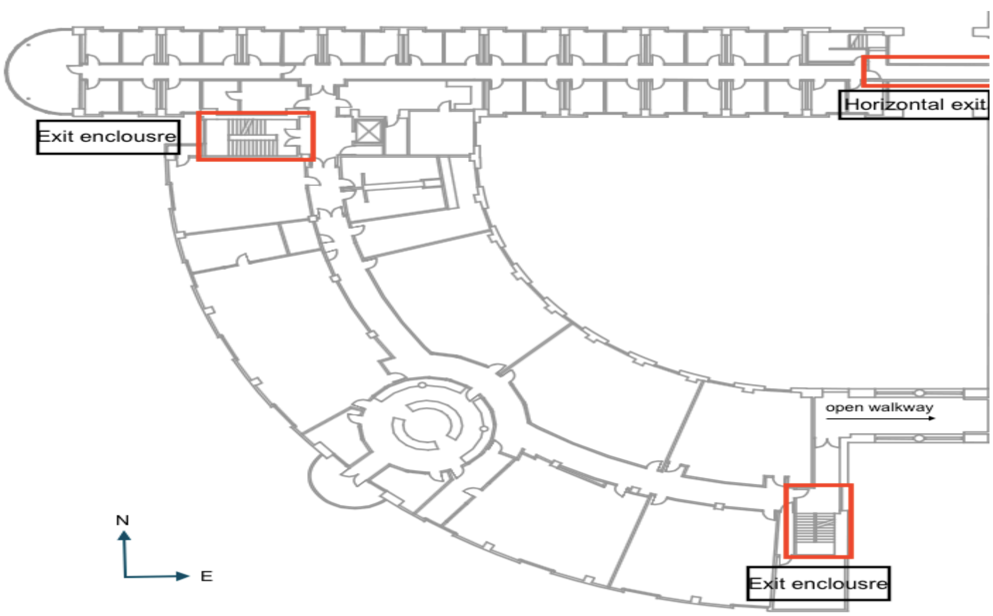



***Figure 19*** *Means of Egress on The Third Floor*

**Figure 20** Horizontal Exit on The Third Floor towards the Education building

The fourth floor has similar configuration as the third floor, except there is no connection to the education building. Also, the northeast exit enclosure path of egress stops at third floor and has no connection to other floors, where occupants has a choice to either discharge directly to education building or to access the corridor of third floor in the same building.

## 3.5 Exit Arrangement

### *3.5.1 Number of exits*

According to Table 7.4.1.2 of LSC 2015, areas that have occupant load less than 50 persons are allowed to be served with only one exit, and areas with occupant load exceeds 50 and less than 500 should have at least two exits. All spaces inside the building meets the requirements of LSC 2015. The highest occupant load is on the second floor with more 50 than and less than 500. There should be at least two means of egress. The number of exits on the second floor and other floors meets and exceeds the requirements stated by LSC 2015.

### *3.5.2 Arrangement of exits*

According to Table 7.5.1.3.2 of the LSC 2015, whenever two exits are existing they shall be located at a distance from one another not less than one-half the length of the maximum overall diagonal dimension of the building or area to be served. However, the longest diagonal is

approximately 203 ft. on the third floor (as shown in Figure 21). The farthest two exits in that floor are separated by 165 ft. which is more than 101.5 ft.(0.5X203).


**Figure 21** Representation of the diagonal in the third floor

### *3.5.3 Horizontal Exits*

As it is stated in Section 3.3.83.1 of the LSC 2015, a horizontal exit is a way of passage from one building to another building on approximately the same level. The horizontal exits inside any building provide an additional means of egress and increases the exit capacity. In business building, there are three horizontal exits serving the building on the second and third floors. The horizontal exits meet the requirements of Section 7.2.4.3 of the LSC 2015 in terms of fire barriers.

## 3.6 Corridors

Corridors in the Orfalea College of Business building are 1-hour fire resistance rated, and have a minimum width of 44 inches, which meets the requirements of LSC 2015. The Corridor on the fourth floor has numerous trash cans in the walkway (as shown in Figure 22). I have measured the corridor width with these trash cans to ensure that corridor is within the limitation of 44” width. I found the width is 45.5”, which is above the minimum width.

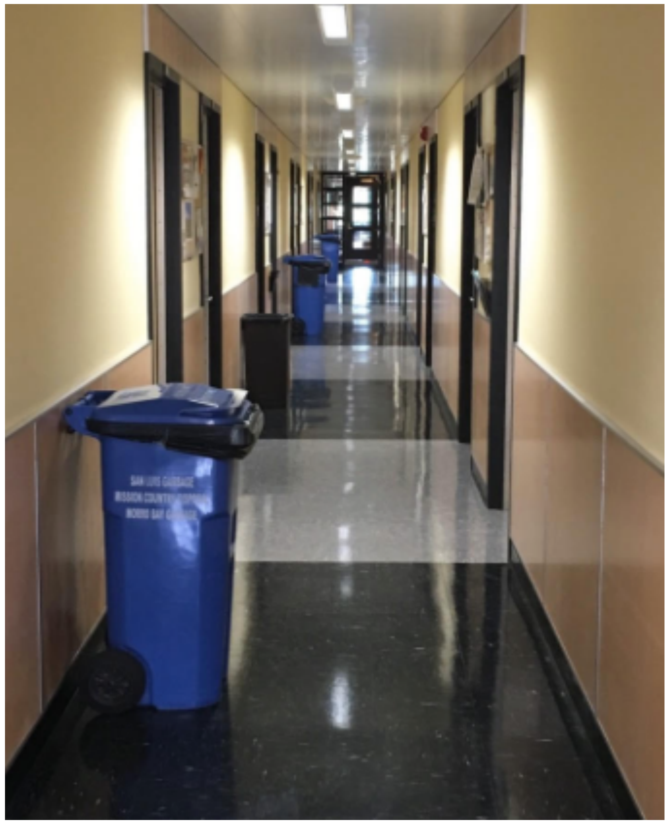


**Figure 22** Corridor on the fourth floor

## 3.7 Travel Distances

***Table 6*** *Travel distance limits*

| | Common Path Limit | | | | Dead-End Limit | | | | Travel Distance Limit | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unsprinklered | | Sprinklered | | Unsprinklered | | Sprinklered | | Unsprinklered | | Sprinklered | |
| Type of Occupancy | ft | m | ft | m | ft | m | ft | m | ft | m | ft | m |
| **Assembly** | | | | | | | | | | | | |
| New | 20/75 | 6.1/23[a] | 20/75 | 6.1/23[a] | 20 | 6.1[b] | 20 | 6.1[b] | 200 | 61[c] | 250 | 76[c] |
| Existing | 20/75 | 6.1/23[a] | 20/75 | 6.1/23[a] | 20 | 6.1[b] | 20 | 6.1[b] | 200 | 61[c] | 250 | 76[c] |
| **Business** | | | | | | | | | | | | |
| New | 75 | 23[l] | 100 | 30[l] | 20 | 6.1 | 50 | 15 | 200 | 61 | 300 | 91 |
| Existing | 75 | 23[l] | 100 | 30[l] | 50 | 15 | 50 | 15 | 200 | 61 | 300 | 91 |

In the business building, two occupancies assembly and business are included. The travel distance limits for them will be followed according to Table A.7.6 of the LSC 2015, which is represented in this report by Table 6. For travel distances, the limit is 200 ft. for unsprinklered buildings. All

areas inside this building meet this requirement; however, Table 7 represents the highest travel distances inside the building for each occupancy.

***Table** 7 Travel distances*

| TRAVEL DISTANCE | | | | | |
|---|---|---|---|---|---|
| **Room** | **Floor** | **Occupancy** | **Distance (ft)** | **Limit (ft)** | **Status** |
| 209 | Second | Assembly | 110 | 200 | OK |
| 329 | Third | Business | 111 | 200 | OK |

## 3.8 Common Path of Travel

Section 3.3.42 of LSC 2015, defines common path of travel as "The portion of exit access that must be traversed before two separate and distinct paths of travel to two exits are available". The limits of common path of travel are represented in Table A.7.6 of the LSC 2015. In the Business building, rooms 201, 204, 205 and 206 on the second floor represent the highest common path of travel in the building (as shown in Table 8). All rooms have a distance to reach a common path of travel more than the allowable distance for unsprinklered existing building.

*Table 8 Common Path of Travel Limits*

| Common Path of Travel | | | | | |
|---|---|---|---|---|---|
| **Room** | **Floor** | **Occupancy** | **Distance (ft)** | **Limit (ft)** | **Status** |
| 201 | Second | Assembly | 39 | 20 | Exceed |
| 204 | Second | Assembly | 40.5 | 20 | Exceed |
| 205 | Second | Assembly | 38 | 20 | Exceed |
| 206 | Second | Assembly | 37 | 20 | Exceed |
| 341 | Third | Business | 62 | 75 | OK |
| 301 B | Third | Business | 35 | 75 | OK |

## 3.9 Exit Signs

According to Section 7.10.1.2.1 of LSC 2015, exits, other than main exterior exit doors that obviously and clearly are identifiable as exits, shall be marked by an approved sign that is readily visible from any direction of exit access. Figures 23 and 24 show two locations that should have been marked by an exit signs in the building.

**Figure 23** Corridor on Third Floor.

Figure 23 shows a view from the third floor corridor where the exit sign of the exit door is not visible.

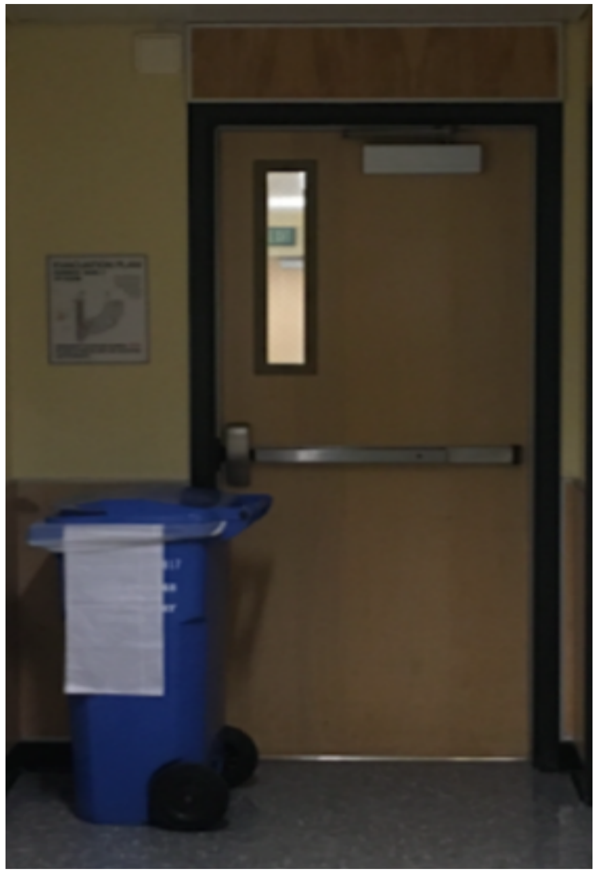


**Figure 24** Exit door to horizontal exit

Figure 24 shows the exit door that leads to the horizontal exit enclosure on the third floor, with no exit sign to mark it. All other locations on building are in compliance with LSC 2015 requirements.

## 3.10 Interior Finish

The building must meet the requirements of Section 7.1.4. of LSC 2015, interior finishes in exit, exit access, and other spaces. These requirements are summarized in Table 9.

***Table 9*** *Requirements for Interior Finishes*

| Use | Exits | Exit Access and Corridors | Other Spaces |
|---|---|---|---|
| Assembly – Existing > 300 occupant load | A | A or B | A or B |
| Business – Existing | A or B | A or B | A or B or C |

The ratings used in the Table 9 are summarized below;

- Class A interior wall and ceiling finish — flame spread index, 0–25 (new applications); smoke developed index, 0–450.
- Class B interior wall and ceiling finish — flame spread index, 26–75 (new applications); smoke developed index, 0–450.
- Class C interior wall and ceiling finish — flame spread index, 76–200 (new applications); smoke developed index, 0–450.

Section 10.3 of LSC 2015 tells more about decorations and furnishings, which includes containers for waste or linen and mattresses and other products. Section 10.5.3 of LSC 2015 states that furnishings or decorations of an explosive or highly flammable character shall not be used.

## 3.11 Total Building Movement Time

The total occupant load for each entire floor is given in Appendix A. These occupant loads will be used in an analysis to determine the total evacuation time for the Orfalea College of Business building.

***Table 10*** *Summary of building exit components*

| Component | Effective width, ft. | Specific Flow, p/ft*min | Flow Rate, p/min |
|---|---|---|---|
| | | **Second Floor** | |
| Main Stairway | 4.4 | 18.5 | 81.4 |
| Door into Main Stairway | 5 | 24 | 120 |
| Southeast Stairway | 3.5 | 18.5 | 64.7 |
| Door into Southeast Stairway | 2 | 24 | 48 |
| Door through Horizontal Exit | 7 | 24 | 168 |
| Open Stairway | 1.67 | 18.5 | 30.9 |
| Door into Open Stairway | 5 | 24 | 120 |
| | | **Third Floor** | |
| Main Stairway | 4.4 | 18.5 | 81.4 |
| Door into Main Stairway | 5 | 24 | 120 |
| Southeast Stairway | 3.5 | 18.5 | 64.7 |

| | | | |
|---|---|---|---|
| Door into Southeast Stairway | 2 | 24 | 48 |
| Door through Horizontal Exit | 2 | 24 | 48 |
| | **Fourth Floor** | | |
| Main Stairway | 4.4 | 18.5 | 81.4 |
| Door into Main Stairway | 2 | 24 | 48 |
| Northeast Stairway | 3.5 | 18.5 | 64.7 |
| Southeast Stairway | 3.5 | 18.5 | 64.7 |
| Doors into Southeast and Northeast Stairways | 2 | 24 | 48 |

The hydraulic calculation procedure outlined in Chapter 59 of the SFPE Handbook will be used for this analysis. After calculating the occupant load for each space in the building, the characteristics of the limiting features of egress must be determined. A summary of the effective width, specific flow, and flow rate of each pertinent building component is given in Table 10.

The effective width of a component is equal to its nominal width minus twice the boundary layer width given in Table 59.1 in the SFPE Handbook. The boundary layer width given for stairwells is 6 inches, the boundary layer for a corridor is 8 inches, and the boundary layer for a door is 6 inches.

The typical door through a horizontal exit in second floor is 96 inches wide, so the effective width is 84 inches, or 7 feet. The door through a horizontal exit in third floor is 36 inches wide, so the effective width is 24 inches, or 2 feet. The doors into the northwest and southwest stairways are 36" wide, so the effective width is 24 inches, or 2 feet. The stairways themselves are either 65 for the main exit or 54 inches wide for northwest and southwest stairways, giving an effective width of 4.4 and 3.5 feet, respectively.

The specific flow of a component is calculated as:

$$F_S = D * v$$

where $F_s$ is specific flow, D is the density of the flow, and v is the velocity of the flow. The starting density of people on the floor will be assumed as the value that produces the maximum possible specific flow, 0.175 p/ft$^2$. This density value was taken from the SFPE Handbook, which recommends that this density be used for engineering designs.

The velocity of the flow is calculated as:

$$v = k - 2.86 * k * D$$

where k is the proportionality constant for egress components (SFPE Handbook, Table 59.2) and D is the density of the flow. For 7-11 stair treads, k is 212 ft/min. For a door, corridor, or walkway, k is 275 ft/min.

The flowrate is calculated as:

$$flow\ rate = F_S * effective\ width$$

Using these three equations above, the values in Table 10 were calculated.

## 3.12 Movement Time Calculation Procedure

To obtain an estimate of how long it would take to evacuate the entire building, the analysis in this section will focus on total evacuation. Occupants must use the stairways, horizontal exit to the education building, or the main exit enclosure to totally evacuate the building.

The flowrate through the typical horizontal exit door is 40 p/min, but the flow rate for the horizontal exit in the second floor is much higher with 160 p/min. The flowrate through stairway entrance/discharge doors is 48 p/min.

For stairways in northeast and southeast, the limiting egress component is the stairway entrance/discharge door, which has a lower flowrate than the stairway itself. For the stairways in northeast and southeast, the limiting egress component is the stairway, which has a lower flowrate than the entrance/discharge door.

The floor-to-floor vertical distance is 12 feet. Using a conversion factor of 1.85 (SFPE Handbook), this translates to an equivalent horizontal travel distance of 22.2 feet. Between each floor there is a 26 feet of landing that must also be traveled. At a velocity down the stairway of 105.9 feet/min.

$$\frac{48.2 \text{ feet of travel total}}{105.9 \text{ feet/min}} = 0.46 \text{ minutes}$$

In order to calculate the minimum required egress time, it will be assumed that occupants use each exit in the optimum balance. This means that the queue that forms at every exit dissipates at the same time, so that no one exit takes longer to evacuate people than any other exit. This will optimize egress time.

## 3.12 Hand Calculation

The fourth floor has an occupant load of 153 occupants, the third floor has 410 occupants, the second floor has 393 occupants, and the occupants on the first floor have a direct access to public way in each single room.

If the exits are used in the optimum balance, the egress time through each exit with its allocated occupant load will be the same for every floor. So for the fourth floor:

$$\frac{Northeast\ stairway\ occup.}{48\ p/min} = \frac{Southeast\ stairway\ occup}{48\ p/min} = \frac{Main\ stairway\ occup}{48\ p/min}$$

Northeast stairway occup+ Southeast stairway occup+ Main stairway occup = 153

Solving the equations above yields about 1.06 minutes for each egress component to evacuate its occupant load, if occupants are distributed among the egress components optimally.

For simplicity, it will be assumed that the entire occupant load from one floor must completely evacuate before the stairwells will evacuate anyone else from another floor. The effective time to

evacuation would be the same as if one entire floor evacuated before another.

For the third floor:

$$\frac{Horizontal\ exit\ occup}{48\ p/min} = \frac{Southeast\ stairway\ occup}{48\ p/min} = \frac{Main\ stairway\ occup}{81.4\ p/min}$$

Horizontal occup+ Southeast stairway occup+ Main stairway occup = 410

Solving the equations above yields about 2.3 minutes for each egress component to evacuate its allocated occupant load, if occupants are distributed among the egress components optimally.

For the second floor:

$$\frac{Horizontal\ exit\ occup}{168\ p/min} = \frac{Southwest\ stairway\ occup}{48\ p/min} = \frac{Open\ stairway\ occup}{30.9\ \ p/min} = \frac{Main\ stairway\ occup}{81.4\ p/min}$$

Horizontal occup+ Southwest stairway occup+ Open stairway occup+ Main stairway occup = 393

Solving the equations above yields about 1.19 minutes for each egress component to evacuate its allocated occupant load, if occupants are distributed among the egress components optimally.

The calculated movement time for all occupants to completely evacuate the building is 5.01 minutes.

It should be noted that several optimizing assumptions are inherent in this calculation, so this is the minimum possible evacuation time for the building. It is highly likely that the actual movement time would take longer than this. This calculation does not take into account the effect of a stairway or other exit being compromised during an evacuation, which could significantly increase the needed movement time. Also, it is virtually certain that occupants will not use the exits in an optimum balance as was calculated, which would also increase the needed movement time. This calculation simply gives an estimate of the minimum time needed to fully evacuate the entire building, if each exit is operational and the exits are used optimally.

## 3.13 Pathfinder Simulation Comparison with Hand Calculations

An evacuation simulation was built using the Pathfinder program to verify the hand calculated total building movement time. Figure 25 shows a screenshot from the Pathfinder model that was used. The widths of all exit components in the Pathfinder model match those found in the actual building. The actual occupant load of each floor was also reproduced in the Pathfinder model.

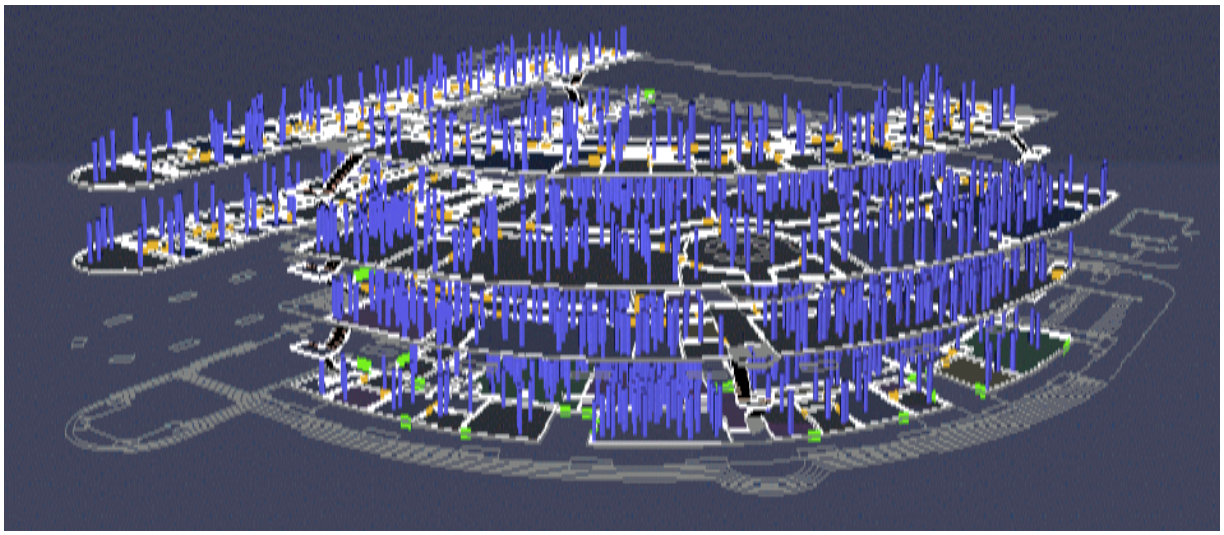


**Figure 25** Pathfinder model

As shown by Table 11, the evacuation times modeled in Pathfinder using both the SFPE and Steering calculation methods are close compared to the time calculated by hand.

***Table 11*** *Summary of Evacuation Time*

| Calculation Method | Total Building Evacuation Time |
|---|---|
| Pathfinder (SFPE calculation method) | 4.05 minutes |
| Pathfinder (Steering calculation method) | 5.12 minutes |
| Hand calculation | 5.01 minutes |

## 3.14 Pre-Movement Time

Besides the movement time calculated, the pre-movement time is another important component of total evacuation time. Pre-movement time for various buildings depends on the type of occupancy of the building. For example, residential buildings tend to have longer pre-movement times than office buildings, most likely because people spend time gathering important belongings or rounding up kids evacuating. Season will also play an important role, where many studies have shown that people showed a significantly longer time to start evacuate in cold weather which motivated many occupants to get their coats before leaving.

In an office building, people spend less pre-movement time because there aren't many valuable and important belongings to secure except perhaps a laptop or cell phone.

I used data for mid-rise office buildings, which were collected by Proulx and Fahy study[1] on pre-movement times. For a mid-rise office building, which resembles Building 3, the pre-movement times range from 0.36 seconds to 1.01 seconds, the value will be used is 48 seconds, since it is likely that the characteristics of the occupants resemble those of the other mid-rise office buildings studied.

## 3.15 Egress System Summary

In general, the egress system met code requirements with regards to how many exits the building has, where those exits are located, and how far people have to travel to get them and exit discharge. The building still has some issues with exit signs, common path of travel, and corridor obstructions. In the next parts of this report, means of fire protection used to protect occupants in the event of fire, including; water based suppression systems, fire alarm and detection systems, and structural fire protection will be discussed in more detail.

[1] Proulx, G. and Fahy,R.,"The Time Delay to Start Evacuation: Review of Five Case Studies".

# 4. Water-based fire suppression system

The time when the Orfalea College of Business Building was built, automatic fire sprinklers were not required, which is different from current standards and codes. The current water-based fire suppression system consists of three dry standpipes that are located in the stairwells of the building as well as a wet pipe system to connect fire hoses inside cabinets. The building is located around two miles from the nearest fire station, which is "San Luis Obispo Fire Station number two". The approximate time to response by the fire department and arrive is 10 to 15 minutes after the smoke detectors initiate. The accessibility of the building and removal of the fire hoses was taken into consideration to estimate this time.

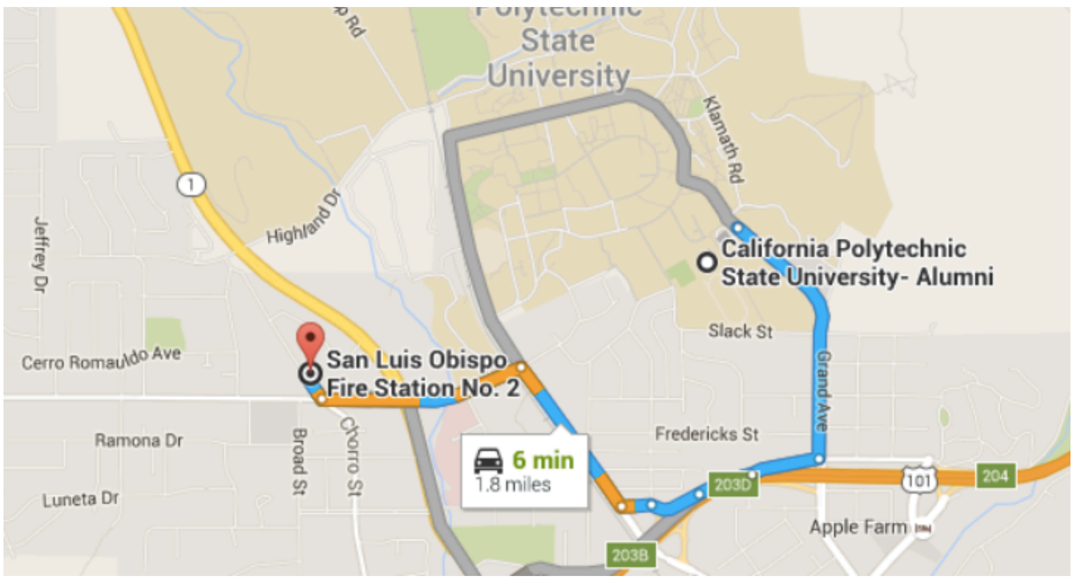



**Figure 26** Nearest fire station to the building (Google Maps)

A dry standpipes system has been installed in the stairs of the building for the purpose of connecting all four levels. Fire hose cabinets were installed in different locations of the building to give the ability for manual fire suppression. Later, these fire hoses were removed and replaced by fire extinguishers. All of these fire extinguisher should meet the standards of NFPA 10.

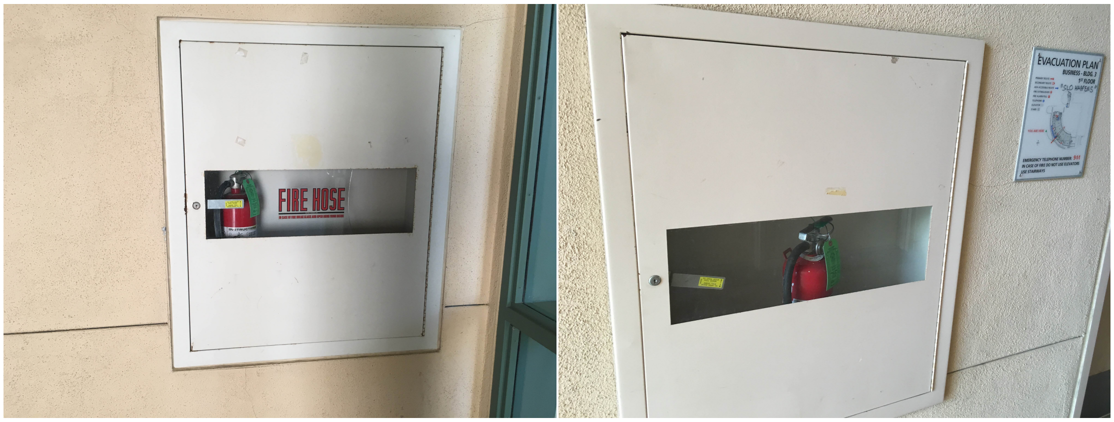



**Figure 27** Fire hoses replaced with fire extinguisher

The dry pipe system that currently serves Building 3 is sealed and has no pressure to limit unwanted particles from going throughout the system. The system relies on the fire department to charge the system through the fire department connections, or by using the valves in Room 117 in the first floor of the building. Originally, the water pressure was not adequate, and because of that there was a fire pump added to the system to provide enough pressure. Later on, campus received a new connection, which caused the added fire pump to be removed.

The sources of the water for this building are located on the first floor at the south of the building. However, as it is mentioned before, the source of the water for fire suppression system is located in Room 117. The fire hose cabinets in the business building have a 1.5” connection, while the fire risers have a 2.5” connection (as shown in Figure 28).

**Figure 28** Riser with 2.5” connection

## 4.1 Water Supply

Since the Orfalea College of Business building is currently unsprinklered, there is no available information for any flow test that has been done for the flow of the building. Because of that, the flow test for another building inside the campus of California Polytechnic State University will be used. The building is the Engineering 192. This building has business occupancy with light hazard classification, it consists of offices, classrooms, mechanical equipment, storage, the building has an area of 18,575 $ft^2$.

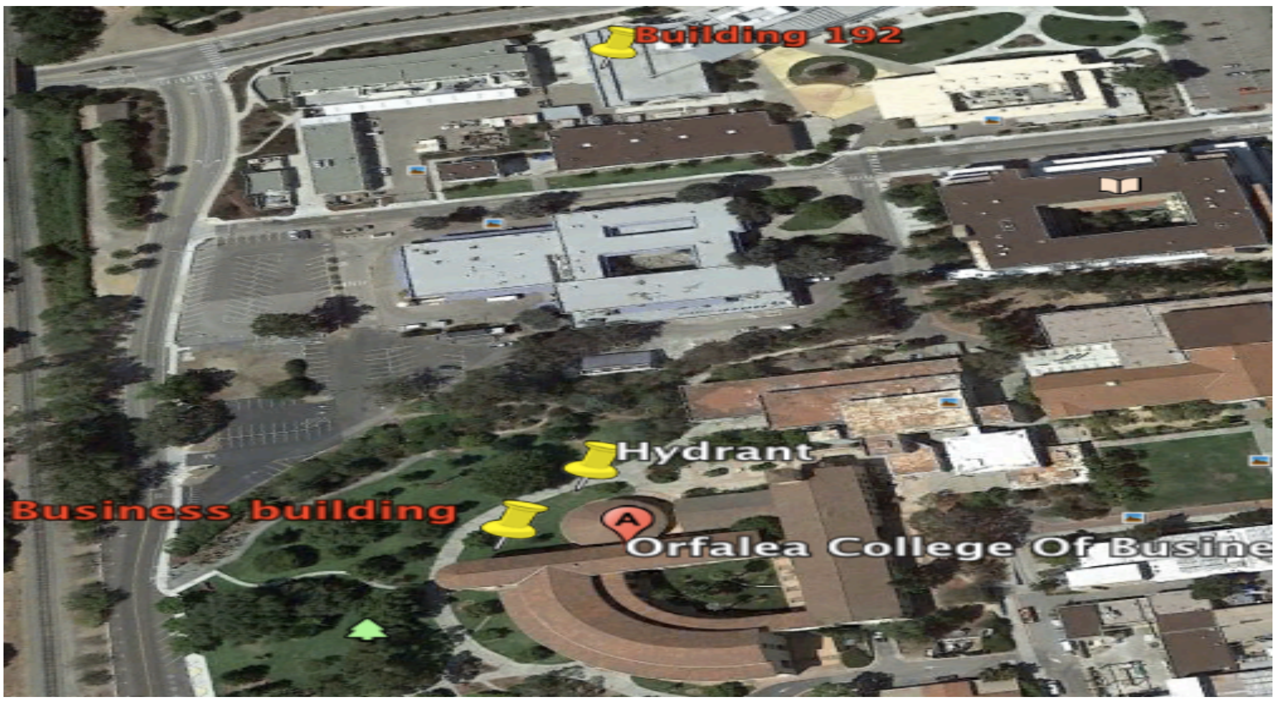



**Figure 29** Google earth screenshot shows the two different buildings

The water supply details are provided by a water flow test, which is summarized in Table 12.

***Table 12*** *Water supply details*

| Category | Value |
|---|---|
| Static pressure | 80 psi |
| Residual pressure | 60 psi |
| Water Flow | 1210 gpm |

## 4.2 Sprinkler System Design Criteria

The Orfalea College of Business building is not equipped with an automatic sprinkler system. The Room design method will be used to design a system for this building (NFPA 13, Section 11.2.3.3), where the water supply requirements for sprinklers only shall be based on the room that creates the greatest demand. However, all rooms shall be enclosed with walls having a fire-resistance rating equal to the water supply duration indicated in (NFPA 13, Table 11.2.3.1.2).

Since the Orfalea College of Business building is used mostly for educational uses and offices for faculty members, it will be classified as Light Hazard and will be protected with a wet pipe sprinkler system. The sprinkler heads will have 1⁄2-inch sprinkler orifice and nominal K-factor of 5.6 (NFPA 13, Section 8.3.4.1), with a maximum sprinkler coverage area of 225 square feet (NFPA 13, Table 8.6.2.2.1[a]). The sprinklers will be designed to provide a minimum density of 0.1 GPM/ft$^2$ for the design area of 1,500 square feet (NFPA 13, Figure 11.2.3.1.1). A hose stream demand of 100 GPM will be provided (NFPA 13, Table 11.2.3.1.2). The water supply will last for a duration of 30 minutes (NFPA 13, Table 11.2.3.1.2).

However, the Orfalea College of Business building also contains some rooms with high-powered electrical equipment, mechanical rooms, and lab storage spaces. The electrical and mechanical equipment spaces are expected to experience fires with moderate rates of heat release, and are classified as Ordinary Hazard Group 1 under (NFPA 13, Section 5.3.1.1). The storage spaces in the building are mainly used to store paper products, office supplies, and medical instruments and equipment, not exceeding 8 feet in height. Because the quantity of combustibles in these spaces is moderate, combustibility is low, and stockpiles of combustibles do not exceed 8 feet in height, the storage spaces are classified as Ordinary Hazard Group 1 under (NFPA 13, Section 5.3.1.1).

Areas classified as Ordinary Hazard Group 1 will be protected with a wet pipe sprinkler system, with 1⁄2-inch sprinkler orifice and nominal K-factor of 5.6 minimum, with a maximum sprinkler coverage area of 130 square feet (NFPA 13 Table 8.6.2.2.1[b]). The sprinklers will be designed to provide a minimum density of 0.15 GPM/ft$^2$ for the design area of 1,500 square feet (NFPA 13, Figure 11.2.3.1.1). A hose stream demand of 250 GPM will be provided (NFPA 13, Table 11.2.3.1.2). The water supply will last for a duration of 60 minutes (NFPA 13 Table 11.2.3.1.2), since all sprinkler system water flow alarm devices and supervisory devices are electrically supervised and monitored at an approved location (NFPA 13, Section 11.2.3.1.3).

Since the room density method is used, the area of the room with the greatest demand will be used. The room making the greatest demand is the largest room on the fourth floor, Room 401, with an area of 625 ft$^2$ (as shown in Figures 30 and 31).


**Figure 30** Location of the room with greatest demand in the floor plan


**Figure 31** Picture for the room with greatest demand in the building

Most of the rooms on the highest floor of the business building are used as faculty offices with an area not exceeding 105 ft. which is why they have only one sprinkler head. The risers will be at each stair in the floor. Figure 32 shows the closest riser to the room with the highest demand.

**Figure 32** Closest riser to room with greatest demand

## 4.3 Hydraulic Calculation Summary

Assumptions used for the hydraulic calculations are shown in Table 13.

***Table 13*** *Hydraulic calculation assumptions*

| Classification | Light Hazard |
|---|---|
| Pipes | All schedule 40 steel **C=120** |
| Cross Main | 3” |
| Minimum Discharge | 0.10 |
| Riser | 4” |
| Branch lines | 1,1.25,1.5 |

***Table 14*** *Hydraulic calculation results*

| | |
|---|---|
| **CALCULATION DESIGN INFORMATION** | |
| AREA NAME | BUSINESS COLLEGE |
| HAZARD | LIGHT |
| DENSITY | 0.10 GPM/Sq.ft |
| AREA PER HEAD | 225 Sq.ft |
| HOSE ALLOWANCE | 100 GPM |
| DURATION | 30 min |
| **SYSTEM DEMAND** | |
| PRESSURE DEMAND | 62 psi |
| FLOW DEMAND | 163 GPM |
| FIRE PUMP REQUIRMENT | NOT REQURED |

Hydraulic calculation for the room with the greatest demand was performed using the hand calculation method. The calculated system demand is 163 GPM at a pressure of 62 psi. Figure 33 shows system demand and water supply curves. It can be seen that the system demand curve is well below the water supply curve, this is why the system does not need a fire pump.

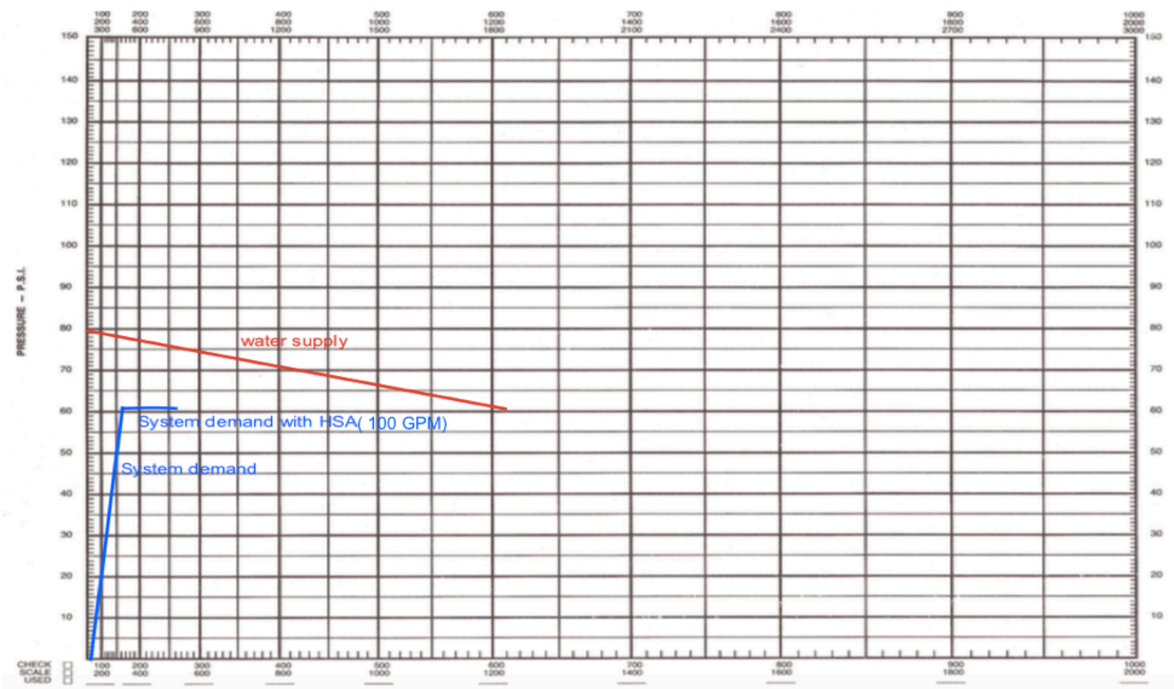



**Figure 33** Water supply and system demand curve

## 4.4 System Hardware and Installation Requirements

Where they are required, sprinklers will be installed throughout in accordance with NFPA 13. Only new sprinklers will be installed (NFPA 13 Section 6.2.1). A supply of at least six (6) spare sprinklers will be maintained on the premises so that any sprinklers that have operated or been damaged in any way can be promptly replaced (NFPA 13 Section 6.2.9.1). A minimum of two (2) sprinklers of each type and temperature rating should be provided (NFPA 13 Section A.6.2.9.1).

Underground pipe will not be permitted to extend into the building through the slab or wall not more than 24 inches (NFPA 13 Section 6.3.1.1.1). Schedule 40 black steel pipe will be used in aboveground portions of the system, and C150 Class 900 PVC plastic pipe will be used in underground portions of the system. Piping will meet the requirements of NFPA 13 Chapter 6.

All valves controlling connections to water supplies and to supply pipes to sprinklers will be listed indicating valves (NFPA 13 Section 6.7.1.3). A listed underground gate valve equipped with a listed indicator post will be permitted (NFPA 13 Section 6.7.1.3.1). Drain and test valves will be approved (NFPA 13 Section 6.7.3). Valves will be identified in accordance with NFPA 13 Section 6.7.4. The floor control valves and valves controlling flow to sprinklers in circulating closed loop

systems will be supervised by a central station (NFPA 13 Section 8.16.1.1.2.2).

The fire department connections to the system will consist of two (2) 2 1⁄2 inch connections using NH internal threaded swivel fittings (NFPA 13 Section 6.8.1), and will be of an approved type (NFPA 13 Section 6.8.3). The pipe size for the fire department connections will be a minimum of 4 inches (NFPA 13 Section 8.17.2.3).

The alarm apparatus for the wet pipe system used for the building will consist of a listed alarm check valve or other listed water flow detection alarm device with the necessary attachments required to give an alarm (NFPA 13 Section 6.9.2.1). An alarm unit will include a listed mechanical alarm, horn, or siren or a listed electric gong, bell, speaker, horn, or siren (NFPA 13 Section 6.9.3.1).

Signs will be attached to various components of the sprinkler system in accordance with (NFPA 13 Table A.6.10).

An approved pressure gauge will be installed in the system riser (NFPA 13 Section 7.1.1.1). Pressure gauges will also be installed above and below each alarm check valve or system riser check valve where such devices are present (NFPA 13 Section 7.1.1.2).

The wet pipe system will be provided with a listed relief valve not less than 1⁄2 inch in size and set to operate at 175 psi or 10 psi in excess of the maximum system pressure, whichever is greater (NFPA 13 Section 7.1.2.1). Provisions will be made to drain the system in accordance with NFPA 13 Section 8.16.2.4, and to flush the system in accordance with (NFPA 13 Section 8.16.3).

The alarm test connection for the system will be in accordance with (NFPA 13 Section 8.17.4.2). Sprinkler system piping will be hung, seismically braced, and restrained in accordance with Chapter 9 of NFPA 13.

## 4.5 Suppression System Inspection, Testing, and Maintenance Requirements

The inspection, testing, and maintenance (ITM) requirements for the Orfalea College of Business building sprinkler system are described below. The sprinkler system will be inspected, tested, and maintained in accordance with NFPA 25.

The property owner or designated representative will be responsible for properly maintaining the sprinkler system in the Building (NFPA 25 Section 4.1.1). ITM will be performed by qualified personnel (NFPA 25 Section 4.1.1.2). Where the property owner or designated representative is

not the occupant, the property owner or designated representative will be permitted to delegate the authority for ITM and the managing of impairments of the fire protection system to a designated representative (NFPA 25 Section 4.1.1.3). Where a designated representative has received the authority for ITM and the managing of impairments, the designated representative will comply with the requirements identified for the property owner or designated representative throughout NFPA 25 (NFPA 25 Section 4.1.1.4).

Where changes in the occupancy, hazard, water supply, building modification, or other condition that affects the installation criteria of the sprinkler system are identified, corrective action will be taken to evaluate the adequacy of the installed system to continue to protect the building (NFPA 25 Section 4.1.7.1). A summary of the components of the sprinkler system in the Building and their ITM frequencies in accordance with NFPA 25 are summarized in Table 15 below.

***Table 15*** *ITM requirements for sprinkler system*

| Components | Inspection | Testing | Maintenance |
|---|---|---|---|
| Pressure Gauges | **NFPA 25 2-2.4.1** - Shall be inspected monthly to ensure that they are in good condition and that normal water supply pressure is being maintained | **NFPA 25 2-3.2** - Gauges shall be tested or replaced every 5 years with a calibrated gauge. Gauges not accurate to within 3 percent of the full scale shall be recalibrated or replaced | **NFPA 25 2-3.2** - Gauges shall be tested or replaced every 5 years with a calibrated gauge. Gauges not accurate to within 3 percent of the full scale shall be recalibrated or replaced |
| Control Valves | **NFPA 25 9-3.3.2** - The inspection shall verify that the valves are in the following condition: (a) In the normal open or closed position. (b) Properly sealed, locked, or supervised. (c) Accessible (d) Provided with appropriate wrenches | **NFPA 25 9-3.4** - Each control valve shall be operated annually through its full range and returned to its normal position. | **NFPA 25 9-3.5** The operating stems of outside screw and yoke valves shall be lubricated annually. The valve then shall be closed and reopened to test its operation and distribute the lubricant. |

| | | | |
|---|---|---|---|
| Alarm Valve | **NFPA 25 9-4.1.1** - Alarm valves shall be externally inspected monthly. The valve inspection shall verify the following: (a) The gauges indicate normal supply water is being maintained. (b) The valve is free of physical damage. (c) All valves are in the appropriate open or closed position. (d) There is no leakage from the retartding chamber or alarm drains.<br><br>**NFPA 25 9-4.1.2** - Alarm valves and their associated strainers, filters, and restriction orifaces shall be inspected internally every 5 years unless tests indicate a greater frequency in required. | **NFPA 25 2-3.3.1** - Testing the waterflow alarms on wet pipe systems shall be accomplished by opening the inspector's test connection on a quarterly interval. | **NFPA 25 9-4.1.3.1** - Internal components shall be cleaned/repaired as necessary in accordance with the manufacturer's instructions. |
| Sprinklers | **NFPA 25 2-2.1.1** - Sprinklers shall be inspected from the floor level annually. Sprinklers shall be free of corrosion, foreign materials, paint, and physical damage and shall be installed in the proper orientation. Any sprinkler shall be replaced that is painted, corroded, damaged, loaded, or in improper orientation. | **NFPA 25 2-3.1.1** - Where sprinklers have been in service for 50 years, they shall be replaced or representative samples from one or more sample areas shall be submitted to a recognized testing laboratory acceptable the authority have jurisdiction for field service testing. Test procedures shall be repeated on a 10-year interval. | **NFPA 25 2-4.1.1** - Replacement sprinklers shall have the proper characteristics for the application intended. These include the following: (a) Style (b) Orifice size and K-factor (c) Temperature rating (d) Coating, if any (e) Deflector type (f) Design requirements. |

| | | | |
|---|---|---|---|
| Relief Valve | **NFPA 25 9-5.1.1** - All valves shall be inspected quarterly. The inspection shall verify that the valves are in the following condition: (a) In the open position (b) Not leaking (c) Maintaining downstream pressures in accordance with the design criteria (d) In good condition, with hand wheels installed and unbroken. | **NFPA 25 9-5.1.2** - A full flow test shall be conducted on each valve at 5-year intervals and shall be compared to previous tests results. If adjustments are necessary, they shall be in accordance with the manufacturer's instructions.<br><br>**NFPA 25 9-5.1.3** - A partial flow test adequate to move the valve from its seat shall be conducted annually. | All damaged or missing components noted during the inspections shall be repaired or replaced in accordance with the manufacturer's instructions. |
| Pipe and Fittings | **NFPA 25 2-2.2** - Sprinkler pipe and fittings shall be inspected annually from the floor level. Pipe and fittings shall be in good condition and free of mechanical damage, corrosion, leakage, loading, and misalignment. (Exception: Pipe and fittings installed in concealed spaces shall not be required to be inspected.) | | All damaged or missing components noted during the inspections shall be repaired or replaced in accordance with the manufacturer's instructions. |

## 4.6 Water-based Suppression System Summary

The Orfalea College of Business building is does not have an automatic fire sprinkler system. The current water based suppression system consists of three dry pipes and wet pipe. A Fire sprinkler system was designed for the building using room density method to find the system demand. The system demand was found adequate compared with the city water supply. The next part of this report discuss other means of fire protection (Fire Alarm and Detection System) that currently serves the building by providing early warning and notification to occupants.

# 5. Fire alarm system

The type of fire alarm system installed in the Orfalea College of Business building is a supervising station alarm system with a central station service in use. According to (NFPA 72, 3.3.281.1), a Central Station Service Alarm System is a system or group of systems in which the operations of circuits and devices are transmitted automatically to, recorded in, maintained by, and supervised from a listed central station that has competent and experienced servers and operators who, upon receipt of a signal, take such action as required by this Code. Such service is to be controlled and operated by a person, firm, or corporation whose business is the furnishing, maintaining, or monitoring of supervised alarm systems.

The first installation of the building was a Simplex Fire Alarm. Then, to establish a single and uniform system throughout the Cal Poly campus, another Alarm System was installed with Notifier. The fire alarm and detection system was not designed to provide a complete coverage throughout the building. The selective coverage for detection included hallways and mechanical rooms. The building was designed and constructed without fire sprinklers.

## 5.1 Operational Matrix

| | ANNUNCIATE ALARM CONDITION AT FIRE ALARM CONTROL PANEL | ACTIVATE HORNS & STROBES THROUGHOUT BUILDING | ACTIVATE SUPERVISORY ALARM AT FIRE ALARM CONTROL PANEL | ANNUNCIATE TROUBLE CONDITION AT FIRE ALARM CONTROL PANEL | RELEASE DOOR HOLDERS THROUGHOUT BUILDING | SHUT DOWN ASSOCIATED FAN UNIT | SEND ALARM SIGNAL TO CENTRAL STATION | SEND TROUBLE SIGNAL TO CENTRAL STATION |
|---|---|---|---|---|---|---|---|---|
| MANUAL PULL STATION | O | O | | | O | | O | |
| SMOKE DETECTOR | O | O | | | O | | O | |
| DUCT DETECTOR | O | O | | | | O | | |
| FLOW SWITCH | O | O | | | O | | | |
| TAMPER SWITCH | | | O | O | | | | O |
| SYSTEM TROUBLE | | | | O | | | | O |

OPERATIONAL MATRIX

**Figure 34** Operational matrix

As shown by the Figure 34, there are three different types of signal that can be produced by the fire alarm system; the types of inputs that produce alarm signals include any signals initiated by manual pull stations, fire detectors such as smoke and heat detectors, or other signals that indicate evidence of a fire. In the case of the Orfalea College of Business building, activation of any smoke or heat detector, and activation of any pull station initiates an alarm signal. Any of these inputs qualifies as an alarm signal since they all indicate the presence of a fire or evidence of a fire. Alarm signals produced by the Orfalea College of Business building fire alarm system are transmitted to a central station in accordance with NFPA 72 Section 26.3.8, and result in the activation of the building's notification appliances in accordance with NFPA 72, Section 10.12.1.

The types of inputs that produce trouble signals is identified by the operational matrix. A trouble signal in this system is any type of signal that represents that equipment is not responding as intended, except not in an alarm mode. This could be a fault in the system's wiring, an initiating or notification device malfunctioning, primary power failure, or another similar indication of poor electrical connection. Trouble signals produced by the Orfalea College of Business building alarm system are transmitted to a central station in accordance with (NFPA 72 Section 10.15.7), and are annunciated as trouble signals at the fire alarm annunciation panel.

## 5.2 Fire Alarm Control Panel

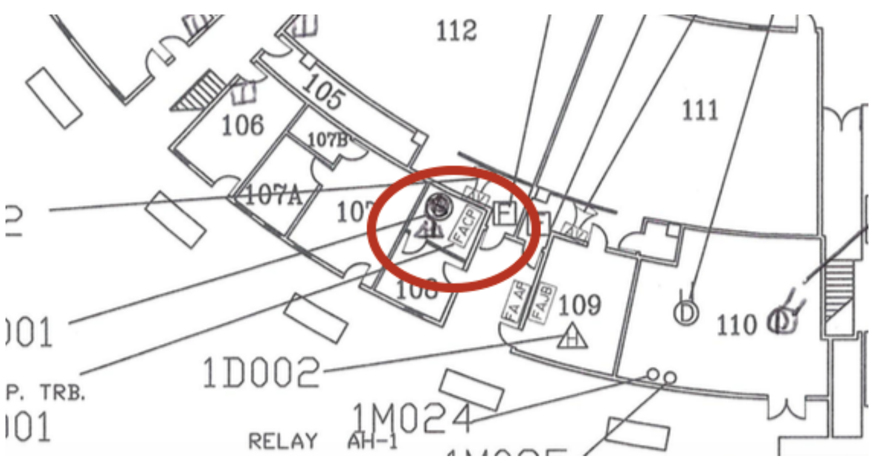



**Figure 35** Fire alarm control panel location

Notifier NFS2-640 FACP is located in the first floor of the building in Room 108, more specification is available with the data sheet attached in Appendix C.

## 5.3 Initiating Devices

The initiating devices utilized as part of the fire alarm system in the Building include manual pull stations, smoke detectors, and duct smoke detectors.

### *5.3.1 Manual Pull Stations*

According to NFPA 72, Section 17.14, each manual pull station is required to be securely mounted with the operable part not less than 42 inches (1.07 m), and not more than 48 inches (1.22 m) above floor level. Manual pull stations are also required to be located within 60 inches (1.52 m) of the exit doorway opening at each exit on each floor. Figure 36 shows the maximum distance for manual pull station from the floor and doorway that is located on the fourth floor.


**Figure 36** Spacing for manual pull station

Additional pull stations are required to be provided so that the travel distance to the nearest pull station will not be in excess of 200 feet (61.0 m), measured horizontally on the same floor, according to NFPA 72, Section 17.14. There are total of 15 manual pull stations used through the building covering the exit doorways and elevator lobbies. All of the manual pull stations around the building have sufficiently met the spacing requirements as per NFPA 72, Section 17.14. The highest travel distance from one manual pull station to another one is represented on the fourth floor with a distance of 165 ft. which well below the maximum distance of 200 ft.

### *5.3.2 Smoke Detectors*

According to NFPA 72, Section 17.7.3.2, Spot-type smoke detectors are required to be located on the ceiling, or wall mounted between the ceiling and 12 inches (300 mm) down from the ceiling to the top of the detector.

**Figure 37** Notifier Intelligent Plug-In Photoelectric Smoke Detectors

Notifier FSP-851 Intelligent Photoelectric Smoke Detectors were utilized in Building 3 typically in hallways at the end of corridors and elevator lobbies on the third and fourth floors, as well as to some large assembly classrooms and computer labs. Smoke detector located in elevator lobbies inside the building are shown in Figure 38. Smoke detectors are not installed either in the elevator lobby on the first nor second floors as those areas are open areas, and per NFPA 72 those areas not required to be covered.

**Figure 38** Elevator lobby with smoke detector

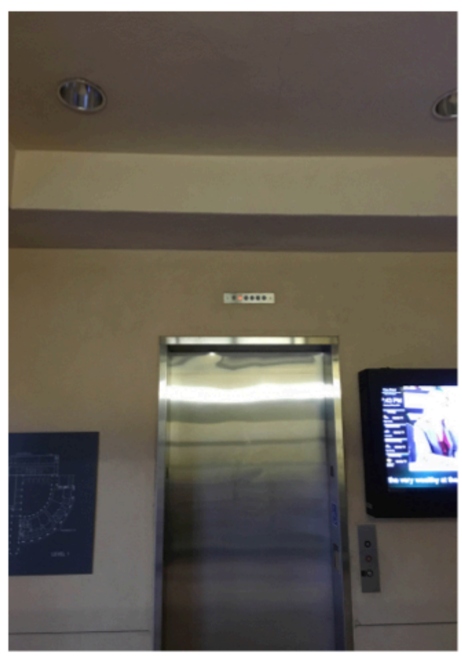


**Figure 39** Elevator lobby without smoke detector

### *5.3.3 Duct Smoke Detectors*

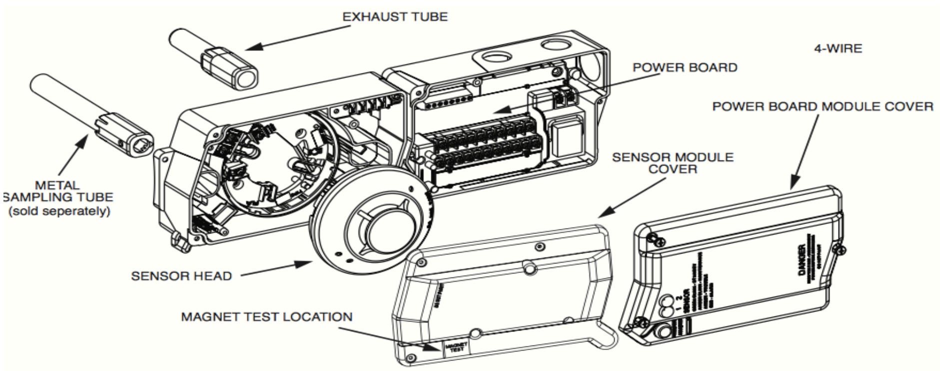



**Figure 40** Typical duct smoke detector

Five duct smoke detectors are used in the building. The primary purpose of duct smoke detection is to prevent injury, panic, and property damage by recirculation of smoke. According to NFPA 72 17.7.5.2.1 detectors that are installed in the duct system in accordance with NFPA 72 17.7.5.1 shall not be used as a *substitute for open area protection*.

### *5.3.4 Thermal Detectors*

**Figure 41** Model 5251P fixed temperature detector

Model 5251P is an intelligent sensor that utilizes a state-of-the-art thermistor sensing circuit for fast response. This sensor is designed to provide open area protection with 50 ft. spacing capability

and is intended for use with compatible control panels. In Building 3 there are a total of five detectors of this type located in FACP, Mechanical and storage rooms.

**Figure 42** 5451 Thermal detector

There is only one detector of 5451 plug-in rate-of-rise with fixed heat detector located in Building 3. Specifically, in the circular reception area that is located on the third floor of the building. This detector from Notifier comes with an activation temperature of 135 F$^{o}$ (57C$^{o}$).

### *5.3.5 Horn and Strobes*


**Figure 43** Gentex GEC3

A combination of audible/visible appliances are installed throughout the building. The location of the installed appliance is determined by the requirements for visible notification appliances (according to NFPA 72, 18.4.8.3).

Wall-mounted visible notification appliances are required to be mounted such that the entire lens is not less than 80 inches (2.03 m) and not greater than 96 inches (2.44 m) above the finished floor. Where low ceiling heights do not permit mounting at the minimum height, visible notification appliances are required to be mounted within 6 inches (150 mm) of the ceiling. Visible notification appliances are permitted to be either wall or ceiling mounted.

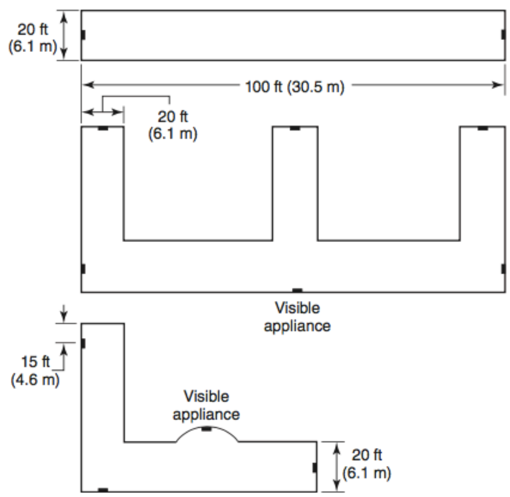



***FIGURE A.18.5.5.5*** *Corridor Spacing for Visible Appliances.*

**Figure 44** Corridor spacing for visible appliances

The installation of visible notification appliances in corridors are required to be located not more than 15 feet (4.57 m) from the end of the corridor with a separation not greater than 100 feet (30.5 m) between appliances.


**Figure 45** Gentex GEC3 at exit in 4th floor

There are a total number of 28 Gentex GEC3 in Building 3 at the exits and required location throughout the building.

## 5.4 Visual Requirements

Current visual devices use a candela rating of 75. This rating has the ability to cover a 45' by 45' room. In order to meet requirements every room requires at least one strobe device that is designed to cover the entire open space. The device in Room 300 on the third floor, is not meeting this requirement.

***Table 16*** *Room Spacing for Wall-Mounted Visible Appliances*

***TABLE 18.5.5.4.1(a)*** *Room Spacing for Wall-Mounted Visible Appliances*

| Maximum Room Size | | Minimum Required Light Output [Effective Intensity (cd)] | |
|---|---|---|---|
| ft | m | One Light per Room | Four Lights per Room (One Light per Wall) |
| 20 × 20 | 6.10 × 6.10 | 15 | NA |
| 28 × 28 | 8.53 × 8.53 | 30 | NA |
| 30 × 30 | 9.14 × 9.14 | 34 | NA |
| 40 × 40 | 12.2 × 12.2 | 60 | 15 |
| 45 × 45 | 13.7 × 13.7 | 75 | 19 |
| 50 × 50 | 15.2 × 15.2 | 94 | 30 |
| 54 × 54 | 16.5 × 16.5 | 110 | 30 |
| 55 × 55 | 16.8 × 16.8 | 115 | 30 |
| 60 × 60 | 18.3 × 18.3 | 135 | 30 |
| 63 × 63 | 19.2 × 19.2 | 150 | 37 |
| 68 × 68 | 20.7 × 20.7 | 177 | 43 |
| 70 × 70 | 21.3 × 21.3 | 184 | 60 |
| 80 × 80 | 24.4 × 24.4 | 240 | 60 |
| 90 × 90 | 27.4 × 27.4 | 304 | 95 |
| 100 × 100 | 30.5 × 30.5 | 375 | 95 |
| 110 × 110 | 33.5 × 33.5 | 455 | 135 |
| 120 × 120 | 36.6 × 36.6 | 540 | 135 |
| 130 × 130 | 39.6 × 39.6 | 635 | 185 |

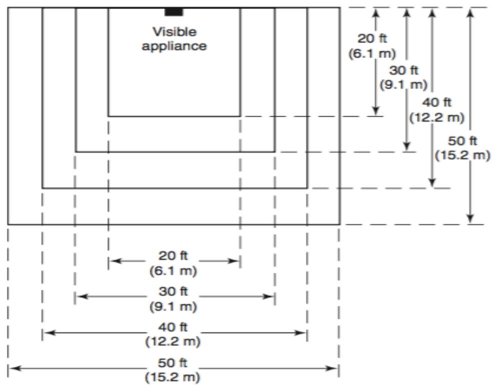



***FIGURE 18.5.5.4.1*** *Room Spacing for Wall-Mounted Visible Appliances.*

**Figure 46** Room Spacing for Wall-Mounted Visible Appliances

## 5.5 Audible Requirements

The current horn system has a dBA rating of 82 at 10 feet. According to (NFPA 72, Section 18.4.3) a 15 dBA above ambient is required. In addition, according to (NFPA 72, Table A.18.4.3) educational occupancies has an average ambient sound level of 45; therefore, from any location, a sound level of (45+15) = 60 dBA should be heard.

***Table 17*** *Average ambient sound level*

*TABLE A.18.4.3 Average Ambient Sound Level According to Location*

| *Location* | *Average Ambient Sound Level (dBA)* |
|---|---|
| Business occupancies | 55 |
| Educational occupancies | 45 |
| Industrial occupancies | 80 |
| Institutional occupancies | 50 |
| Mercantile occupancies | 40 |
| Mechanical rooms | 85 |
| Piers and water-surrounded structures | 40 |
| Places of assembly | 55 |
| Residential occupancies | 35 |
| Storage occupancies | 30 |
| Thoroughfares, high-density urban | 70 |
| Thoroughfares, medium-density urban | 55 |
| Thoroughfares, rural and suburban | 40 |
| Tower occupancies | 35 |
| Underground structures and windowless buildings | 40 |
| Vehicles and vessels | 50 |

## 5.6 Mass Notification System

According to NFPA 72, 24.5.1.2 in-building mass notification system shall include one or more of the following components:

- Autonomous control unit (ACU)
- Local operating console (LOC)
- Fire alarm control interface
- Notification appliance network
- Initiating devices
- Interface to other systems and alerting sources

This building is only installed with horns and strobes to be used with fire emergencies with no other component stated in NFPA 72 Section 24.5.1.2. The installed system within the building cannot be considered a mass notification system.

## 5.7 Smoke Management

Methods for designing smoke control include: material control by limiting materials that produce large quantities of toxic smoke, containment by containing smoke to area of origin through smoke control doors or smoke dampers, extraction by natural or mechanical means, pressurization differentials created to direct smoke movements from high pressure areas to areas of low pressure, and suppression by reduction of the fire size that results in reduced smoke production.

The building does utilize 28 smoke dampers;

- 4 on the First Floor
- 2 on the Second Floor
- 8 on the Third Floor
- 12 on the Fourth Floor
- 2 in the Silo

that are activated by fusible links to restrict the spread of smoke in the HVAC system. Also, fire and smoke rated doors working as barriers are an integral part of the smoke management system in the building. The building has 17 electromagnetic door holders, that are activated by smoke detector so the doors will close and smoke does not spread. When I visited the building, I figured out that the electromagnetic door holder used for the third floor main exit enclosure is not working properly, which might present a serious hazard in the event of fire.


**Figure 47** Location of improperly working electromagnetic door

## 5.8 Primary Power Supply

The branch circuit providing primary power to the fire alarm equipment will supply no other loads and be supplied by commercial light and power (NFPA 72 Section 10.6.5.1).

## 5.9 Secondary Power Supply

The secondary power system will automatically provide power to the fire alarm and emergency communication systems within 10 seconds whenever the primary power supply fails to provide the minimum voltage required for operation (NFPA 72 Section 10.6.6.1). Storage batteries dedicated to the system are permitted to supply secondary power to ensure required operation (NFPA 72 Section 10.6.6.3.1). The secondary power supply will have sufficient capacity to operate the system under quiescent load for a minimum of 24 hours and then will be capable of operating the system during a fire or emergency condition for a period of 15 minutes at maximum connected load. Battery calculations will include a 20 percent safety margin to the calculated amp-hour rating (NFPA 72 Section 10.6.7.2.1[1]). Battery charging will be in accordance with NFPA 72 Section 10.6.10.3.

The building's secondary power supply was determined by performing a battery calculation in accordance with NFPA 72 10.6.7.2.2 as shown in Table 18.

***Table 18** Secondary power supply*

| Description | Standby Current Per Unit (Amps) | | QTY | | Standby Current Per Unit (Amps) | Alarm Current Per Unit (Amps) | | QTY | | System Alarm Current (Amps) |
|---|---|---|---|---|---|---|---|---|---|---|
| FACU | 0.25 | X | 1 | = | 0.25 | 1.405 | X | 1 | = | 1.405 |
| Smoke Detector | 0.03 | X | 16 | = | 0.84 | 0.067 | X | 16 | = | 1.072 |
| Duct Smoke Detector | 0.026 | X | 5 | = | 0.13 | 0.087 | X | 5 | = | 0.435 |
| Heat Detector | 0.03 | X | 4 | = | 0.06 | 0.07 | X | 4 | = | 0.28 |
| Horn/Strobe | 0 | X | 28 | = | 0 | 0.176 | X | 28 | = | 4.928 |

| | |
|---|---|
| Total System Standby Current (Amps) | 1.28 |
| Total System Alarm Current (Amps) | 8.12 |

REQUIRED OPERATING TIME OF SECONDARY POWER SOURCE FROM NFPA 72 10.6.7.2.1

STANDBY: 24 HOURS ALARM: 5 MINUTES × 1/60 0.0833 HOURS

| Required Standby Time (Hours) | | Total System Standby Current (Amps) | | Required Standby Capacity (Amp-Hours) | | Required Alarm Time (Hours) | | Total System Alarm Current (Amps) | | Required Alarm Current (Amp-Hours) |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | X | 1.28 | = | 30.72 | | 0.0833 | X | 8.12 | = | 0.676 |

| Required Standby Capacity (Amp-Hours) | | Required Alarm Capacity (Amp-Hours) | | Total Required Capacity (Amp-Hours) | | Factor of Safety | | Required Battery Capacity (Amp-Hours) |
|---|---|---|---|---|---|---|---|---|
| 30.72 | + | 0.676 | = | 31.396 | X | 1.2 | = | 37.67 |

Information regarding the battery in the Business building was not found, however, it should maintain a capacity greater than the required battery capacity.

## 5.10 Inspection, Maintenance and Testing

The purpose for inspections is to ensure compliance with the approved design documents and to ensure installation is in accordance with NFPA 72 and other required installation standards. Visual inspections shall be performed in accordance with the schedules that can be found in NFPA 72 Table 14.3.1 or more often if required by authority having jurisdiction. Table 19 shows a portion of this table regarding initiating devices. System and associated equipment shall be tested according to NFPA Table 14.4.3.2. Other testing descriptions for initiating devices and alarm notification devices can be found below. System equipment must be maintained in accordance with the manufacturer's published instructions. The frequency of maintenance of system equipment will depend on the type of equipment and the local ambient conditions. The frequency of cleaning of system equipment will also depend on the type of equipment and the local ambient conditions. All apparatus requiring resetting to maintain normal operation shall be reset as promptly as possible after each test and alarm.

***Table 19*** *ITM requirements for sprinkler system*

| Component | Testing | Inspection | Maintenance |
|---|---|---|---|
| All equipment | Test components in accordance with NFPA 72 Table 14.4.3.2 | Annual visual inspection (NFPA 72 Table 14.3.1) | Ensure that there are no changes that affect equipment performance, i.e. building modifications, occupancy changes, device location, change in environment, physical obstructions, damage, cleanliness |
| Control equipment | Functions: Annual test<br><br>Fuses: Annual test<br><br>Lamps and LED's: Annual test<br><br>Primary power supply: Annual test | Fuses, interfaced equipment, lamps and LED's, primary (main) power supply: Annual visual inspection<br><br>(NPFA 72 Table 14.3.1)<br><br>Trouble signals: Semiannual visual inspection (NFPA 72 Table 14.3.1) | Verify a system normal condition<br><br>Verify correct receipt of alarm, supervisory, and trouble signals; circuit supervision; test secondary power system response |
| Digital alarm communicator transmitter (DACT) | Annual test | Annual visual inspection (NFPA 72 Table 14.3.1) | Verify location, physical condition, and a system normal condition |
| Batteries | Annual test | Semiannual visual inspection (NFPA 72 Table 14.3.1) | Inspect for corrosion, leakage, tightness of connections |
| Notification appliance circuit power extenders | Annual test | Annual visual inspection (NFPA 72 Table 14.3.1) | Verify fuse ratings, verify lamps and LED's indicate normal operating status |

| | | | |
|---|---|---|---|
| Duct smoke detectors | Annual test | Semiannual visual inspection (NFPA 72 Table 14.3.1) | Verify rigid mounting, no penetrations in duct near detector, confirm proper orientation |
| Manual fire alarm boxes | Annual test | Semiannual visual inspection (NFPA 72 Table 14.3.1) | Verify proper installation |
| Smoke detectors | Annual test | Semiannual visual inspection (NFPA 72 Table 14.3.1) | Verify proper installation  Test sensitivity, put into alarm condition and check response at control unit |
| Supervisory signal devices | Annual test | Quarterly visual inspection (NFPA 72 Table 14.3.1) | Verify proper installation  Test method depends on type of supervisory component tested |
| Fire alarm control interface | Semiannual test | Semiannual visual inspection (NFPA 72 Table 14.3.1) | Verify location and condition |
| Audible appliances | Annual test | Semiannual visual inspection (NFPA 72 Table 14.3.1) | Verify location and condition  Verify operation of notification appliances |
| Visible appliances | Annual test | Semiannual visual inspection (NFPA 72 Table 14.3.1) | Verify location and condition Verify that each appliance flashes |

## 5.11 Fire Alarm and Detection System Summary

The original detection system in the Business building was not providing a full coverage for the building. It mostly covered the end of corridors to activate the automatic doors, and cover the high hazards rooms like mechanical and electrical rooms were covered by a heat detector. In 2016, the coverage was expanded to cover large assembly rooms such as: classrooms and computer labs, as well as provide full coverage for fourth floor corridors. The notification system still only covers the corridors and the two largest areas, Room 300 and the Silo. In Room 300, the visual coverage does not meet the NFPA 72 requirement, while it is sufficient in the Silo. Since the building has no full coverage of alarm and detection system and no automatic fire sprinkler, it seems that the building relies largely on the passive structural features, which will be discussed in the next part of this report.

# 6. Structural Fire Protection

## 6.1 Structural Overview

The Orafale College of Business building is a four story building and has a circular lecture hall called “Silo”. The average height of each story is 10 feet with a height from floor to floor of 12 feet. The total height of the building from the front is 64 feet. The building is designed to be unsprinkelered. The materials used for construction are concrete blocks and structural steel. The building was built under the requirements of the UBC 1985 title 24, the construction is type II fire resistant. The structural frame, floors and shaft enclosures are designed to meet the UBC,1985, two-hour fire resistance rating. The exterior non-bearing walls used gypsum wall board or concrete for fire resistance.

## 6.2 Building Area

The Orafale college of business has a total area of 81,738 $ft^2$. Table 20 shows the area for each floor.

***Table 20*** *Building area*

| Floor | Area $ft^2$ |
|---|---|
| First Floor and Silo | 29,308 |
| Second | 16,730 |
| Third | 22,700 |
| Floor | 13,000 |
| Total | 81,738 |

## 6.3 Construction Type

To identify the allowable types of building construction that could be used for this building, IBC 2015 Table 504.3 for allowable building height and IBC 2015 Table 504.4 for allowable number of stories above grade plane will be used.

*Table 21* Allowable building height

| OCCUPANCY CLASSIFICATION | SEE FOOTNOTES | TYPE I A | TYPE I B | TYPE II A | TYPE II B | TYPE III A | TYPE III B | TYPE IV HT | TYPE V A | TYPE V B |
|---|---|---|---|---|---|---|---|---|---|---|
| A, B, F, M, S, U | NS[b] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 85 | 70 | 60 |
| H-1, H-2, H-3, H-5 | NS[c, d] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 50 | 40 |
| | S | | | | | | | | | |
| H-4 | NS[c, d] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 85 | 70 | 60 |
| I-1 Condition 1, I-3 | NS[d, e] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 85 | 70 | 60 |
| I-1 Condition 2, I-2 | NS[d, f, e] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | | | | | | |
| I-4 | NS[d, g] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 85 | 70 | 60 |
| R | NS[d, h] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 50 | 40 |
| | S13R | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 85 | 70 | 60 |

Based on the examination for Table 21, Types IIB, Type IIIB, and Types V were ruled out in terms of the building height types IA, IB IIA and IV HT are allowed. Table 22 will be used to identify the appropriate types based on the allowable number of stories.

*Table 22* Allowable number of stories

| OCCUPANCY CLASSIFICATION | SEE FOOTNOTES | TYPE I A | TYPE I B | TYPE II A | TYPE II B | TYPE III A | TYPE III B | TYPE IV HT | TYPE V A | TYPE V B |
|---|---|---|---|---|---|---|---|---|---|---|
| A-1 | NS | UL | 5 | 3 | 2 | 3 | 2 | 3 | 2 | 1 |
| | S | UL | 6 | 4 | 3 | 4 | 3 | 4 | 3 | 2 |
| A-2 | NS | UL | 11 | 3 | 2 | 3 | 2 | 3 | 2 | 1 |
| | S | UL | 12 | 4 | 3 | 4 | 3 | 4 | 3 | 2 |
| A-3 | NS | UL | 11 | 3 | 2 | 3 | 2 | 3 | 2 | 1 |
| | S | UL | 12 | 4 | 3 | 4 | 3 | 4 | 3 | 2 |
| A-4 | NS | UL | 11 | 3 | 2 | 3 | 2 | 3 | 2 | 1 |
| | S | UL | 12 | 4 | 3 | 4 | 3 | 4 | 3 | 2 |
| A-5 | NS | UL | UL | UL | UL | UL | UL | UL | UL | UL |
| | S | UL | UL | UL | UL | UL | UL | UL | UL | UL |
| B | NS | UL | 11 | 5 | 3 | 5 | 3 | 5 | 3 | 2 |
| | S | UL | 12 | 6 | 4 | 6 | 4 | 6 | 4 | 3 |
| E | NS | UL | 5 | 3 | 2 | 3 | 2 | 3 | 1 | 1 |
| | S | UL | 6 | 4 | 3 | 4 | 3 | 4 | 2 | 2 |

According to Table 22, Types IIB, Type IIIB, and Types V were ruled out in terms of the building height. Types IA, IB IIA and IV HT are allowed.

Section 506.3 of the IBC 2015 allows the building area increase, amount of increase regulated by section 506.3.3 as:

$$I_f = \left[\frac{F}{P} - 0.25\right] W/30 \quad \text{[ Equation 5-5] IBC 506.3.3}$$

where:

$I_f$ = Area factor increase due to frontage.

F = Building perimeter that fronts on a public way or open space having a minimum distance of 20 ft.

P = Perimeter of entire building (feet).

W = Width of public way or open space.

Since F/P = 0.5, and W/30= 1, $I_f$ = 0.25.

According to Section 506.2.4 of the IBC 2015, mixed-occupancy multistory buildings allowable area should be determined in accordance with the following equation:

$$A_a = [\,A_t + (NS\ x\ I_f)] \quad \text{[ Equation 5-3] IBC 506.2.4}$$

where:

$A_a$ = Allowable area ($ft^2$).

$A_t$ = Tabular allowable area factor in accordance with Table 506.2 of the IBC,2015.

NS= Tabular allowable area factor in accordance with Table 506.2 for nonsprinkled building.

$I_f$ = Area factor increase due to frontage (percent).

By using the allowable area factors for Types IIA and IV HT that found in IBC 2015 Table 506.2, the allowable areas found to be less than the actual area of the building. However, Types IA and IB have unlimited allowable areas factors that makes them the only two appropriate types for the Business building.

## 6.4 Structural Fire Protection Requirements

***Table 23*** *Requirement for structural element per IBC 2015*

| BUILDING ELEMENT | TYPE I | | TYPE II | | TYPE III | | TYPE IV | TYPE V | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | HT | A | B |
| Primary structural frame[f] (see Section 202) | 3[a] | 2[a] | 1 | 0 | 1 | 0 | HT | 1 | 0 |
| Bearing walls | | | | | | | | | |
| Exterior[e, f] | 3 | 2 | 1 | 0 | 2 | 2 | 2 | 1 | 0 |
| Interior | 3[a] | 2[a] | 1 | 0 | 1 | 0 | 1/HT | 1 | 0 |
| Nonbearing walls and partitions Exterior | See Table 602 | | | | | | | | |
| Nonbearing walls and partitions Interior[d] | 0 | 0 | 0 | 0 | 0 | 0 | See Section 602.4.6 | 0 | 0 |
| Floor construction and associated secondary members (see Section 202) | 2 | 2 | 1 | 0 | 1 | 0 | HT | 1 | 0 |
| Roof construction and associated secondary members (see Section 202) | 1 1/2[b] | 1[b,c] | 1[b,c] | 0[c] | 1[b,c] | 0 | HT | 1[b,c] | 0 |

The requirement for fire protection of the building structure and main element is shown in Table 23. For Type I-A, the primary structural frame of the building, interior and exterior load-bearing walls should have a fire resistance rating of 3 hours. For Floor construction and secondary members should have a rating of 2 hours. The roof construction and secondary members must have a rating of 1-1/2 hours. Interior walls and portions are not required to have a rating. Following the footnote for primary structural frame and bearing walls support a roof only rating can be reduced by maximum 1 hour.

According to the same Table 601 IBC 2015, for Type I-B the primary structural frame, interior and exterior bearing wall, floor construction and secondary members are required to have a rating of 2 hours. Interior non-bearing walls and portions are not required to be rated. However, the roof construction and secondary members are required to have a 1-hour rating.

## 6.5 Existing fire resistance rating

Table 24 shows the current status of the building as it was designed to meet the UBC 1985, followed by Figures 48,49,50 and 51 show floor plans with fire resistance rating of elements.

***Table 24** Building element status*

| Building Element | Status |
|---|---|
| Primary Structural Frame | 2 |
| Bearing walls exterior | 1 |
| Non-bearing walls and partitions interior | 0 |
| Non-bearing walls partitions exterior | 2 |
| Floor and secondary | 2 |
| Roof and construction | 1 |
| Shaft | 2 |
| Corridor | 1 |


**Figure 48** First floor resistance ratings

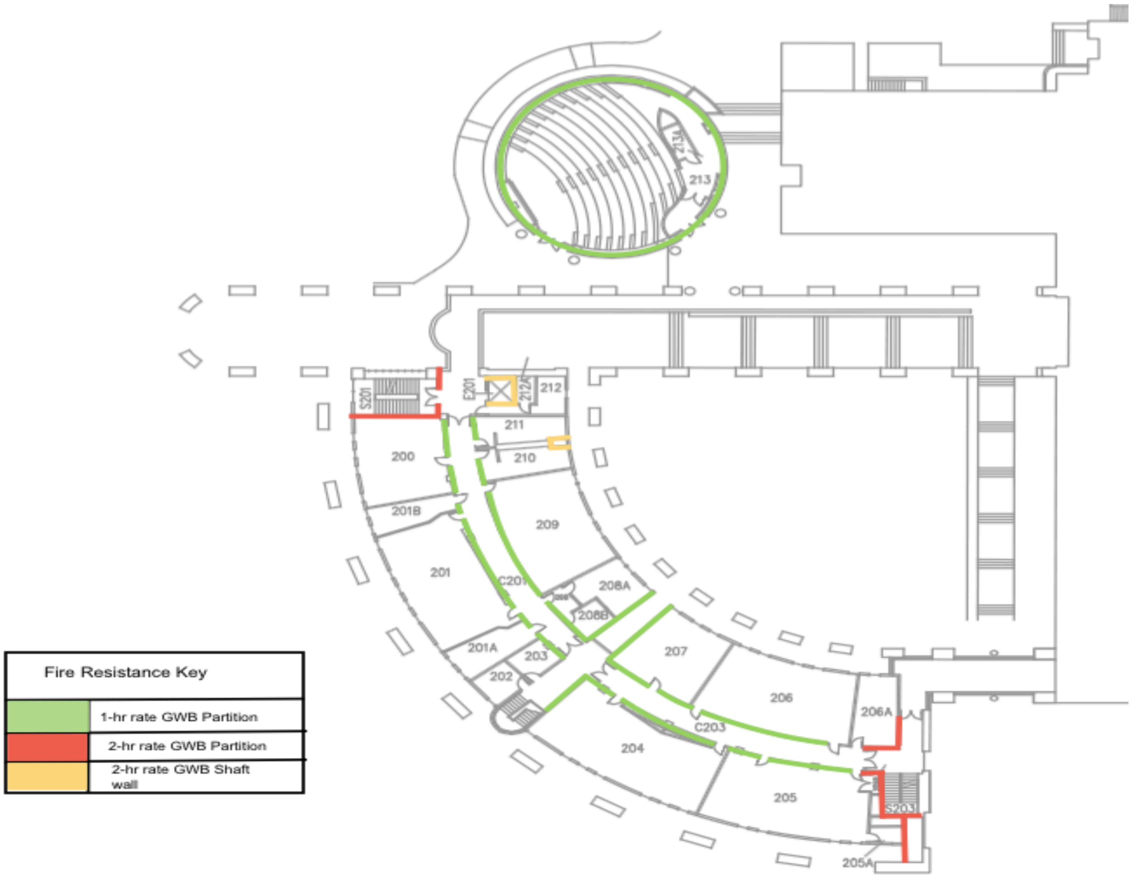



**Figure 49** Second floor resistance ratings


**Figure 50** Third floor resistance ratings


**Figure 51** Fourth floor resistance ratings

## 6.6 Fire Exposure

The Orfalea College of Business building and education building are adjacent as well as have two connecting levels. The actual separation between the buildings is 20 ft. Since the two buildings are located within the same community, 10 ft of separation must meet requirement for this distance. Table 25 shows the required rating for separation of 10 ft.

**Figure 52** Exterior exposure

***Table 25*** *Fire resistance rating for fire separation distance of 1o ft.*

| FIRE SEPARATION DISTANCE = X (feet) | TYPE OF CONSTRUCTION | OCCUPANCY GROUP H[e] | OCCUPANCY GROUP F-1, M, S-1[f] | OCCUPANCY GROUP A, B, E, F-2, I, R, S-2, U[h] |
|---|---|---|---|---|
| X < 5[b] | All | 3 | 2 | 1 |
| 5 ≤ X < 10 | IA<br>Others | 3<br>2 | 2<br>1 | 1<br>1 |
| 10 ≤ X < 30 | IA, IB<br>IIB, VB<br>Others | 2<br>1<br>1 | 1<br>0<br>1 | 1[c]<br>0<br>1[c] |
| X ≥ 30 | All | 0 | 0 | 0 |

IBC 2015, 705.8 allow for only 15% of exterior wall opening area for unsprinklered buildings with unprotected openings as shown in Table 26.

***Table 26*** *Fire resistance rating for fire separation distance of 10 ft.*

| FIRE SEPARATION DISTANCE (feet) | DEGREE OF OPENING PROTECTION | ALLOWABLE AREA[a] |
|---|---|---|
| 0 to less than 3[b, c, k] | Unprotected, Nonsprinklered (UP, NS) | Not Permitted[k] |
| | Unprotected, Sprinklered (UP, S)[i] | Not Permitted[k] |
| | Protected (P) | Not Permitted[k] |
| 3 to less than 5[d, e] | Unprotected, Nonsprinklered (UP, NS) | Not Permitted |
| | Unprotected, Sprinklered (UP, S)[i] | 15% |
| | Protected (P) | 15% |
| 5 to less than 10[e, f, j] | Unprotected, Nonsprinklered (UP, NS) | 10%[h] |
| | Unprotected, Sprinklered (UP, S)[i] | 25% |
| | Protected (P) | 25% |
| 10 to less than 15[e, f, g, j] | Unprotected, Nonsprinklered (UP, NS) | 15%[h] |
| | Unprotected, Sprinklered (UP, S)[i] | 45% |
| | Protected (P) | 45% |

The “Silo” in Orfalea College of Business building and education building are adjacent too. The actual separation between the building is 15 ft. Since the two building are located within the same community, 7.5 ft. of separation must meet requirement for this distance. Table 27 shows the required rating for separation of 7.5 ft.

***Table 27*** *Fire resistance rating for fire separation distance of 7.5 ft.*

| FIRE SEPARATION DISTANCE = X (feet) | TYPE OF CONSTRUCTION | OCCUPANCY GROUP H[e] | OCCUPANCY GROUP F-1, M, S-1[f] | OCCUPANCY GROUP A, B, E, F-2, I, R, S-2, U[h] |
|---|---|---|---|---|
| X < 5[b] | All | 3 | 2 | 1 |
| 5 ≤ X < 10 | IA | 3 | 2 | 1 |
| | Others | 2 | 1 | 1 |
| 10 ≤ X < 30 | IA, IB | 2 | 1 | 1[c] |
| | IIB, VB | 1 | 0 | 0 |
| | Others | 1 | 1 | 1[c] |
| X ≥ 30 | All | 0 | 0 | 0 |

IBC 2015, 705.8 allow for only 10% of exterior wall opening area for unsprinklered buildings with unprotected openings as shown in Table 28.

***Table 28*** *Fire resistance rating for fire separation distance of 10 ft.*

| FIRE SEPARATION DISTANCE (feet) | DEGREE OF OPENING PROTECTION | ALLOWABLE AREA[a] |
|---|---|---|
| 0 to less than 3[b, c, k] | Unprotected, Nonsprinklered (UP, NS) | Not Permitted[k] |
| | Unprotected, Sprinklered (UP, S)[i] | Not Permitted[k] |
| | Protected (P) | Not Permitted[k] |
| 3 to less than 5[d, e] | Unprotected, Nonsprinklered (UP, NS) | Not Permitted |
| | Unprotected, Sprinklered (UP, S)[i] | 15% |
| | Protected (P) | 15% |
| 5 to less than 10[e, f, j] | Unprotected, Nonsprinklered (UP, NS) | 10%[h] |
| | Unprotected, Sprinklered (UP, S)[i] | 25% |
| | Protected (P) | 25% |
| 10 to less than 15[e, f, g, j] | Unprotected, Nonsprinklered (UP, NS) | 15%[h] |
| | Unprotected, Sprinklered (UP, S)[i] | 45% |
| | Protected (P) | 45% |


**Figure 53** Silo Exterior exposure

## 6.7 Summary for Structural Fire Protection

The building was designed under the requirement of 1985 UBC, CAL title 24 to meet 2 hours rating of structural frames, floors and shaft enclosures as well as 1-hour rating for roof. The examination of this building under International Building Code 2015 identified that Type I-B meets these requirements.

The prescriptive analysis of this building has considered the design of egress, suppression, detection and alarm systems, in addition to the structural fire protection. The next section of this report will consider how these separate fire protection features would work together in a performance-based analysis.

# 7. Performance-Based Analysis

The performance-based analysis consisted of ensuring the fire protection systems for the Business building would perform under the most likely fire scenario. The system must provide protection for all occupants not intimate with the initial fire development. The Life Safety Code design fire scenario 6 will be used. It is described as: it is the most severe fire resulting from the largest possible fuel load characteristic of the normal operation of the building, and it addresses the concern regarding a rapidly developing fire with occupants present. For the scenario, the fire protection goal is to minimize fire related injuries. The stakeholder (building owner and AHJ) objective is to allow safe egress for all occupants outside the room of origin. The design objective is to maintain tenable conditions. The next part will discuss the tenability criteria for the likely scenario, or the conditions which occupants can be exposed to without being affected by the fire.

## 7.1 Tenability Criteria

The main goal of establishing these criteria is to ensure that any occupant who is not intimate with ignition will not be exposed to instantaneous or cumulative untenable conditions.

### *7.1.1 Visibility*

Visibility is an important factor as the absence of vision may cause delay or prevent escape from building and make people exposed to smoke longer time. Thus, finding and maintaining reasonable tenability range is an essential part to prevent any failure in any emergency event. Generally, occupants will not use any escape route when the visibility in the route is less than three meters. The well-known Japanese fire scientist Tadashia Jin, has categorized visibility distance based on the degree of familiarity with building: 13 m for unfamiliar people and 4 m for familiar people. Purser and McAllister's chapter in SFPE handbook 5th edition, visibility limit is based on the size of enclosure, with 10 m suitable for large enclosures and 5 m for small ones. A conservative value of 9 m will be used as tenability for the design in this report.

### *7.1.2 Toxic gases Exposure*

Asphyxiant gases, particularly CO2, HCN, and CO, incapacitate occupants by reducing their access to oxygen. CO interacts with hemoglobin in the blood to chemically reduce the body's access to oxygen, and affects occupants quickly even in low concentrations, According to SFPE Handbook 5$^{th}$ edition Table 63.9, for light human activity a value of 30,000-35,000 ppm.min will cause incapacitation, For such a fire scenario where CO concentration is below 3,500 ppm for 10 minute, incapacitation would not be expected as the total does would not exceed 35,000 pp.min. If concentration of CO gets above 3,500 the tenability criteria would be considered exceeded. For higher exposure time, when evacuation takes around 20 minutes, CO concentration of 35,000 pp.min/20 gives a limit of 1500 ppm; therefore, this limit is set the tenability criteria for CO

exposure.

### *7.1.3 Heat exposure*

In the SFPE 5$^{th}$ edition research from Dr. David Purser states that the temperatures above 121°C will cause pain, blisters, and burns. To be more conservative, the maximum threshold for heat exposure for the scenario analysis will be set at half of this value of 60 °C.

Table 29 shows different tenability thresholds used for the performance based analysis scenario.

***Table 29*** *Tenability Criteria*

| Tenability Criterion | Threshold Limit |
|---|---|
| Visibility | 9 m |
| Carbon Monoxide | 1,500 ppm |
| Temperature | 60 °C |

These values will be monitored in the simulations at a height of 6 feet (1.8m) above floor level. If any of these values are exceeded, the conditions in the building will be considered untenable thereby marking the end to the ASET.

## 7.2 Design Fire

The design fire scenario that will be chosen for the Orafale College of business building will be based on a hazard analysis considering the various types of spaces in the building and the types of commodities likely to be present in those spaces. The fire protection systems in place in those spaces will also be considered.

## 7.3 Design Fire Location

There are several storage rooms that contain cleaning supplies for the restrooms. These rooms are generally very small compared to other spaces in the building. Machinery rooms and electrical rooms in the building present a possible design fire scenario. The large mechanical and electrical rooms are located at end of each level and they contain high-powered electrical equipment and hot machinery that pose a greater ignition hazard than what is found elsewhere in the building. However, even though there is a greater ignition risk, these machinery and electrical rooms do not contain large quantities of combustibles and they are protected by heat detection devices. The classrooms and offices in building do not contain obvious high flammability fuel loads. The fuel load consists mainly of desks, chairs, paper products, limited quantities of plastics, and possibly small electronic appliances. The electronic appliances found in the offices may present a lower ignition risk than the machinery and electrical rooms, but the offices have a much denser fuel load. The particular space used for the design fires will be in the break room located on the fourth floor. This room has a greater fuel load compared to other places and does not have any automatic detection system. The door in this room is found to be always kept open allowing for possible smoke movement into the corridor.

## 7.4 Fire Burning Characteristics

The break room selected as the location for the design fire will contain a fuel load consisting primarily of desks, chairs, tables, paper products, and electronics such as, printers, and fax machines, and a three seat sofa consist of 90% polyurethane foam material. The selected fire represents the fire that could occur in the three seat sofa. The smoke will move through the open door that will affect the egress path in the corridor in of fourth floor. This three seat sofa does not meet the technical bulletin 133. Babraskus chapter (Ch.26 in SFPE Handbook 5$^{th}$ edition) was used to get the historical heat release rate for a similar configuration and materials used. The NIST fire test for a polyurethane three seat sofa (F32) gave a HRR of 3000 kW.

**Fig. 26.114** HRR of several upholstered furniture items tested at NIST

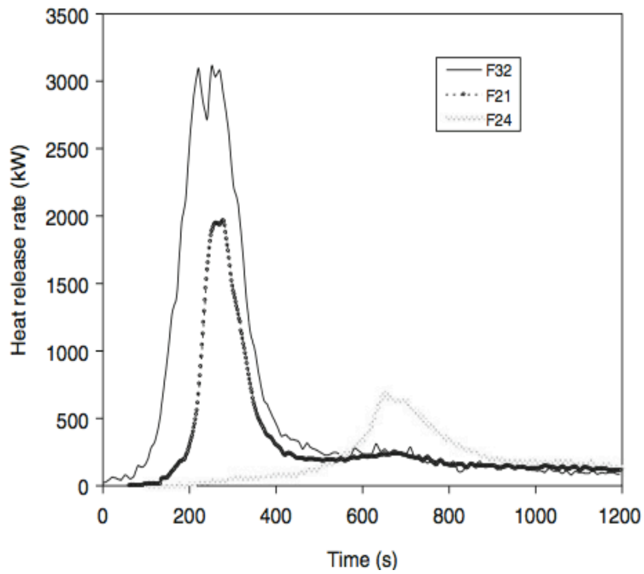



**Figure 54** Heat release rate for upholstered furniture.

The modeling for this fire is assumed to follow a $t^2$ fire with heat release coefficient value of 0.0469 $kW/s^2$. The soot yield values for a polyurethane fuel found in table A.39 in SFPE handbook 5th edition give a value of: 0.01 g/g. The CO yield is 0.04 g/g.

## 7.5 Pyrosim Modeling

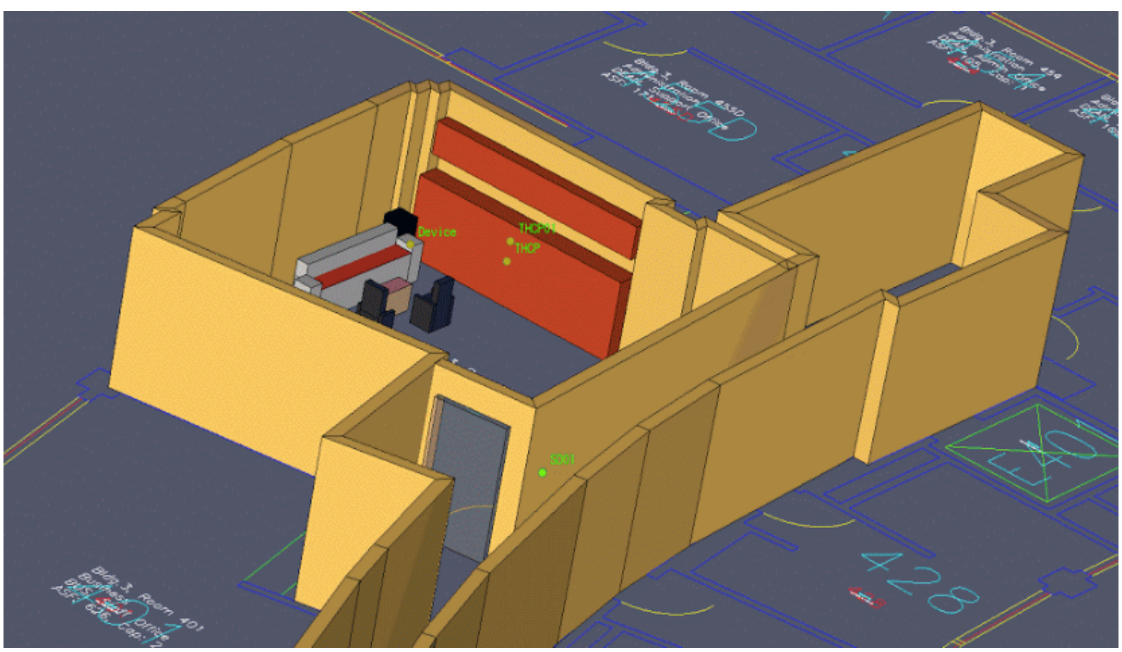



**Figure 55** Scenario 1 representation in Pyrosim.

The Pyrosim model of the fourth floor in the building includes the room of fire origin and the corridor. For simplicity, not all of furniture and combustibles were included in the Pyrosim model. All surfaces are modeled as inert, again, for simplicity and ease of calculation. If the thermal properties of every surface in the building were modeled, the calculation times would greatly increase.

The mesh sizes in the Pyrosim model were all set as cubes with dimensions of 0.25 m, for room and corridor of simulation. The chemical model of the design fires was inputted as the reaction, using a composition of 6.3 carbon, 7.1 hydrogen, 2.1 oxygen, and 1.0 nitrogen. A carbon monoxide yield of 0.04 and a soot yield of 0.1 were used. This model was run for the fourth floor to determine when the smoke detector in the corridor would activate. Finally, visibility, temperature, and carbon monoxide gas concentration slice files were included in the large-scale floor model, at 1.8 m above the walking surface.

## 7.6 Smoke Detector Activation

One of the important computer analysis result is the time when the smoke detector closest smoke detector to the room of the fire that located in the corridor activates. The photoelectric smoke detector activated at time of 38 seconds.

## 7.7 Tenability Analysis of the Design Fire

A summary of the findings of the design fire is shown below in Table 30. The only situation in which tenability was determined to be not violated in the model was the toxicity criterion in corridor. The visibility limit of 9 m along the corridor leading to the exit is violated at 42 seconds. A screenshot of the scenario is shown in Figure 56. The time when the visibility was violated at 42 seconds the temperature was still tenable in the corridor with temperature below 60 °C. The time when the temperature was violated along the corridor is 61.2 seconds as shown in Figure 57. Toxicity limit was not exceeded in the corridor along the time of simulation as shown in Figure 58.

***Table 30*** *Tenability Criteria results*

| **Scenario** | **Visibility** | **Thermal effect** | **Toxicity exposure** |
|---|---|---|---|
| Scenario #1 | Violated at 42 sec. | Violated at 61.2 sec. | Passed |

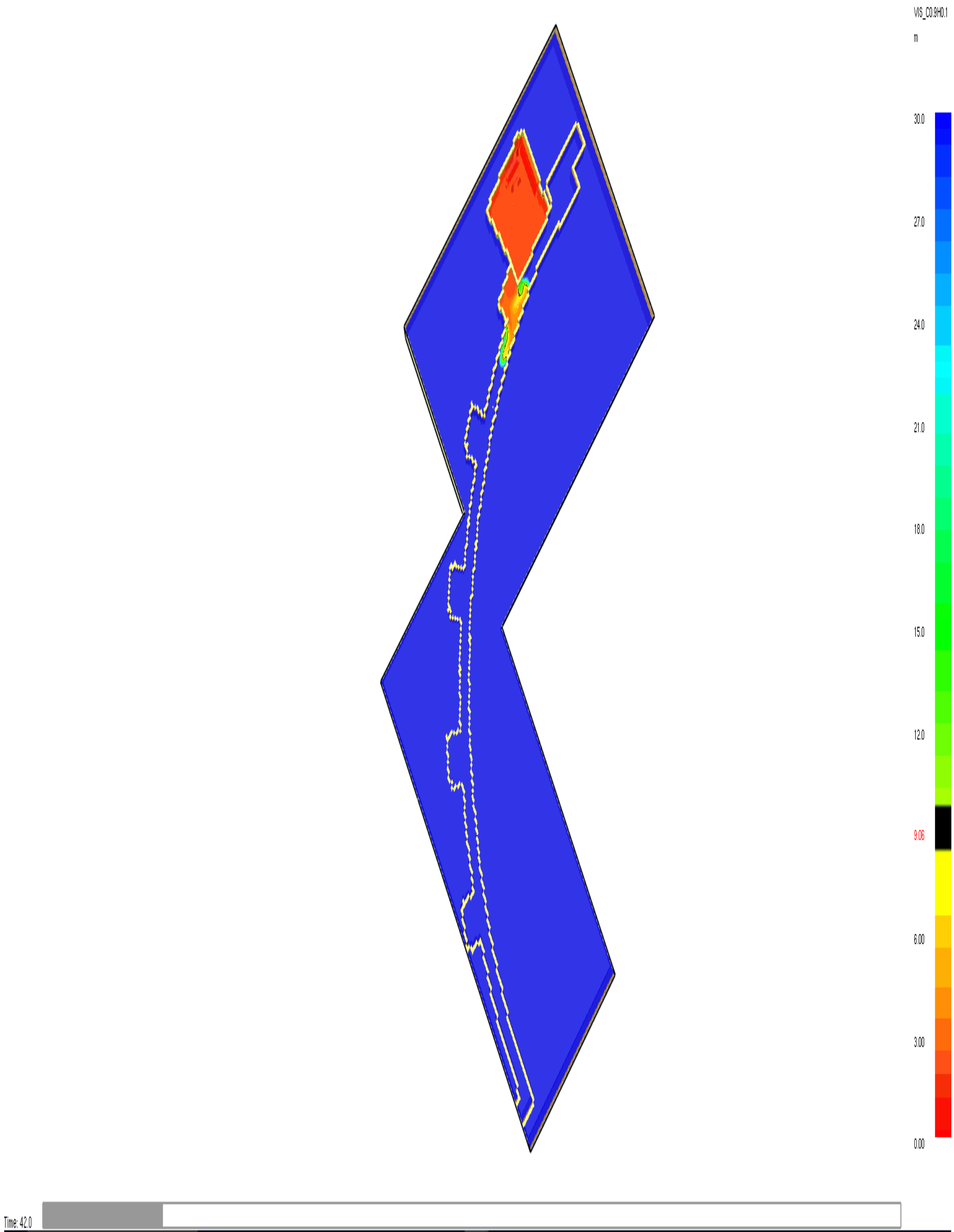



**Figure 56** Visibility violation time

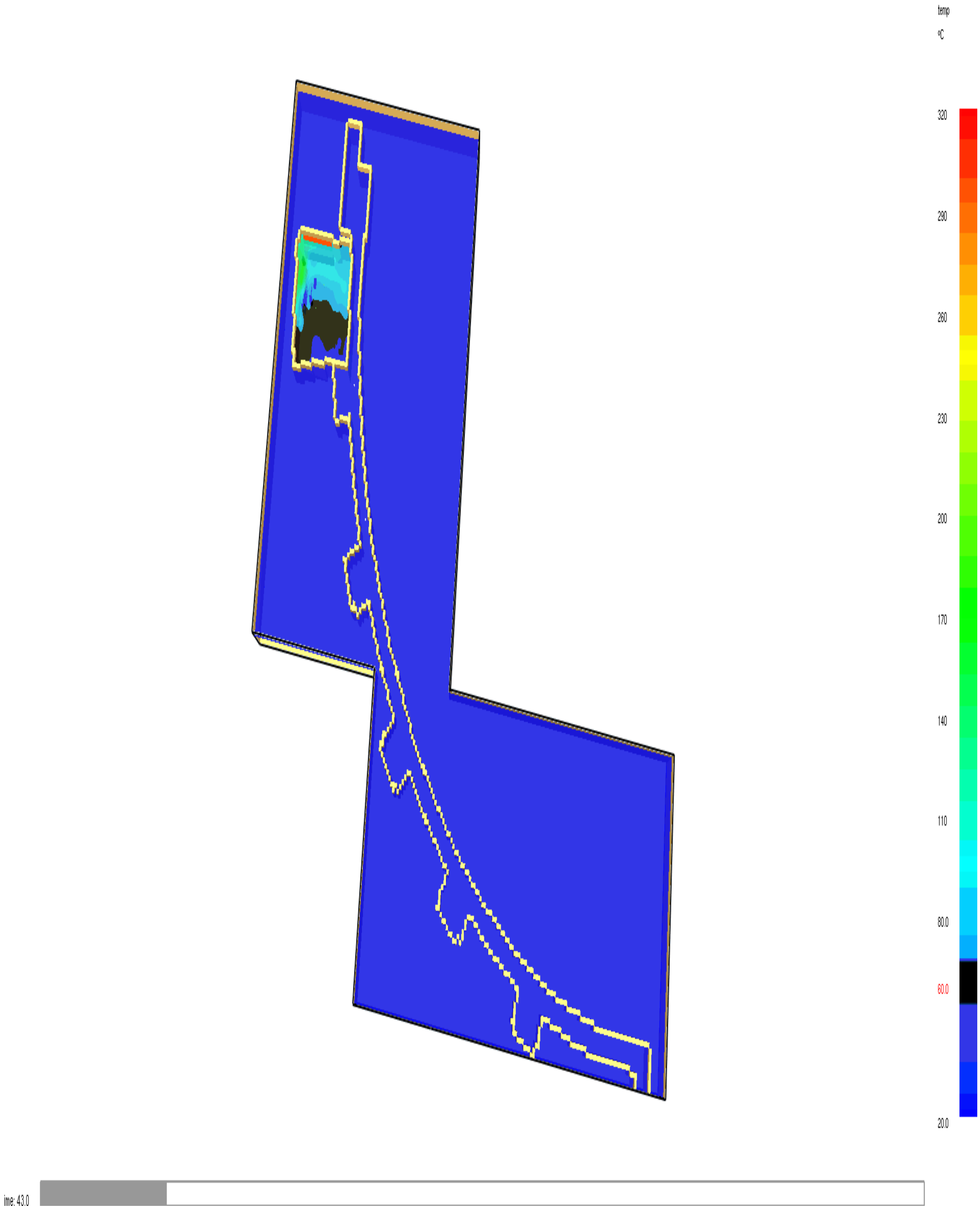



**Figure 57** Temperature at 42 seconds.

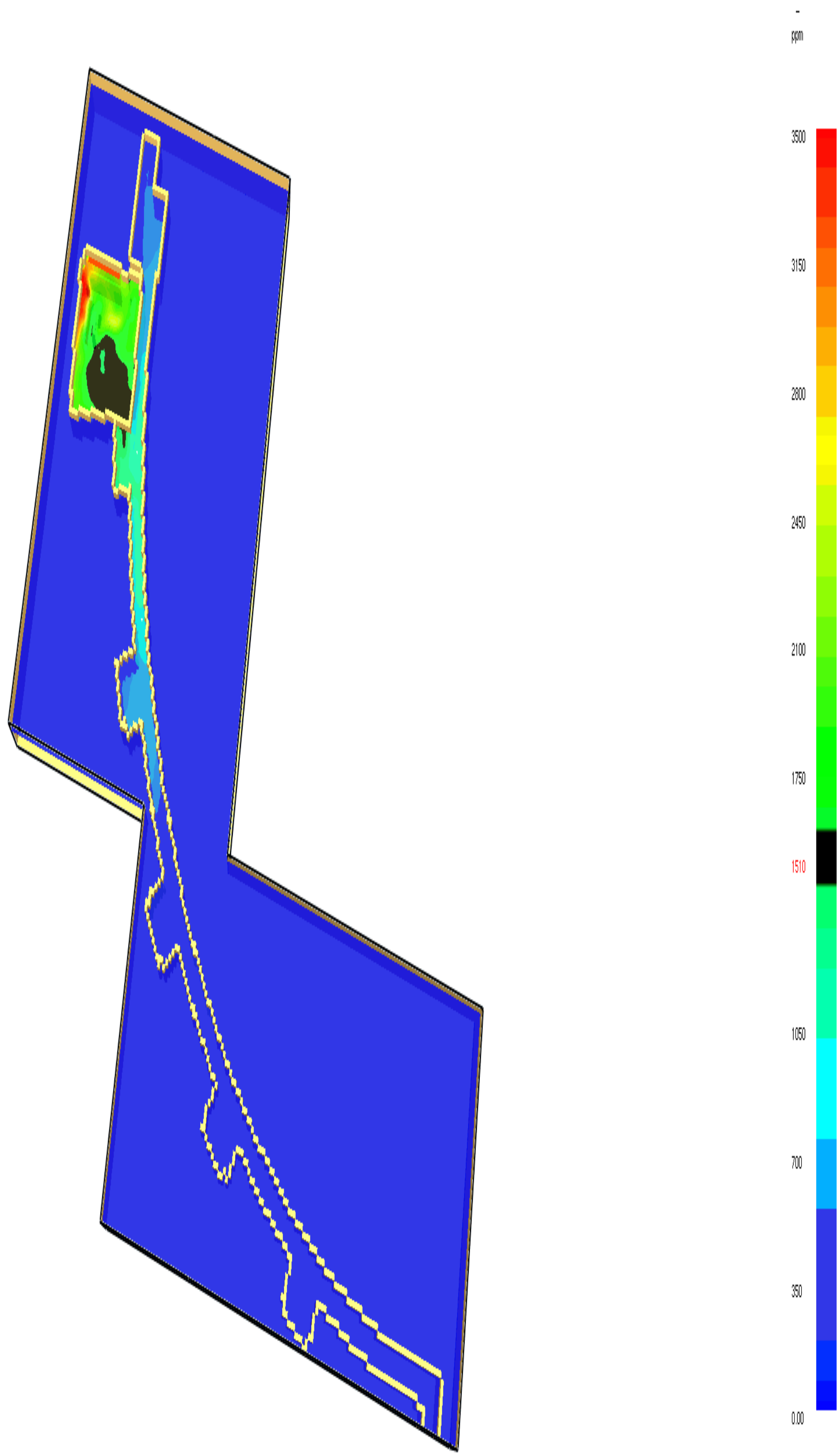



**Figure 58** Temperature violation time.

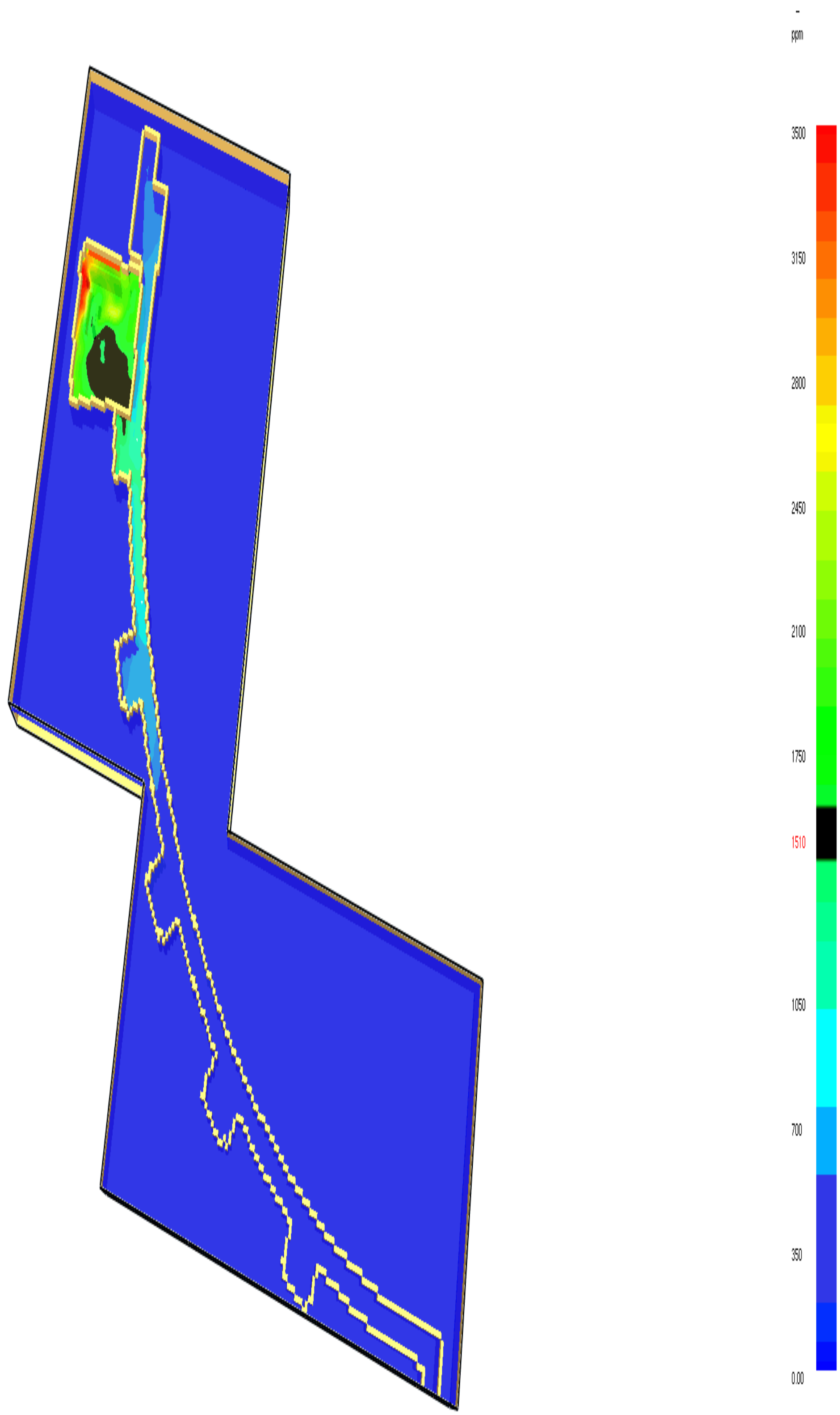



**Figure 59** Toxicity along the corridor at end of the simulation

## 7.8 RSET/ASET Summary

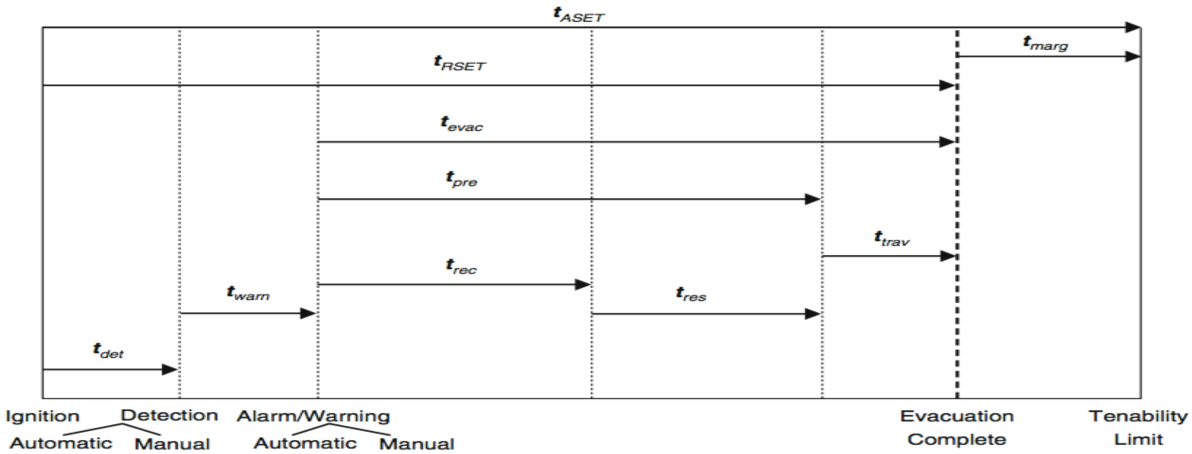



**Figure 60**. Required safe egress time. (SFPE handbook 5th edition)

The time when the smoke detection activates is 38 seconds, pre-movement time is 48 seconds, the movement time for the fourth floor is 80 seconds. The sum of these values gives the required safe egress time. The total RSET is equal to 166 seconds, while the first tenability criterion was violated at 42 seconds giving the ASET.

$$RSET = t_d + t_{warn} + t_{pre} + t_{evac}$$

where:

$t_d + t_{warn}$ = 38 seconds.

$t_{pre}$ = 36seconds.

$t_{evac}$ = 80 seconds.

RSET = 166 seconds X 1.5 (safety factor) = 249 seconds.

Since RSET > ASET, the building has **failed** to provide enough time for occupants on the fourth floor to evacuate safely without being affected by the fire.

## 7.9 Other possible scenario

For the other possible scenario in the Business building, the Life Safety Code scenario 1 will be followed. The scenario accounts for occupant activities, contents and furnishings, fuel properties and ignition sources and ventilation condition. Room 301 on the third floor was chosen for a design fire. It is used as a reception office and has a small auxiliary room contains electrical wires. It has different upholstered furnishings, tables and chairs. The room has two doors one to Room 300 and the other to the corridor (as shown in Figures 61), both are propped open. The room which has open door with is Room 300 (as shown Figure 62), used as student area and has set of computers, tables and chairs. The ignition source might be an overheated heated electric wire inside the auxiliary room, then an upholstered chair located in front of the auxiliary room to catch a fire. The propped open door makes high possibility of smoke movement to the corridor, where people could be prevented to reach the exit safely. The other concern is that the exit located on the third floor has its electromagnetic door holder works improbably. When the smoke detector in Room 301 activates the door will not be closed, which makes it possible to have the smoke spread into the exit enclosure.

**Figure 61** Two doors dropped open


**Figure 62** Room 300

## 7.9 Conclusion and Recommendation

This report represents a comprehensive evolution of the fire protection and life safety features of the Orfalea College of Business building under the requirements of the Life Safety Code 2015 and IBC 2015. The perspective analysis was first performed. The requirements for the egress system, water based suppression system, fire detection and alarm system, and structural fire protection were evaluated. The egress system met code requirements with regards to how many exits the building has, where those exits are located, how far people have to travel to get them and exit discharge, but it still has some issues with exit signs, common path of travel, exit and corridor obstructions. Signs should be provided on the missing locations. Obstructions should be removed from exits and corridors. The building has no automatic sprinkler suppression system, a design for sprinkler system based on the room with the largest demand was performed. It was found that the system demand meets the water supply and there is no need for a fire pump. The alarm and

detection system in the building does not provide a full coverage. In Room 300, the visual coverage does not meet the NFPA 72 requirement, and more devices are recommended to meet the coverage requirements. As a type I-B building, the building is compliant with IBC, 2015 requirements for structural fire protection. Following the prescriptive analysis, a performance-based analysis was conducted to investigate the ability of the fire protection and life safety features in the building to perform under challenging fire scenarios. Models using the Pathfinder and FDS computer programs were built, and a design fire scenario for a three seat sofa in a break room on the fourth floor was investigated. The required safe egress time is 249 seconds, and the visibility was violated at 42 seconds. The results of the fire scenario yield to a recommendation to use upholstered furniture in compliance with Technical Bulletin 133 to limit the heat release rates. Installation a smoke detector inside that room will have a reasonable impact for the system by reducing the time for the smoke activation compared to current situation where the nearest smoke detection is located within the adjacent corridor. However, another important factor in the system failure is that the door in that room is kept open while it was originally designed to stay closed to prevent the smoke movement.

# Appendix A

- First Floor Occupant Load.
- Second Floor Occupant Load.
- Third Floor Occupant Load.
- Fourth Floor Occupant Load.

Business 0030 Floor1

Figure 63 First Floor Occupant Load

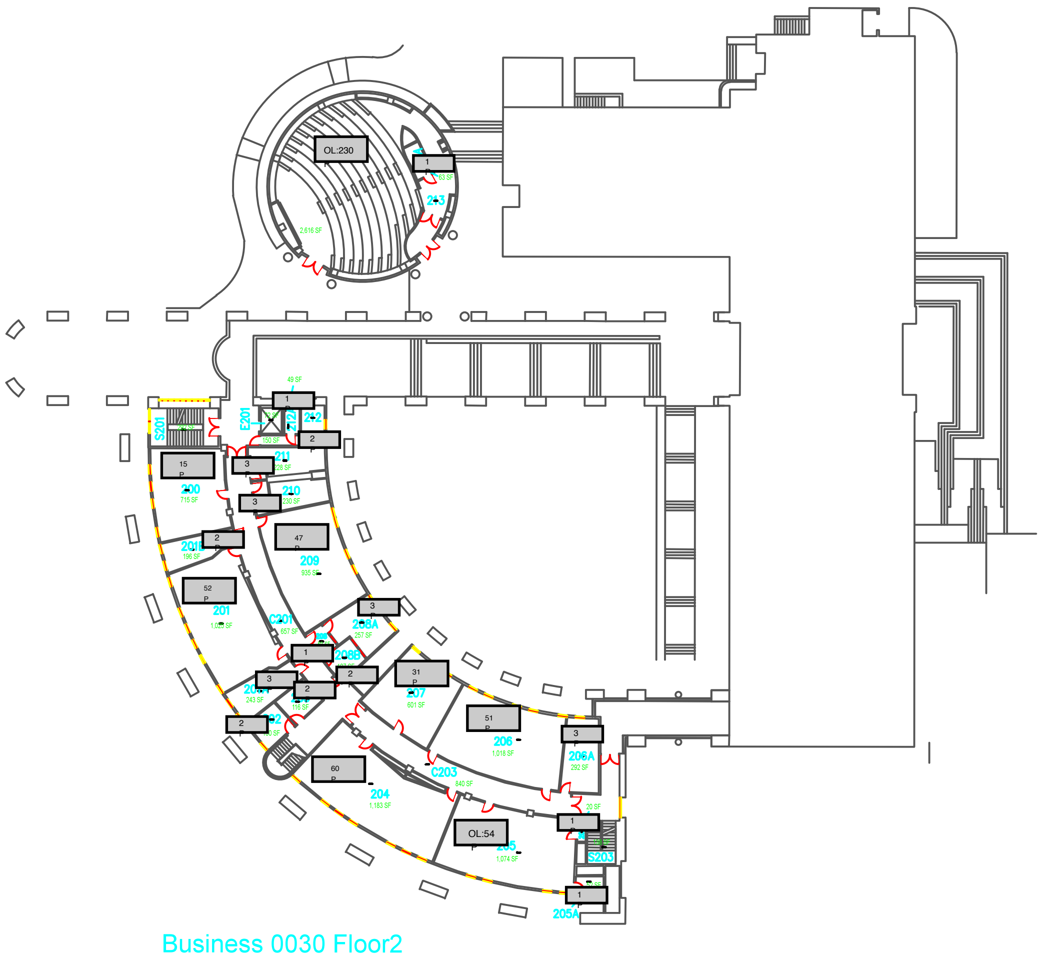



Figure 64 Second Floor Occupant Load

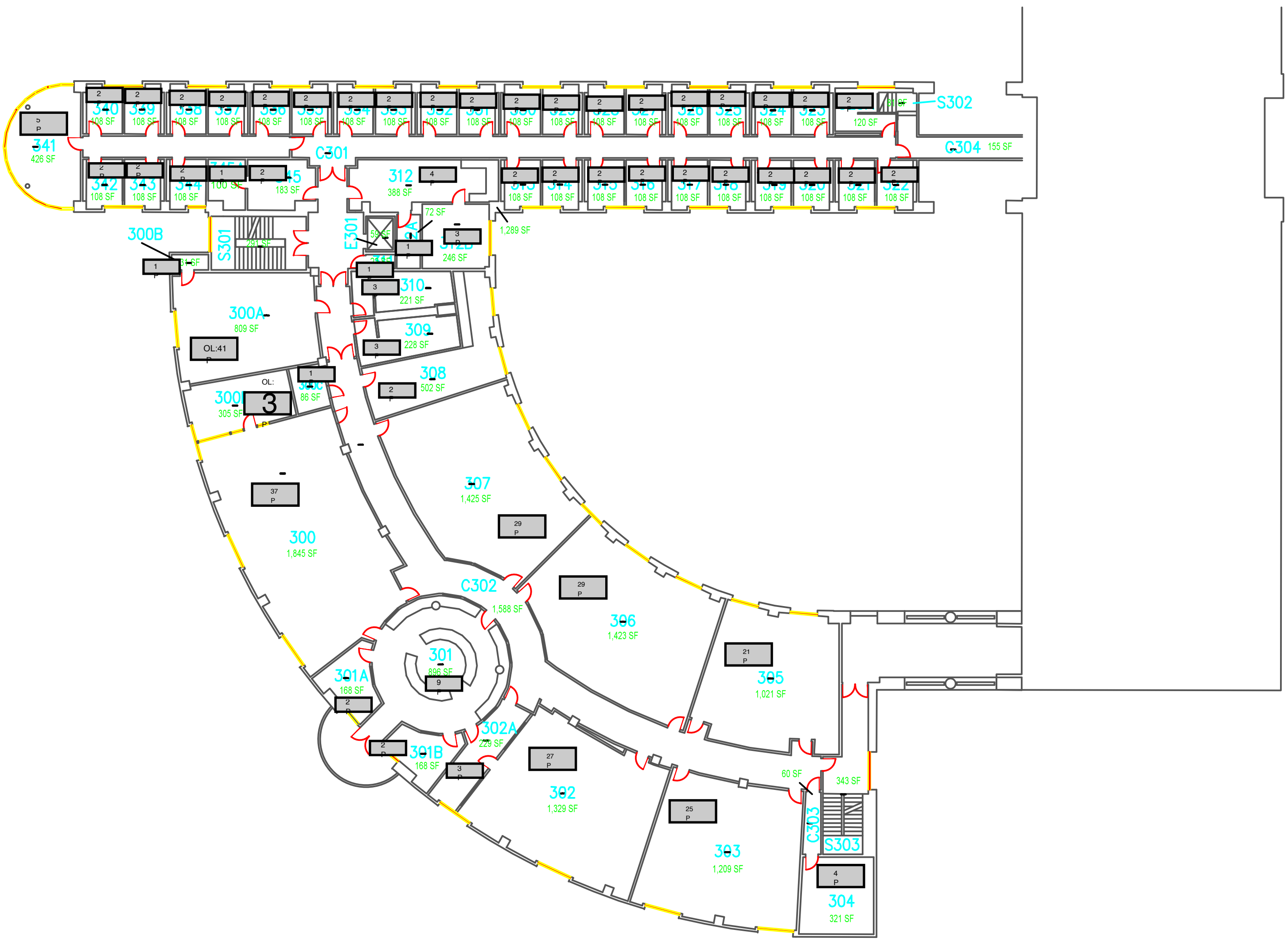


Figure 65 Third Floor Occupant Load

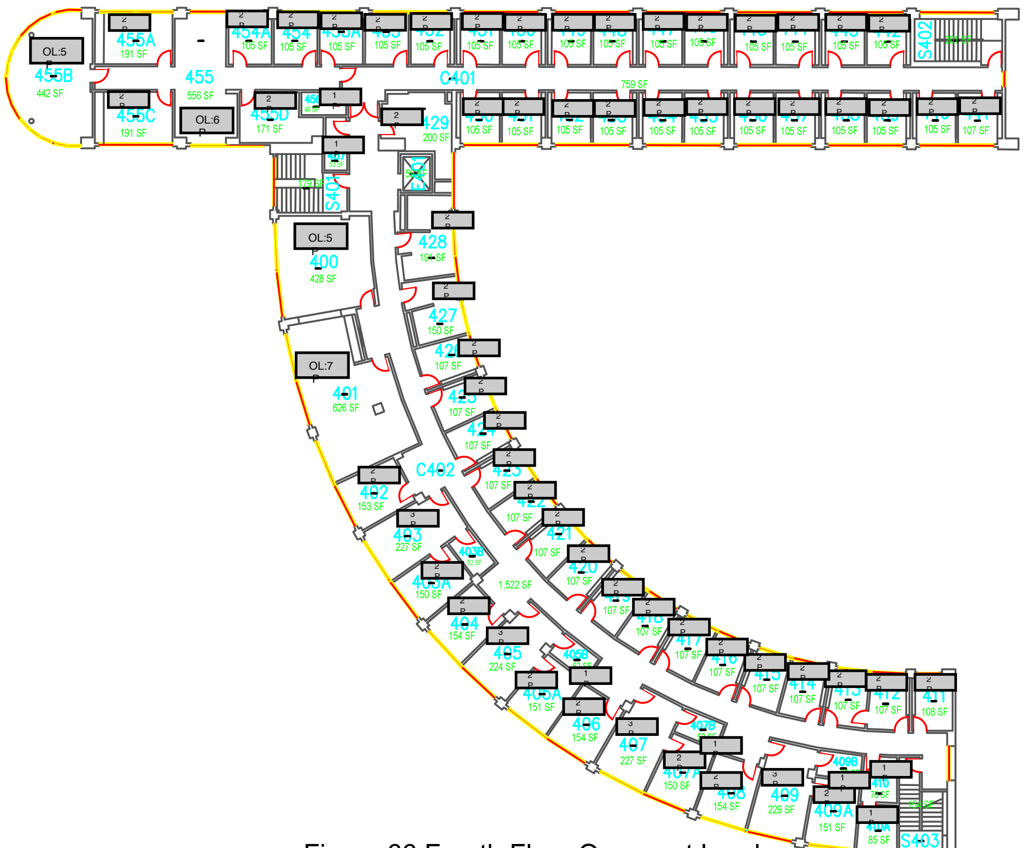


Figure 66 Fourth Floor Occupant Load

# Appendix B

- Sprinkler layout for fourth floor.
- Hydraulic Calculation.

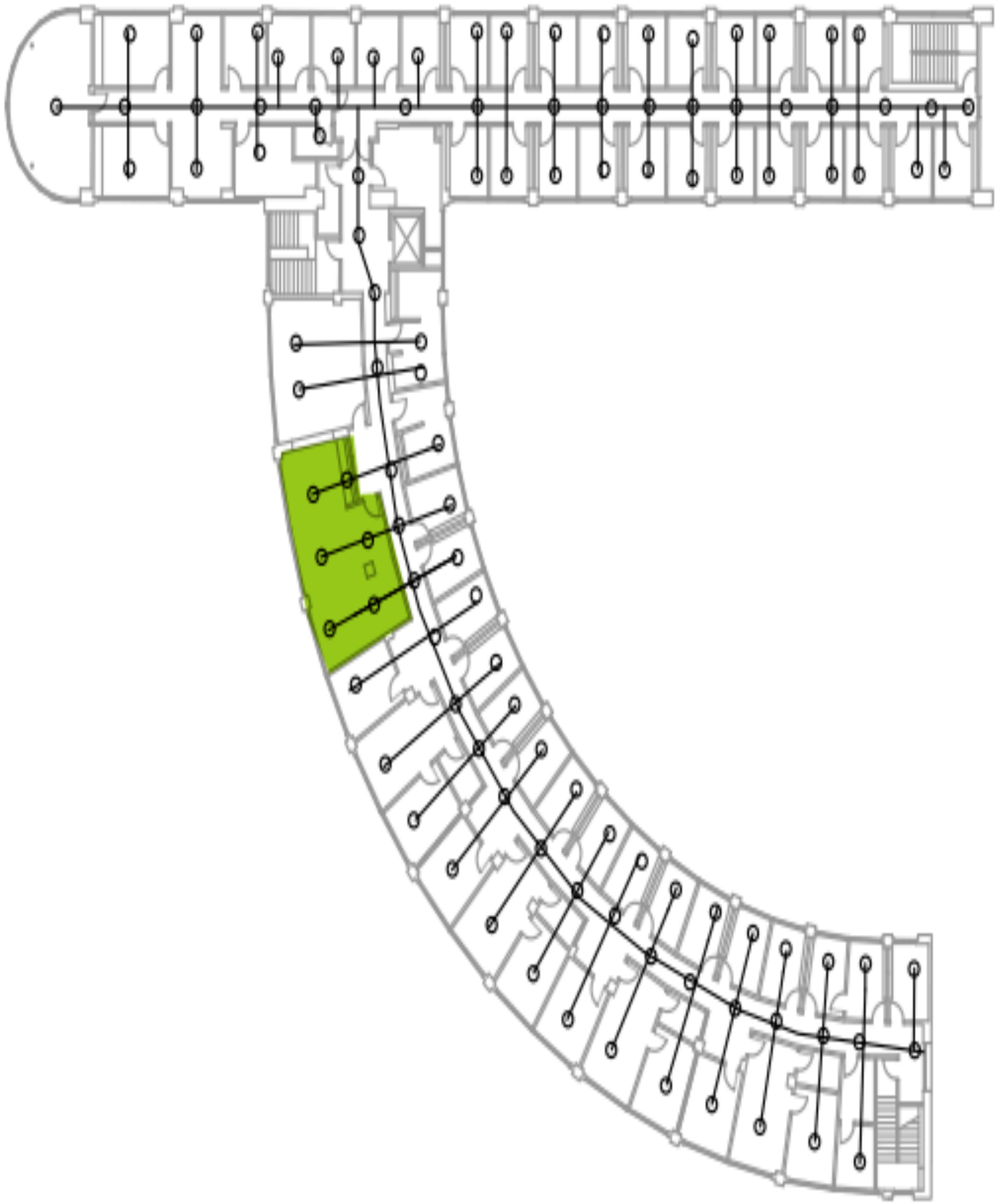


**Figure 63** Sprinkler system layout

CONTRACT NAME Sulaiman Al Mohammadi SHEET 1 OF 1

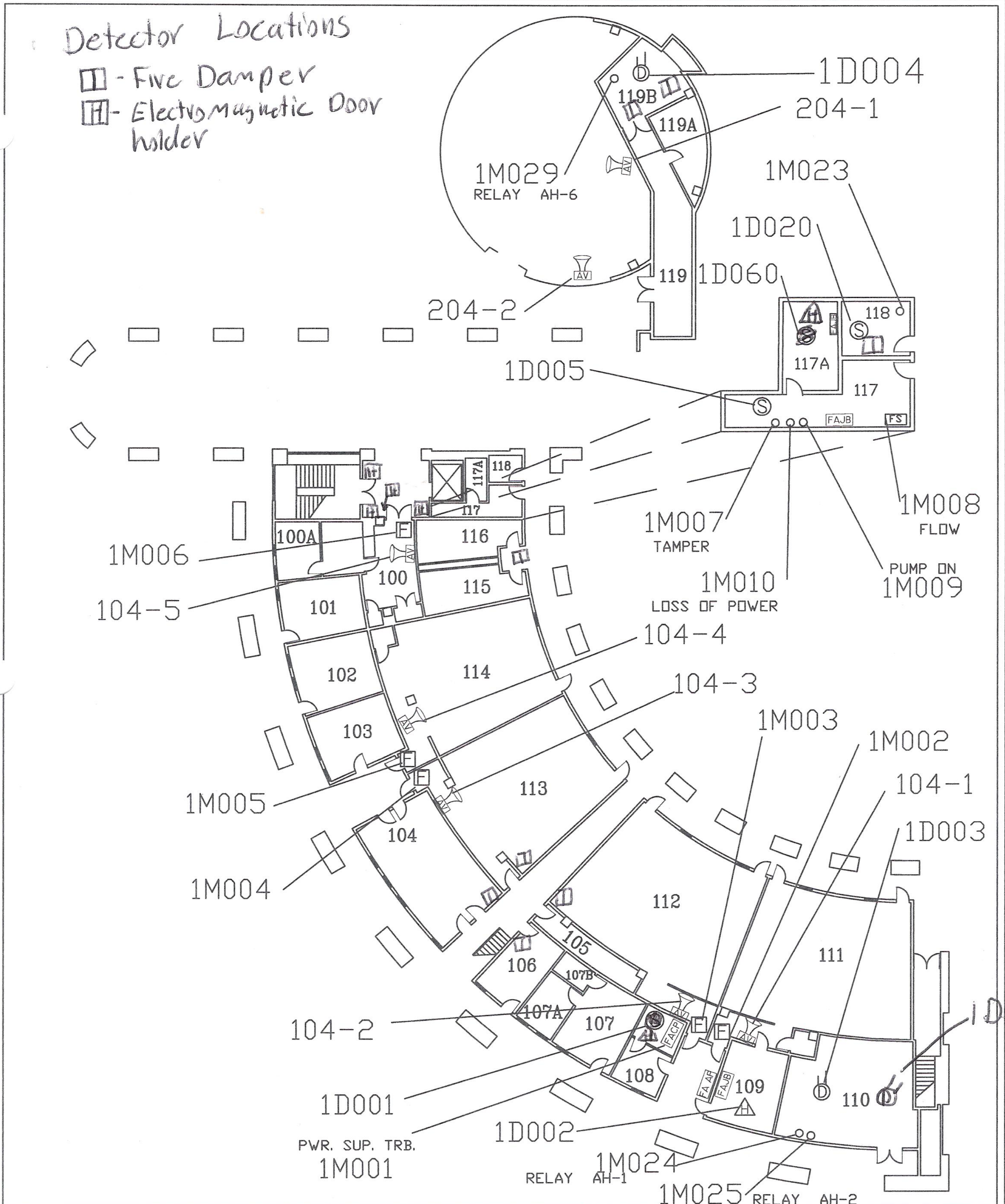
| | NOZZLE IDENT. AND LOCATION | FLOW IN GPM | PIPE SIZE | PIPE FITTINGS AND DEVICES | EQUIV. PIPE LENGTH | FRICTION LOSS PSI/FT | PRESSURE SUMMARY | NORMAL PRESSURE | k = 5.6<br>D = 0.1<br>A = 225 (p... 1-)<br>NOTES |
|---|---|---|---|---|---|---|---|---|---|
| 1 | BL-1 | q | 1.049 | | L 10 | C=120 | Pt 16.1 | Pt | |
| | 1-2 | | | | F - | | Pe | Pv | |
| | | Q 22.5 | | | T 10 | 0.162 | Pf 1.05 | Pn | |
| 2 | Spr2 ↓ | q 23.6 | 1.38 | T | L 8 | | Pt 17.8 | Pt | |
| | | | | | F 7 | 0.160 | Pe | Pv | |
| | CM | Q | | | T 15 | | Pf 2.4 | Pn | |
| 3 | CM | q | | | L 10 | | Pt 20.3 | Pt | k = 10.2 |
| | ↓ | | | | F | | Pe | Pv | ↓ |
| | BL-2 | Q 46.1 | | | T 10 | 0.003 | Pf 0 | Pn | |
| 4 | CM | q 46.1 | 3.068 | | L 9 | | Pt 20.3 | Pt | |
| | ↓ | | | | F | 0.12 | Pe | Pv | |
| | BL-3 | Q 92.19 | | | T 9 | | Pf | Pn | |
| 5 | BL-3 | q | 1.049 | | L 6 | C=120 | Pt 16.1 | Pt | k = 5.6 D = 0.1 |
| | 1-2 | | | | F - | 0.162 | Pe | Pv | $q = k(P)^{0.5}$ |
| | | Q 22.5 | | | T 6 | | Pf 1 | Pn | |
| 6 | BL-3 | q 23.2 | 1.38 | | L 11 | | Pt 17.1 | Pt | |
| | 2-3 | | | | F | | Pe | Pv | |
| | | Q 45.7 | | | T 11 | 0.158 | Pf 1.7 | Pn | |
| 7 | 3 | q 25.2 | 1.61 | | L 7 | C=120 | Pt 20.3 | Pt | |
| | ↓ | | | | F — | =0.169 | Pe | Pv | |
| | CM | Q 70.9 | | | T 7 | | Pf 1.17 | Pn | |
| | | q | | | L | | Pt 21.47 | Pt | |
| | | | | | F | | Pe | Pv | k = 25.4 |
| | | Q | | | T | | Pf | Pn | |
| | B line | q | 3.068 | 45 Elbow | L 50 | | Pt 42 | Pt | |
| | To R | | | | F 3 | | Pe | Pv | |
| | | Q 163.1 | | | T 53 | 0.034 | Pf 14 | Pn | |
| | R | q | 4.26 | 6 45 Elbow | L 122 | | Pt 43.8 | Pt | Pe = 17.02 |
| | ↓ | | | | F 20 | | Pe 17 | Pv | |
| | City M | Q 163 | | | T 142 | 0.007 | Pf 1 | Pn | |
| | | q | | | L | | Pt 62 | Pt | |
| | | | | | F | | Pe | Pv | |
| | | Q | | | T | | Pf | Pn | |
| | | | | | | | Pt | | |

American Fire Sprinkler Association
12750 Merit Drive, Suite 350, Dallas, Texas 75251
Tele: 214.349.5965
Fax: 214.343.8898

Figure 64 Hydraulic Calculation

# Appendix C

- Alarm system shop drawing for old system
- Alarm system shop drawing for upgraded system
- Fire Alarm Control Panel




| CAL POLY COMMUNICATIONS SERVICES | BUSINESS BUILDING (03) First Floor | | Panel #0003 |
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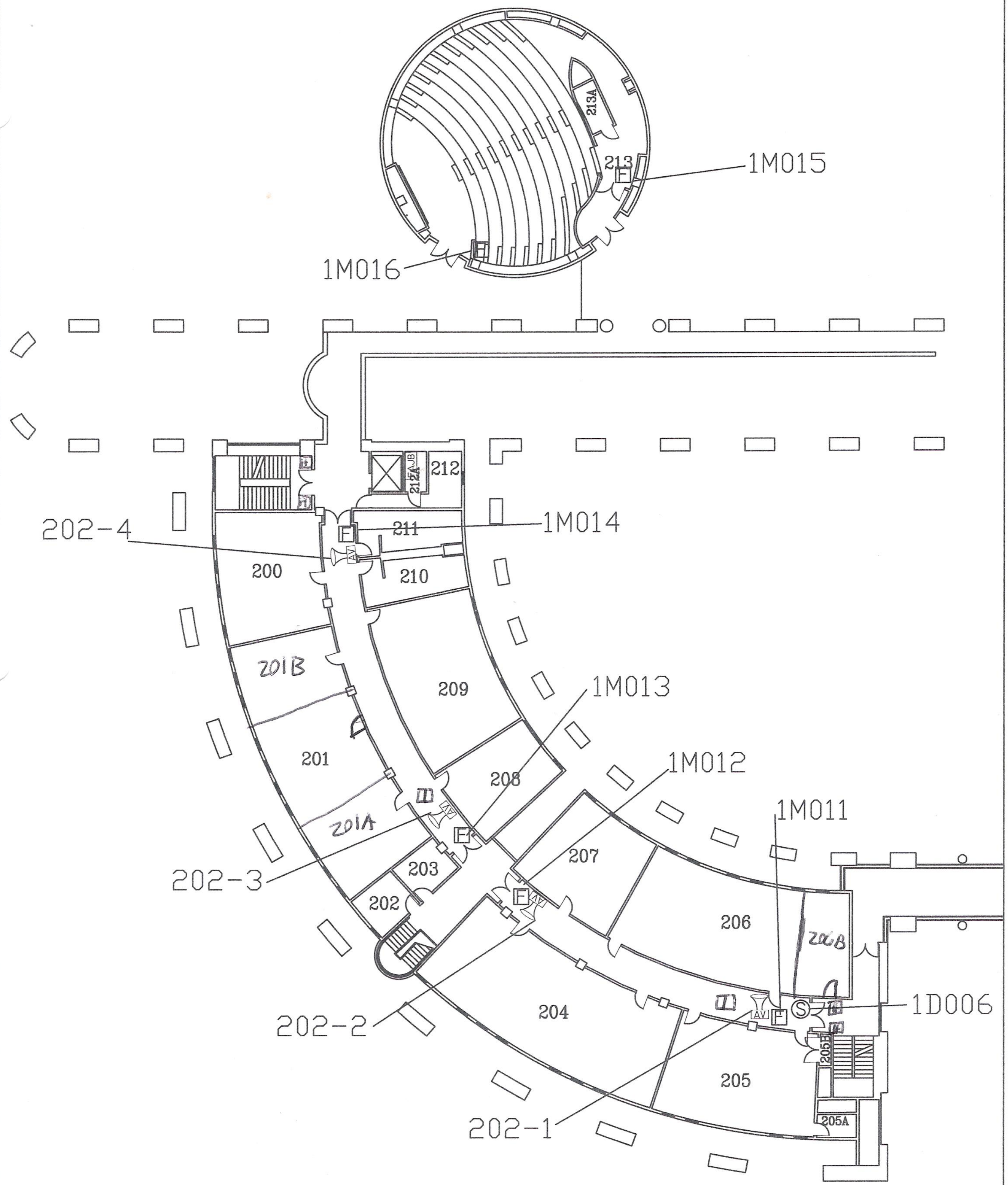
N NORTH




# BUSINESS BUILDING (03)

CAL POLY
COMMUNICATIONS SERVICES

Second Floor

Panel # 0003

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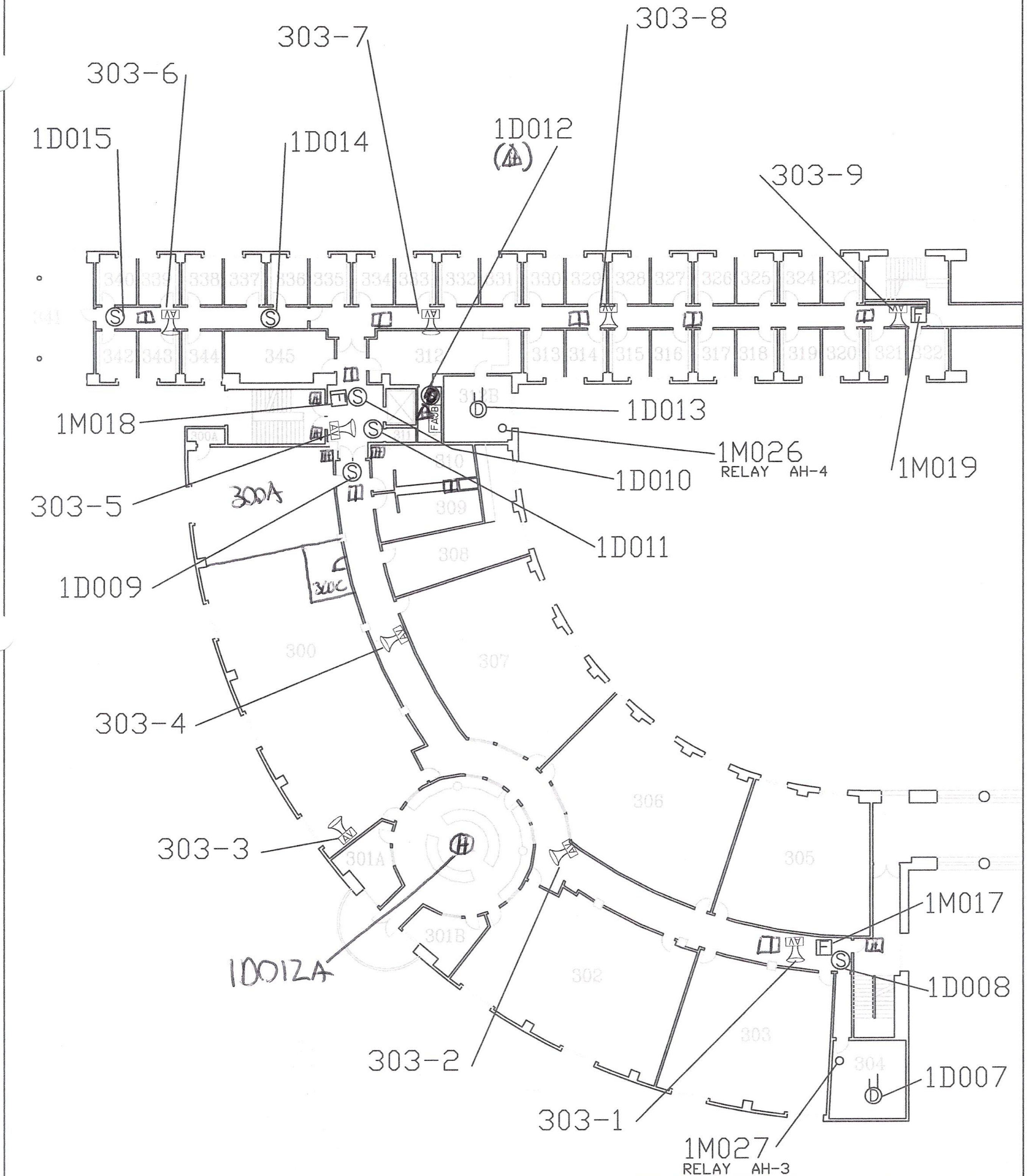


CAL POLY
COMMUNICATIONS SERVICES

# BUSINESS BUILDING (03)

Third Floor

Panel # 0003

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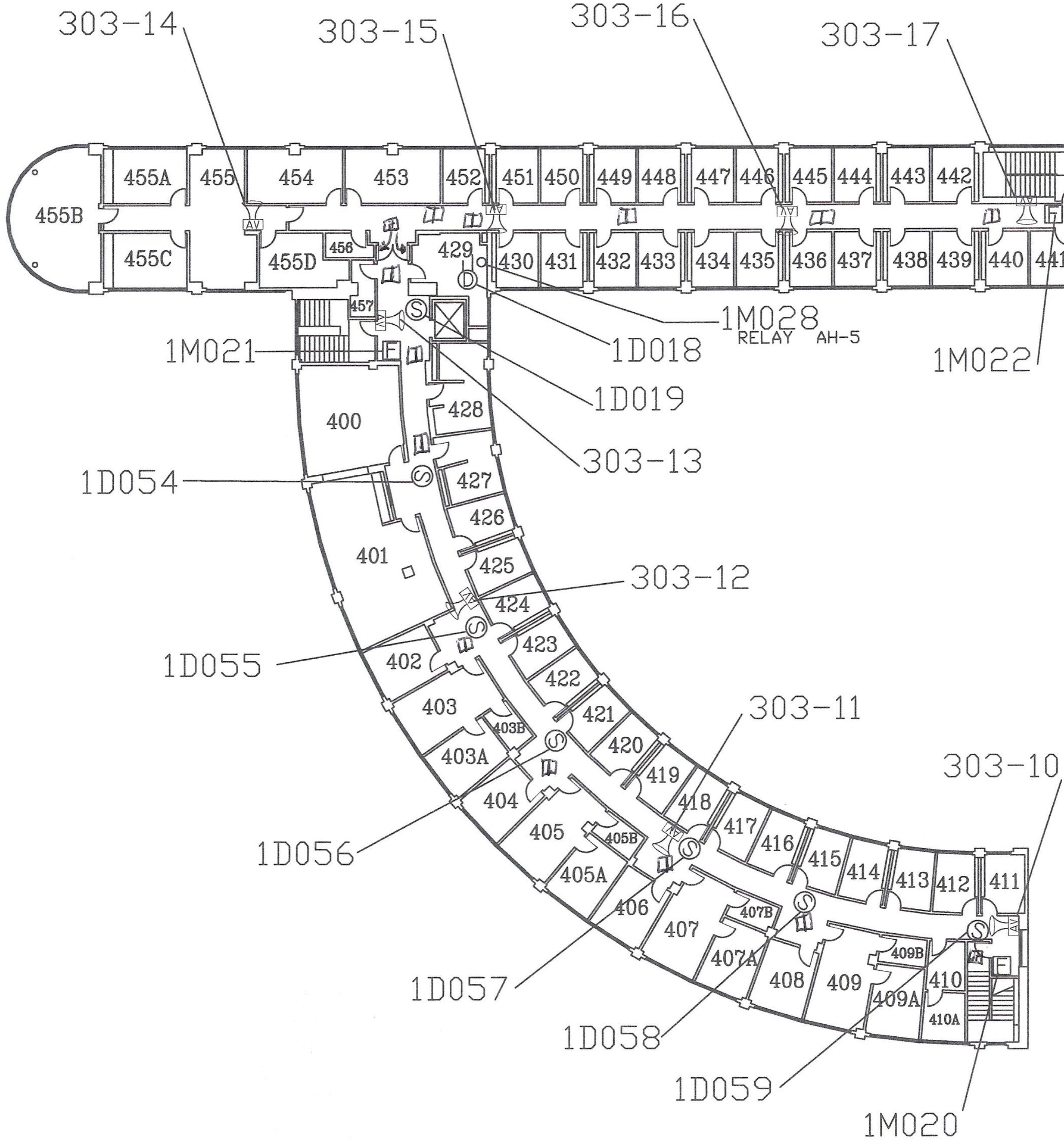


CAL POLY
COMMUNICATIONS SERVICES

# BUSINESS BUILDING (03)

Fourth Floor

Panel # 0003

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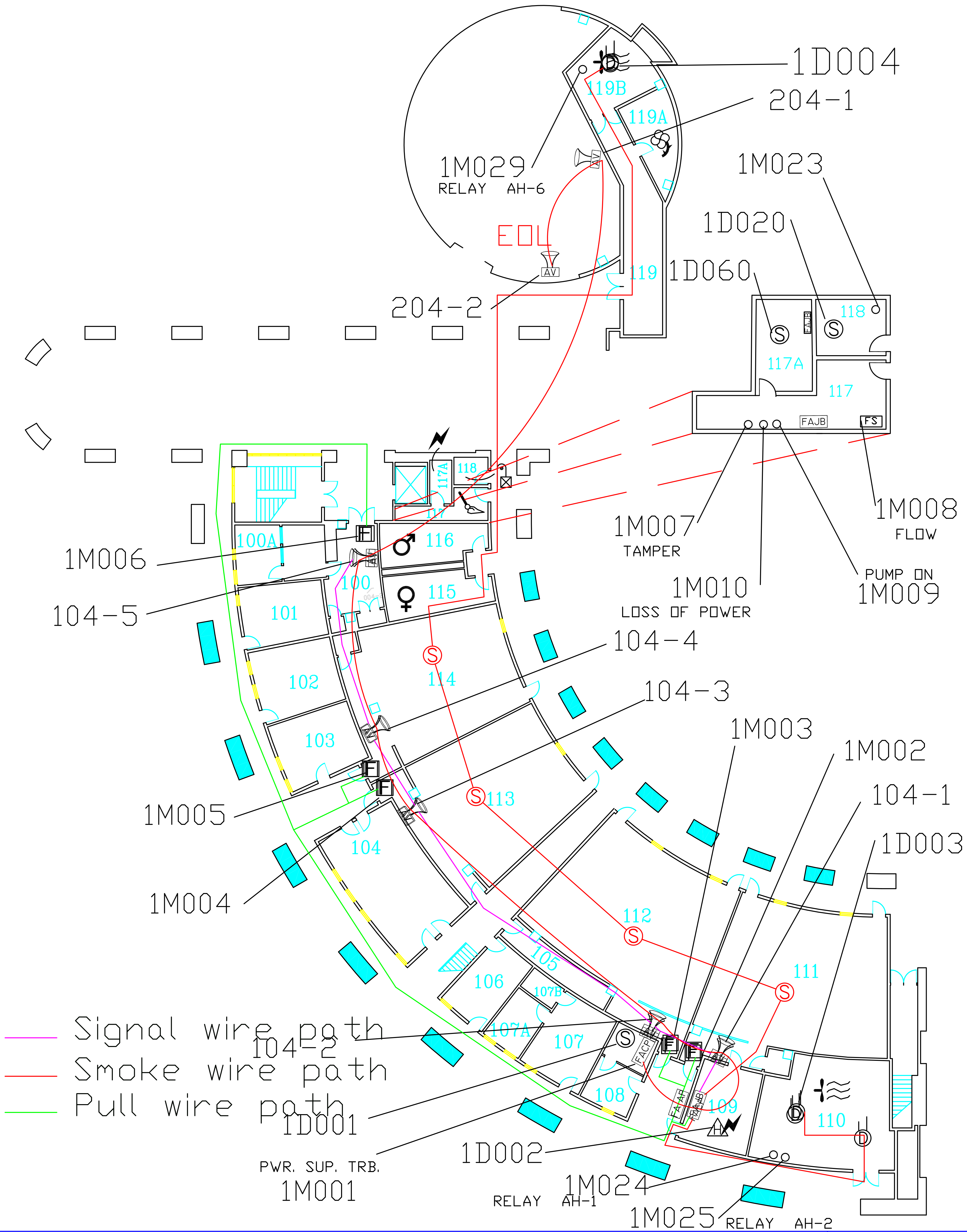


CAL POLY
COMMUNICATIONS SERVICES

# Business Building (03)

First Floor

Panel #0003

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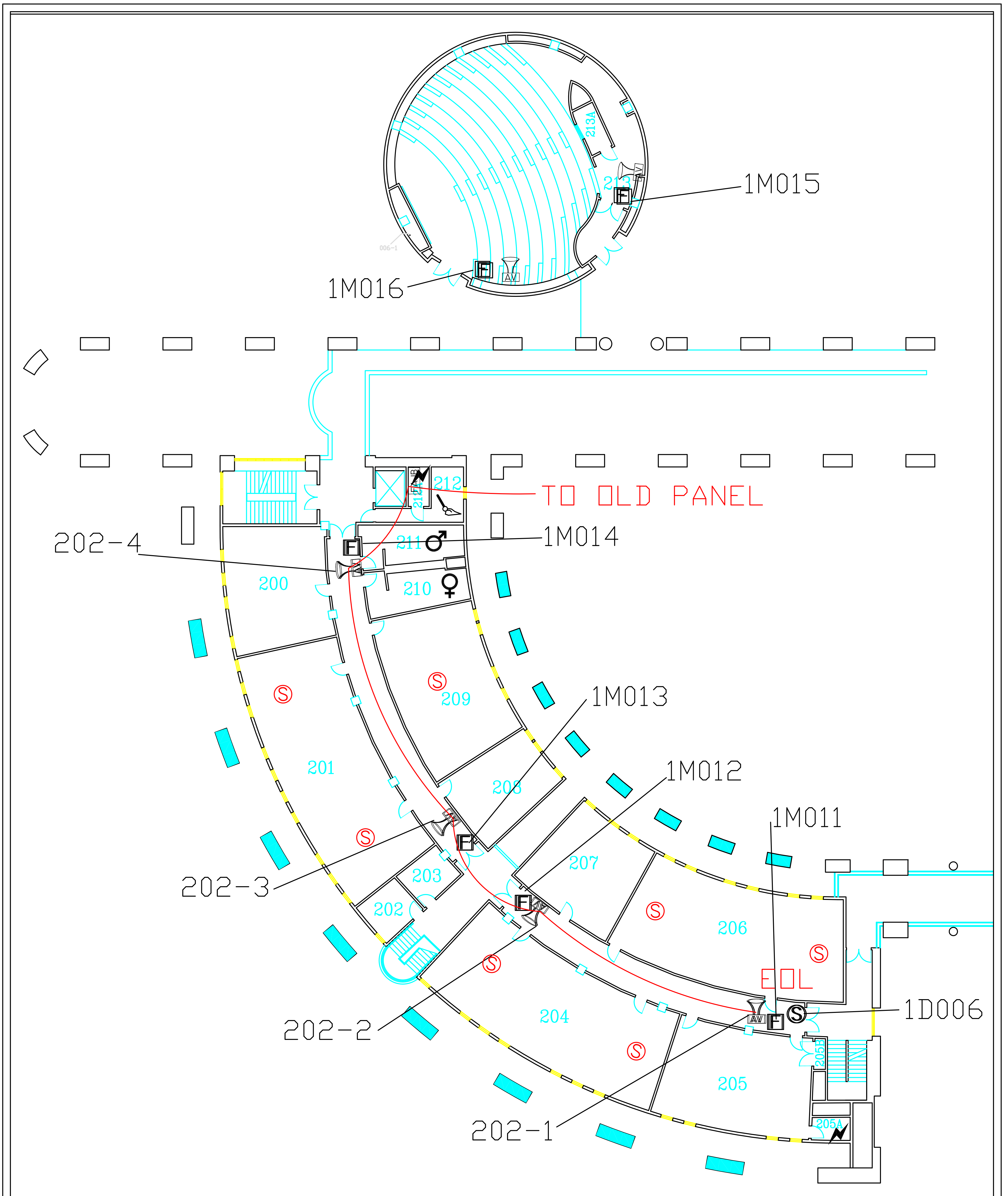


| CAL POLY COMMUNICATIONS SERVICES | BUSINESS BUILDING (03) Second Floor Panel # 0003 | | |
|---|---|---|---|
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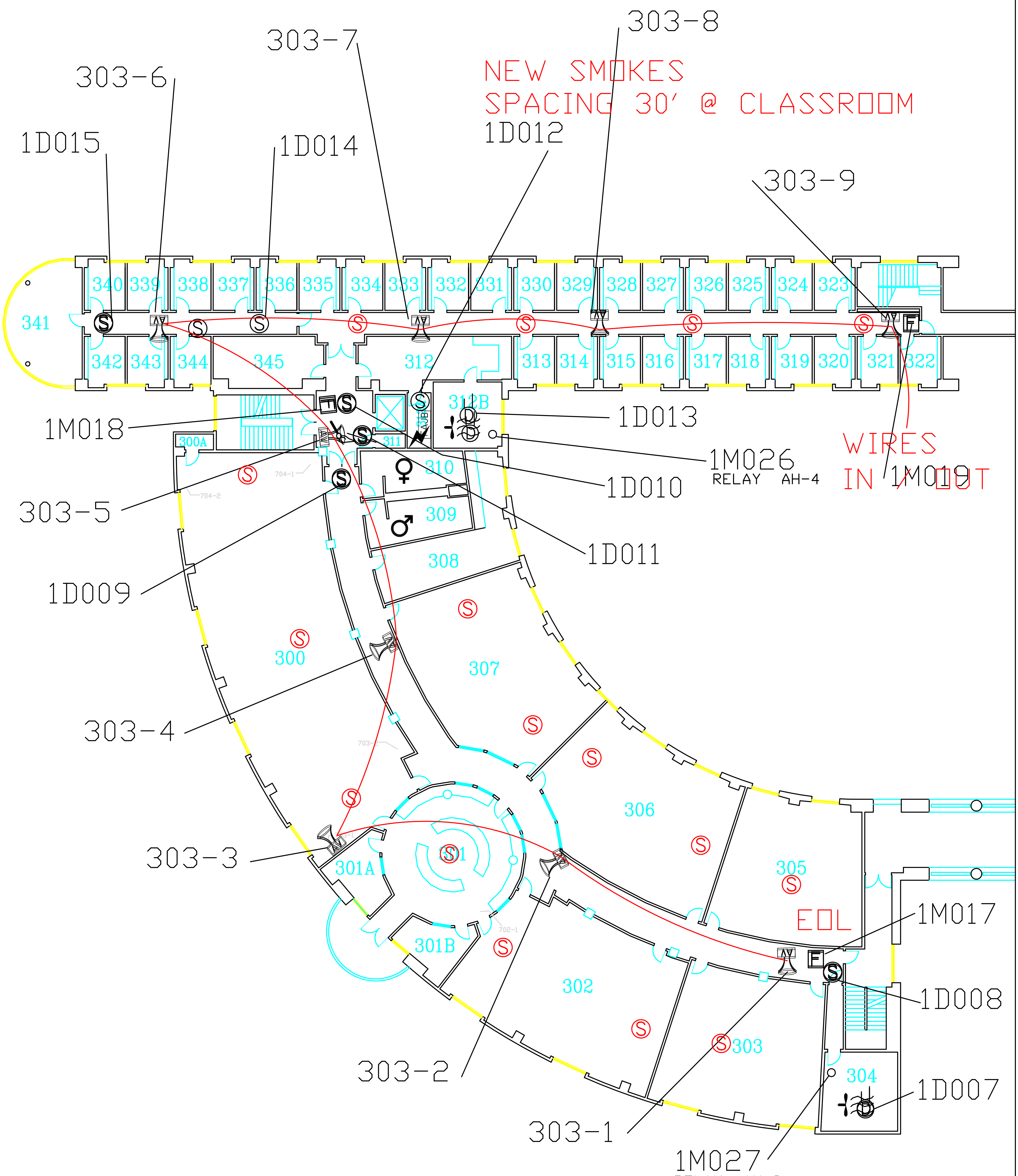


| CAL POLY COMMUNICATIONS SERVICES | BUSINESS BUILDING (03) | | | N NORTH |
|---|---|---|---|---|
| | Third Floor | | Panel # 0003 | |
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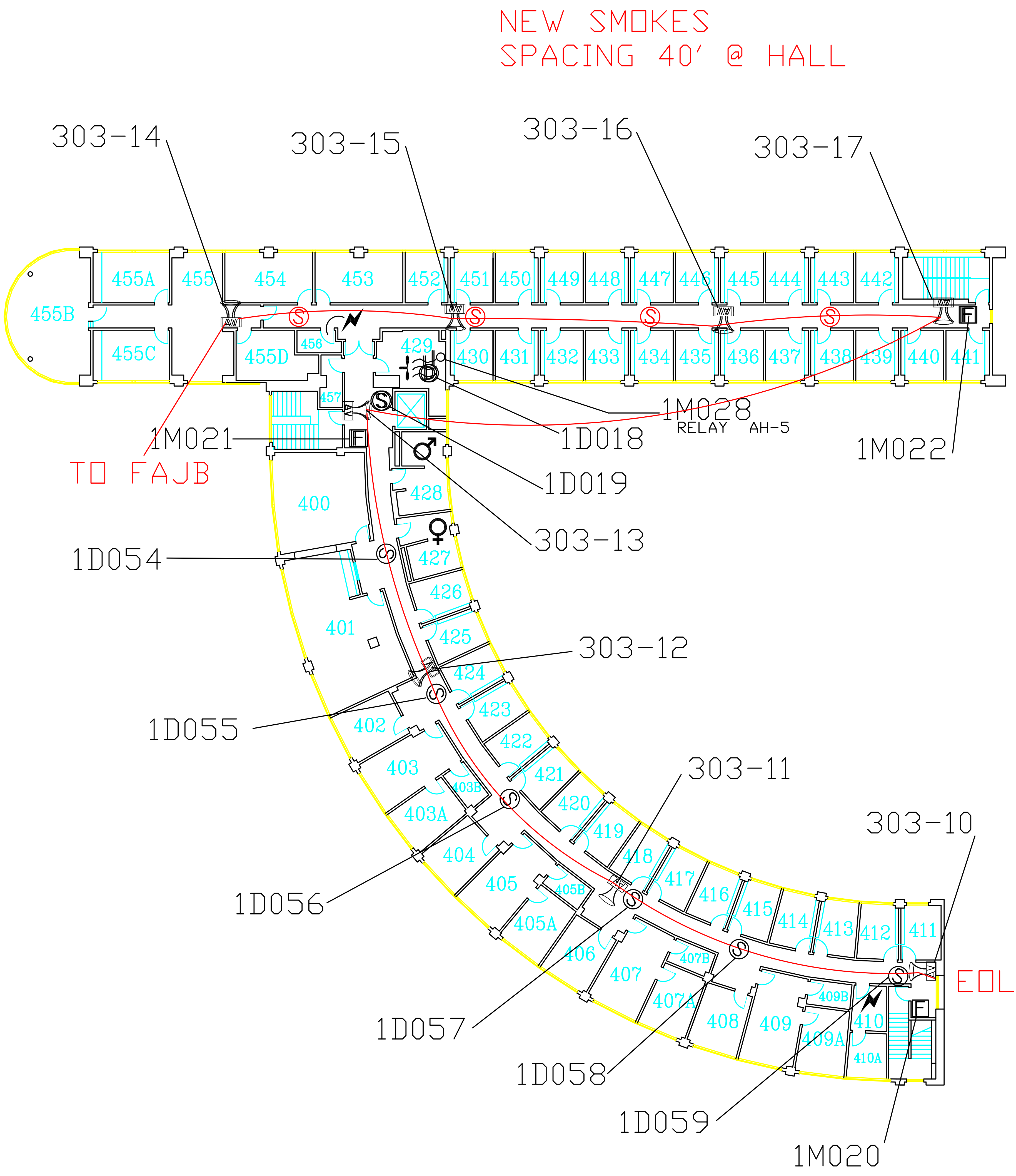


CAL POLY
COMMUNICATIONS SERVICES

# BUSINESS BUILDING (03)

Fourth Floor

Panel # 0003

| DATE | REVISED BY | FILENAME | NOTES | SCALE |
|---|---|---|---|---|
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N
NORTH

# NFS2-640(E)

## Intelligent Addressable Fire Alarm System

NOTIFIER®
by Honeywell

**Intelligent Fire Alarm Control Panels**

## General

The NFS2-640 intelligent Fire Alarm Control Panel is part of the ONYX® Series of Fire Alarm Controls from NOTIFIER.

In stand-alone or network configurations, ONYX Series products meet virtually every application requirement.

The NFS2-640's modular design makes system planning easier. The panel can be configured with just a few devices for small building applications, or networked with many devices to protect a large campus or a high-rise office block. Simply add additional peripheral equipment to suit the application.

A host of other options are available, including single- or multi-channel voice; firefighter's telephone; LED, LCD, or PC-based graphic annunciators; networking; advanced detection products for challenging environments; wireless fire protection; and many additional options.

***NOTE:*** *Unless called out with a version-specific "E" at the end of the part number, "NFS2-640" refers to models NFS2-640 and NFS2-640E; similarly, "CPU2-640" refers to models CPU2-640 and CPU2-640E.*

## Features

- Certified for seismic applications when used with the appropriate seismic mounting kit.
- Approved for Marine applications when used with listed compatible equipment. *See DN-60688.*
- One, expandable to two, isolated intelligent Signaling Line Circuit (SLC) Style 4, 6 or 7.
- Wireless fire protection using SWIFT Smart Wireless Integrated Fire Technology. See DN-60820.
- Up to 159 detectors and 159 modules per SLC; 318 devices per loop/636 per FACP or network node.
  - Detectors can be any mix of ion, photo, thermal, or multi-sensor; wireless detectors are available for use with the FWSG.
  - Modules include addressable pull stations, normally open contact devices, two-wire smoke detectors, notification, or relay; wireless modules are available for use with the FWSG.
- Standard 80-character display, 640-character large display (NCA-2), or display-less (a node on a network).
- Network options:
  - High-speed network for up to 200 nodes (NFS2-3030, NFS2-640, NFS-320(C), NFS-320SYS, NCA-2, DVC-EM, ONYXWorks, NFS-3030, NFS-640, and NCA).
  - Standard network for up to 103 nodes (NFS2-3030, NFS2-640, NFS-320(C), NFS-320SYS, NCA-2, DVC-EM, ONYXWorks, NCS, NFS-3030, NFS-640, NCA, AFP-200, AFP-300/400, AFP-1010, and AM2020). Up to 54 nodes when DVC-EM is used in network paging.
- 6.0 A switch mode power supply with four Class A/B built-in Notification Appliance Circuits (NAC). Selectable System Sensor, Wheelock, or Gentex strobe synchronization.
- Built-in Alarm, Trouble, Security, and Supervisory relays.
- VeriFire® Tools online or offline programming utility. Upload/Download, save, store, check, compare, and simulate panel databases. Upgrade panel firmware.
- Autoprogramming and Walk Test reports.

NFS2-640-DVC_right.jpg

**NFS2-640**

- Multiple central station communication options:
  - Standard UDACT
  - Internet
  - Internet/GSM
- 80-character remote annunciators (up to 32).
- EIA-485 annunciators, including custom graphics.
- Printer interface (80-column and 40-column printers).
- History file with 800-event capacity in nonvolatile memory, plus separate 200-event alarm-only file.
- Alarm Verification selection per point, with automatic counter.
- Presignal/Positive Alarm Sequence (PAS).
- Silence inhibit and Auto Silence timer options.
- March time/temporal/California two-stage coding/strobe synchronization.
- Field-programmable on panel or on PC, with VeriFire Tools program check, compare, simulate.
- Full QWERTY keypad.
- Battery charger supports 18 – 200 AH batteries.
- Non-alarm points for lower priority functions.
- Remote ACK/Signal Silence/System Reset/Drill via monitor modules.
- Automatic time control functions, with holiday exceptions.
- Surface Mount Technology (SMT) electronics.
- Extensive, built-in transient protection.
- Powerful Boolean logic equations.
- Support for SCS Series smoke control system in HVAC mode.

***NCA-2 AS PRIMARY DISPLAY***

- Backlit, 640-character display.
- Supports SCS Series smoke control system in FSCS mode when SCS is connected to the NCA-2 used as primary display.
- Supports DVC digital audio loop.
- Printer and CRT EIA-232 ports.
- EIA-485 annunciator and terminal mode ports.
- Alarm, Trouble, Supervisory, and Security relays.

***FLASHSCAN® INTELLIGENT FEATURES***

- Polls up to 318 devices in less than two seconds.
- Activates up to 159 outputs in less than five seconds.
- Multicolor LEDs blink device address during Walk Test.
- Fully digital, high-precision protocol (U.S. Patent 5,539,389).
- Manual sensitivity adjustment — up to nine levels.
- Pre-alarm ONYX intelligent sensing — up to nine levels.
- Day/Night automatic sensitivity adjustment.
- Sensitivity windows:
  **– Ion** – 0.5 to 2.5%/foot obscuration.
  **– Photo** – 0.5 to 2.35%/foot obscuration.
  **– Laser (VIEW®)** – 0.02 to 2.0%/foot obscuration.
  **– Acclimate Plus™** – 0.5 to 4.0%/foot obscuration.
  **– IntelliQuad™** – 1.0 to 4.0%/foot obscuration.
  **– IntelliQuad™ PLUS –** 1.0 to 4.0%/foot obscuration
- Drift compensation (U.S. Patent 5,764,142).
- Degraded mode — in the unlikely event that the CPU2-640 microprocessor fails, FlashScan detectors revert to degraded operation and can activate the CPU2-640 NAC circuits and alarm relay. Each of the four built-in panel circuits includes a Disable/Enable switch for this feature.
- Multi-detector algorithm involves nearby detectors in alarm decision (U.S. Patent 5,627,515).
- Automatic detector sensitivity testing (NFPA-72 compliant).
- Maintenance alert (two levels).
- Self-optimizing pre-alarm.

***FSL-751 (VERY INTELLIGENT EARLY WARNING) SMOKE DETECTION TECHNOLOGY***

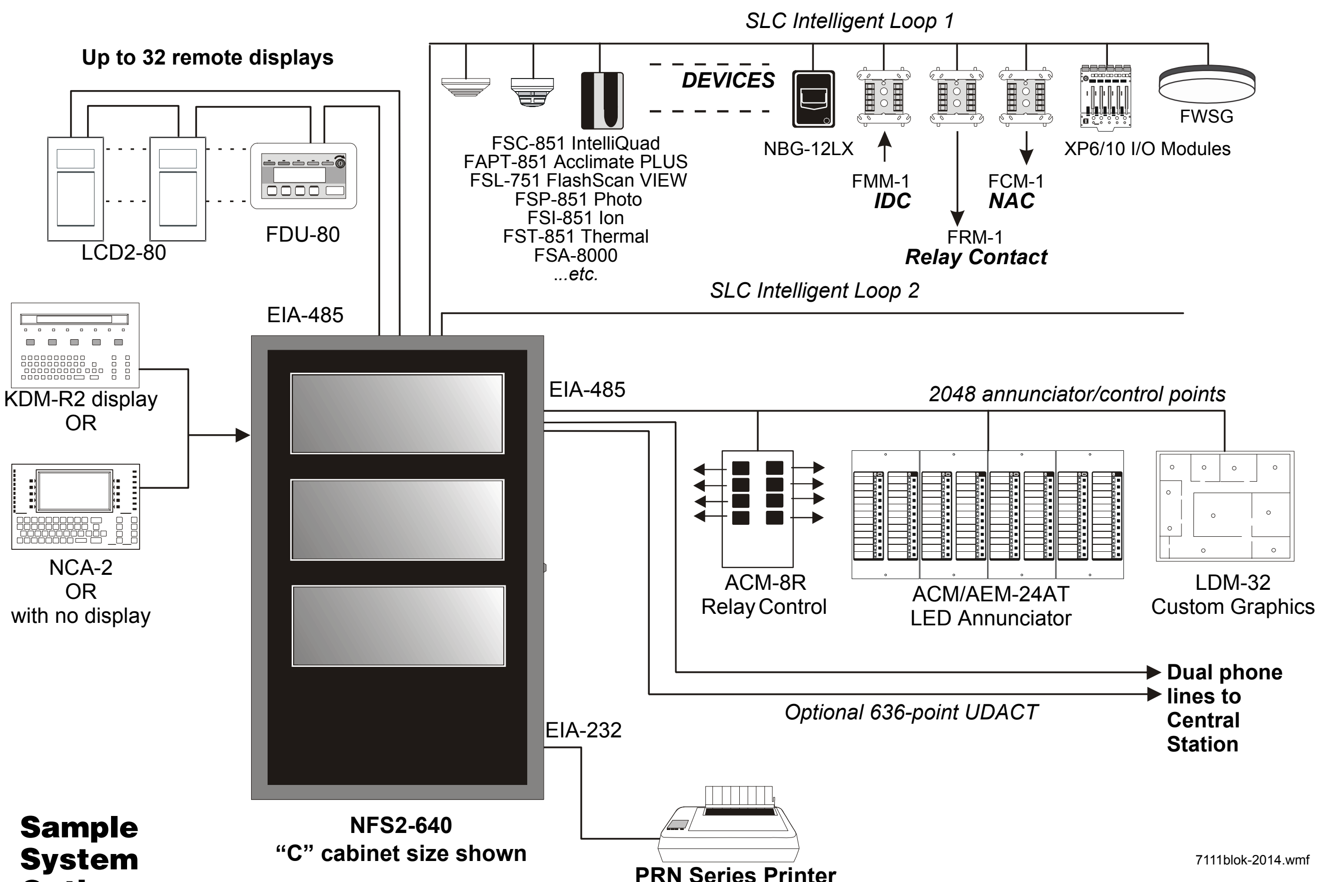
- Advanced ONYX intelligent sensing algorithms differentiate between smoke and non-smoke signals (U.S. Patent 5,831,524).
- Addressable operation pinpoints the fire location.
- Early warning performance comparable to the best aspiration systems at a fraction of the lifetime cost.

***FAPT-851 ACCLIMATE PLUS LOW-PROFILE INTELLIGENT MULTI-SENSOR***

- Detector automatically adjusts sensitivity levels without operator intervention or programming. Sensitivity increases with heat.
- Microprocessor-based technology; combination photo and thermal technology.
- Low-temperature warning signal at 40°F ± 5°F (4.44°C ± 2.77°C).

***FSC-851 INTELLIQUAD ADVANCED MULTI-CRITERIA DETECTOR***

- Detects all four major elements of a fire (smoke, heat, CO, and flame).
- Automatic drift compensation of smoke sensor and CO cell.
- High nuisance-alarm immunity.




**Sample System Options**

#### *INTELLIGENT FAAST® DETECTORS FSA-5000, FSA-8000, AND FSA-20000*

- Connects directly to the SLC loop of compatible ONYX series panels.
- Provides five event thresholds that can be individually programmed with descriptive labels for control-by-event programming; uses five detector addresses.
- Uses patented particle separator and field-replaceable filter to remove contaminants.
- Advanced algorithms reject common nuisance conditions
- FSA-5000 covers 5,000 square feet through one pipe.
- FSA-8000 covers 8,000 square feet through one pipe.
- FSA-20000 covers 28,800 square feet through one to four pipes.

#### *FCO-851 INTELLIQUAD™* PLUS *ADVANCED MULTI-CRITERIA FIRE/CO DETECTOR*

- Detects all four major elements of a fire.
- Separate signal for life-safety CO detection.
- Optional addressable sounder base for Temp-3 (fire) or Temp-4 (CO) tone.
- Automatic drift compensation of smoke sensor and CO cell.
- High nuisance-alarm immunity.

#### *SWIFT WIRELESS*

- Self-healing mesh wireless protocol.
- Each SWIFT Gateway supports up to 50 devices: 1 wireless gateway and up to 49 SWIFT devices.
- Up to 4 wireless gateways can be installed with overlapping network coverage.

#### *RELEASING FEATURES*

- Ten independent hazards.
- Sophisticated cross-zone (three options).
- Delay timer and Discharge timers (adjustable).
- Abort (four options).
- Low-pressure $CO_2$ listed.

#### *DIGITAL VOICE AND TELEPHONE FEATURES*

- Up to eight channels of digital audio.
- 35, 50, 75, and 100/125 watt digital amplifiers (DAA2/DAX series and DS series; NCA-2 required as primary display).
- Solid-state digital message generation.
- Firefighter telephone option.
- 30- to 120-watt high-efficiency amplifiers (AA Series).
- Backup tone generator and amplifier option.
- NFS2-640 can also integrate with the FirstCommand Emergency Communications System. *See DN-60772.*

#### *HIGH-EFFICIENCY OFFLINE SWITCHING 3.0 A POWER SUPPLY (6.0 A IN ALARM)*

- 120 VAC (NFS2-640); 240 VAC (NFS2-640E).
- Displays battery current/voltage on panel (with display).

## FlashScan, Exclusive World-Leading Detector Protocol

At the heart of the NFS2-640 is a set of detection devices and device protocol — FlashScan (U.S. Patent 5,539,389). FlashScan is an all-digital protocol that gives superior precision and high noise immunity.

In addition to providing quick identification of an active input device, this protocol can also activate many output devices in a fraction of the time required by competitive protocols. This high speed also allows the NFS2-640 to have the largest device per loop capacity in the industry — 318 points — yet every input and output device is sampled in less than two seconds. The microprocessor-based FlashScan detectors have bicolor LEDs that can be coded to provide diagnostic information, such as device address during Walk Test.

## ONYX Intelligent Sensing

Intelligent sensing is a set of software algorithms that provides the NFS2-640 with industry-leading smoke detection capability. These complex algorithms require many calculations on each reading of each detector, and are made possible by the high-speed microcomputer used by the NFS2-640.

**Drift Compensation and Smoothing:** Drift compensation allows the detector to retain its original ability to detect actual smoke, and resist false alarms, even as dirt accumulates. It reduces maintenance requirements by allowing the system to automatically perform the periodic sensitivity measurements required by NFPA 72. Smoothing filters are also provided by software to remove transient noise signals, such as those caused by electrical interference.

**Maintenance Warnings:** When the drift compensation performed for a detector reaches a certain level, the performance of the detector may be compromised, and special warnings are given. There are three warning levels: (1) Low Chamber value; (2) Maintenance Alert, indicative of dust accumulation that is near but below the allowed limit; (3) Maintenance Urgent, indicative of dust accumulation above the allowed limit.

**Sensitivity Adjust:** Nine sensitivity levels are provided for alarm detection. These levels can be set manually, or can change automatically between day and night. Nine levels of pre-alarm sensitivity can also be selected, based on predetermined levels of alarm. Pre-alarm operation can be latching or self-restoring, and can be used to activate special control functions.

**Self-Optimizing Pre-Alarm:** Each detector may be set for "Self-Optimizing" pre-alarm. In this special mode, the detector "learns" its normal environment, measuring the peak analog readings over a long period of time, and setting the pre-alarm level just above these normal peaks.

**Cooperating Multi-Detector Sensing:** A patented feature of ONYX intelligent sensing is the ability of a smoke sensor to consider readings from nearby sensors in making alarm or pre-alarm decisions. Without statistical sacrifice in the ability to resist false alarms, it allows a sensor to increase its sensitivity to actual smoke by a factor of almost two to one.

## Field Programming Options

**Autoprogram** is a timesaving feature. The FACP "learns" what devices are physically connected and automatically loads them in the program with default values for all parameters. Requiring less than one minute to run, this routine allows the user to have almost immediate fire protection in a new installation, even if only a portion of the detectors are installed.

**Keypad Program Edit (with KDM-R2)** The NFS2-640, like all NOTIFIER intelligent panels, has the exclusive feature of program creation and editing capability from the front panel keypad, while continuing to provide fire protection. The architecture of the NFS2-640 software is such that each point entry carries its own program, including control-by-event links to other points. This allows the program to be entered with independent per-point segments, while the NFS2-640 simultaneously monitors other (already installed) points for alarm conditions.

VeriFire® Tools is an offline programming and test utility that can greatly reduce installation programming time, and increase confidence in the site-specific software. It is Windows®-based and provides technologically advanced capabili-

ties to aid the installer. The installer may create the entire program for the NFS2-640 in the comfort of the office, test it, store a backup file, then bring it to the site and download from a laptop into the panel.

## Placement of Equipment in Chassis and Cabinet

The following guidelines outline the NFS2-640's flexible system design.

**Rows:** The first row of equipment in the cabinet mounts in the chassis shipped with the FACP. Mount the second, third, or fourth rows of equipment in a CHS-4 series chassis or, for Digital Voice Command products, in CA-1 or CA-2. (For DVC-EM and DAA2/DAX components see *DVC Manual*; for DS series components see *DS-AMP Manual*; for DVC-AO applications, see *AA Series Installation Manual*). Other options are available; see your panel's installation manual.

**Wiring:** When designing the cabinet layout, consider separation of power-limited and non-power-limited wiring as discussed in the *NFS2-640 Installation Manual*.

**Positions:** A chassis offers four basic side-by-side positions for components; the number of modules that can be mounted in each position depends on the chassis model and the size of the individual module. There are a variety of standoffs and hardware items available for different combinations and configurations of components.

It is critical that all mounting holes of the NFS2-640 are secured with a screw or standoff to ensure continuity of Earth Ground.

**Layers:** The control panel's chassis accepts four layers of equipment, including the control panel. The CPU2-640 fills three positions (left to right) in the first-installed layer (the back of the chassis); its integral power supply occupies the center two positions in the next two layers; the optional display occupies (the left) two positions at the front, flush with the door. Some equipment, such as the NCA-2, may be mounted in the dress panel directly in front of the control panel. The NCA-2 can be used as a primary display for the NFS2-640 (use NCA/640-2-KIT) by directly connecting their network ports (required in Canadian stand-alone applications); see NCA-2 data sheet for mounting options *(DN-7047)*.

**Expansion:** Installing an LEM-320 Loop Expander Module adds a second SLC loop to the control panel. The LEM-320 is mounted onto the CPU2-640, occupying the middle-right, second (back) slot on the chassis.

**Networking:** If networking two or more control panels, each unit requires a Network Communication Module or High-Speed Network Communication Module. (HS-NCM can support two nodes; see "Networking Options" on page 5). These modules can be installed in any option board position (see manual), and additional option boards can be mounted in front of the network communication modules.

## KDM-R2 Controls and Indicators

**Program Keypad:** QWERTY type *(keyboard layout, see figure)*.

**12 LED indicators:** Power; Fire Alarm; Pre-Alarm; Security; Supervisory; System Trouble; Signals Silenced; Points Disabled; Control Active; Abort; Pre-Discharge; Discharge.

**Keypad Switch Controls:** Acknowledge/Scroll Display; Signal Silence; Drill; System Reset; Lamp Test.

**LCD Display:** 80 characters (2 x 40) with long-life LED backlight.

## Product Line Information



### *Configuration Guidelines*

*Stand-alone and network systems require a main display. On systems with one FACP (one CPU2-640/-640E), display options are the KDM-R2 or the NCA-2. On network systems (two or more networked fire panel nodes), at least one NCA-2, NCS, or ONYXWorks annunciation device is required. Other options listed as follows;*

**KDM-R2:** 80-character backlit LCD display with QWERTY programming and control keypad. Order two BMP-1 blank modules and DP-DISP2 mounting plate separately. *Requires top row of a cabinet. Required for each stand-alone 80-character display system. The KDM-R2 may mount in network nodes to display "local" node information as long as at least one NCA-2 or NCS/ONYXWorks network display is on the system to display network information. (Non-English versions also available: KDM-R2-FR, KDM-R2-PO, KDM-R2-SP.)*

**NCA-2:** Network Control Annunciator, 640 characters. On single *CPU2-640/-640E* systems, the optional NCA-2 can be used as the Primary Display for the panel and connects directly to the *CPU2-640/-640E*. On network systems (two or more networked fire panel nodes), one network display (either NCA-2 or NCS*/ONYXWorks*) is required for every system. On network systems, the NCA-2 connects to (and requires) a standard Network Communication Module or High-Speed Network Communication Module. Mounts in a row of FACP node or in two annunciator positions. Mounting options include the DP-DISP2, ADP-4B, or in an annunciator box, such as the ABS-2D. In CAB-4 top-row applications, a DP-DISP2 and two BMP-1 blank modules are required for mounting. Required for NFS2-640 applications employing the DVC-EM with DAL devices. Non-English versions are available. For marine applications, order NCA-2-M; for non-English Marine applications, order NCA-2-M and the appropriate KP-KIT-XX. *See DN-7047.*

**CPU2-640:** Central processing unit (CPU) with integral 3.0 A (6.0 A in alarm) power supply for an NFS2-640 system. Includes control panel factory-mounted on a chassis; one Signaling Line Circuit expandable to two; documentation kit. *Order one per system or as necessary (up to 103 network nodes) on a network system. (Non-English versions also available: CPU2-640-FR, CPU2-640-PO, CPU2-640-SP.)*

**CPU2-640E:** Same as CPU2-640 but requires 240 VAC, 1.5 A, (3.0 A in alarm). *(Non-English versions also available: CPU2-640E-PO, CPU2-640E-SP.)*

**NCA/640-2-KIT:** Bracket installation kit required to mount NCA-2 to the CPU2-640/-640E's standard chassis.

**DP-DISP2:** Dress panel for top row in cabinet with CPU2-640/640E installed.

**ADP2-640:** Dress panel for middle rows with CPU2-640/640E.

**BMP-1:** Blank module for unused module positions.

**BP2-4:** Battery plate, required.

**LEM-320:** Loop Expander Module. Expands each NFS2-640 to two Signaling Line Circuits. *See DN-6881.*

### *Networking Options*

**NCM-W, NCM-F:** Standard Network Communications Modules. Wire and multi-mode fiber versions available. *See DN-6861*.

**HS-NCM-W/MF/SF/WMF/WSF/MFSF:** High-speed Network Communications Modules that can connect to two nodes. Wire, single-mode fiber, multi-mode fiber, and media conversion models are available. *See DN-60454.*

**RPT-W, RPT-F, RPT-WF:** Standard-network repeater board with wire connection (RPT-W), multi-mode fiber connection (RPT-F), or allowing a change in media type between wire and fiber (RPT-WF). Not used with high-speed networks. *See DN-6971.*

**ONYXWorks:** UL-listed graphics PC workstation, software, and computer hardware. *See DN-7048 for specific part numbers.*

**NFN-GW-EM-3:** NFN Gateway, embedded. (Replaces NFN-GW-EM.) *See DN-60499.*

**NWS-3: NOTI•FIRE•NET™** Web Server. *See DN-6928.*

**CAP-GW:** Common Alerting Protocol Gateway. *See DN-60756.*

**VESDA-HLI-GW:** VESDAnet high-level interface gateway. *See DN-60753.*

**LEDSIGN-GW:** UL-listed sign gateway. Interfaces with classic and high-speed NOTI•FIRE•NET networks through the NFN Gateway. *See DN-60679.*

**OAX2-24V:** UL-listed LED sign, used with LEDSIGN-GW. *See DN-60679.*

### *Auxiliary Power Supplies and Batteries*

**ACPS-610:** 6.0 A or 10.0 A addressable charging power supply. *See DN-60244.*

**APS2-6R:** Auxiliary Power Supply. Provides up to 6.0 amperes of power for peripheral devices. Includes battery input and transfer relay, and overcurrent protection. Mounts on two of four positions on a CHS-4L or CHS-4 chassis. *See DN-5952.*

**FCPS-24S6/S8:** Remote 6 A and 8 A power supplies with battery charger. *See DN-6927.*

**BAT Series:** Batteries. NFS2-640 uses two 12 volt, 18 to 200 AH batteries. *See DN-6933.*

### *Audio Options*

***NOTE:** For mounting hardware, see "Enclosures, Chassis, and Dress Plates" on page 7 and peripheral data sheets.*

**DVC-EM:** Digital Voice Command, digital audio processor with message storage for up to 32 minutes of standard quality (4 minutes at high quality) digital audio. Capable of playing up to eight simultaneous messages when used with Digital Audio Loop (DAL) devices. *See DN-7045.*

**DVC-RPU**: Digital Voice Command Remote Paging Unit for use with DVC-EM. Includes the keypad/display. *See DN-60726.*

**DS-DB**: Digital Series Distribution Board, provides bulk amplification capabilities to the DVC-EM while retaining digital audio distribuition capabilities. Can be configured with up to four DS-AMPs, supplying high-level risers spread throughout an installation. *See DN-60565.*

**DVC-KD:** DVC-EM keypad for local annunciation and controls; status LEDs and 24 user-programmable buttons. *See DN-7045.*

**DS-AMP/E**: 125W, 25 VRMS, or 100W, 70VRMS. 70VRMS requires DS-XF70V step-up transformer. Digital Series Amplifier, part of the DS-DB system. *See DN-60663.*

**DS-RFM, DS-FM, DS-SFM**: Fiber conversion modules for DVC-EM, DS-DB distribution board, and DAX and DAA2 Series amplifiers. *See DN-60633.*

**DVC-AO:** DVC Analog Output board provides four analog output circuits for use with AA Series amplifiers. Four-channel operation supported. *See DN-7045.*

**DAA2-5025(E):** 50W, 25 Vrms Digital Audio Amplifier assembly with power supply; includes chassis. *See DN-60556.*

**DAA2-5070(E):** 50W, 70.7 Vrms Digital Audio Amplifier assembly with power supply; includes chassis. *See DN-60556.*

**DAA2-7525(E):** 75W, 25 Vrms digital audio amplifier assembly with power supply; includes chassis. *See DN-60556.*

**DAX-3525(E):** 35W, 25 Vrms Digital Audio Amplifier assembly with power supply, includes chassis. *See DN-60561.*

**DAX-3570(E):** 35W, 70.7 Vrms Digital Audio Amplifier assembly with power supply, includes chassis. *See DN-60561.*

**DAX-5025(E):** 50W, 25 Vrms Digital Audio Amplifier assembly with power supply, includes chassis. *See DN-60561.*

**DAX-5070(E):** 50W, 70.7 Vrms Digital Audio Amplifier assembly with power supply, includes chassis. *See DN-60561.*

**TELH-1:** Firefighter's Telephone Handset for use with the DVC-EM when mounted in the CA-2 chassis. *See DN-7045.*

**CMIC-1:** Optional microphone and microphone well assembly used with the CA-1 chassis.

**RM-1/RM-1SA:** Remote microphone assemblies, mount on ADP-4 (RM-1) dress panel or CAB-RM/-RMR (RM-1SA) stand-alone cabinets. *See DN-6728.*

**AA-30:** Audio Amplifier, 30 watts, 25 Vrms. Includes amplifier and audio input supervision, backup input, and automatic switchover, power supply, cables. *See DN-3224.*

**AA-120/AA-100:** Audio Amplifier provides up to 120 watts of 25 VRMS audio power for the NFS-640. The amplifier contains an integral chassis for mounting to a CAB-B4, -C4, or -D4 backbox (consumes one row). Switch-mode power. Includes audio input and amplified output supervision, backup input, and automatic switchover to backup tone. Order the AA-100 for 70.7 VRMS systems and 100 watts of power. *See DN-3224.*

**DAA Series Digital Audio Amplifiers**: Legacy DAA Series amplifiers are compatible with DVC-EM systems running SR4.0. For specific information on DAA-50 series amplifiers, refer to DN-7046. For information on DAA-7525 Series, refer to DN-60257.

**NFC-25/50:** 25 watt, 25 VRMS, emergency Voice Evacuation Control Panel (VECP) with integral commercial microphone, digital message generator, and single-/dual-channel Class A or Class B speaker circuits. *See DN-60772.*

### *Compatible Devices, EIA-232 Ports*

**PRN-6:** 80-column printer. *See DN-6956.*

**PRN-7:** 80-column printer. *See DN-60897.*

**VS4095/5:** Printer, 40-column, 24V. Mounted in external backbox. *See DN-3260.*

**DPI-232:** Direct Panel Interface, specialized modem for extending serial data links to remotely located FACPs and/or peripherals. *See DN-6870.*

### *Compatible Devices, EIA-485 Ports*

**ACM-24AT:** ONYX Series ACS annunciator – up to 96 points of annunciation with Alarm or Active LED, Trouble LED, and switch per circuit. Active/Alarm LEDs can be programmed (by powered-up switch selection) by point to be red, green, or yellow; the Trouble LED is always yellow. *See DN-6862.*

**AEM-24AT:** Same LED and switch capabilities as ACM-24AT, expands the ACM-24AT to 48, 72, or 96 points. *See DN-6862.*

**ACM-48A:** ONYX Series ACS annunciator – up to 96 points of annunciation with Alarm or Active LED per circuit. Active/ Alarm LEDs can be programmed (by powered-up switch selection) in groups of 24 to be red, green, or yellow. Expandable to 96 points with one AEM-48A. *See DN-6862.*

**AEM-48A:** Same LED capabilities as ACM-48A, expands the ACM-48A to 96 points. *See DN-6862.*

**ACM-8R:** Remote Relay Module with eight Form-C contacts. Can be located up to 6,000 ft. (1828.8 m) from panel on four wires. *See DN-3558.*

**FDU-80:** Terminal mode. 80-character, backlit LCD display. Mounts up to 6,000 ft. (1828.8 m) from panel. Up to 32 per FACP. *See DN-6820.*

**LCD2-80:** Terminal and ACS mode. 80-character, backlit LCD display. Mounts up to 6,000 ft. (1828.8 m) from panel. Up to 32 per FACP. *See DN-60548.*

**LDM:** Lamp Driver Modules LDM-32, LDM-E32, and LDM-R32; remote custom graphic driver modules. *See DN-0551.*

**SCS:** Smoke control stations SCS-8, SCE-8, with lamp drivers SCS-8L, SCE-8L; eight (expandable to 16) circuits (HVAC only). *See DN-4818.*

**TM-4:** Transmitter Module. Includes three reverse-polarity circuits and one municipal box circuit. Mounts in panel module position (single-address-style) or in CHS2-M2 position. *See DN-6860.*

**UDACT-2:** Universal Digital Alarm Communicator Transmitter, 636 channel. *See DN-60686.*

**UZC-256:** Programmable Universal Zone Coder provides positive non-interfering successive zone coding. Microprocessor-controlled, field-programmable from IBM®-compatible PCs (requires optional programming kit). Up to 256 programmable codes. Mounts in **BB-UZC** or other compatible chassis (purchased separately). *See DN-3404.*

### *COMPATIBLE INTELLIGENT DEVICES*

**FWSG Wireless SWIFT Gateway:** Addressable gateway supports wireless SLC devices. Not appropriate for ULC applications. *See DN-60820.*

**FSA-5000:** Intelligent FAAST® XS Fire Alarm Aspiration Sensing Technology. Intelligent aspirating smoke detector for applications up to 5,000 sq.ft. For Canadian applications, order FSA-5000A.

**FSA-8000:** Intelligent FAAST® XM Fire Alarm Aspiration Sensing Technology. Intelligent aspirating smoke detector for applications up to 8,000 sq.ft. For Canadian applications, order FSA-8000A. *See DN-60792.*

**FSA-20000:** Intelligent FAAST® XT Fire Alarm Aspiration Sensing Technology. Intelligent aspirating smoke detector for applications up to 28,800 sq.ft. For Canadian applications, order FSA-20000A. *See DN-60849.*

**FSB-200:** Intelligent beam smoke detector. *See DN-6985.*

**FSB-200S:** Intelligent beam smoke detector with integral sensitivity test. *See DN-6985.*

**FSC-851:** FlashScan IntelliQuad Advanced Multi-Criteria Detector. *See DN-60412.*

**FCO-851:** FlashScan IntelliQuad PLUS Advanced Multi-Criteria Fire/CO Detector. *See DN-60689.*

**FSI-851:** Low-profile FlashScan ionization detector. *See DN-6934.*

**FSP-851:** Low-profile FlashScan photoelectric detector. *See DN-6935.*

**FSP-851T:** FSP-851 plus dual electronic thermistors that add 135°F (57°C) fixed-temperature thermal sensing. *See DN-6935.*

**FSP-851R:** FSP-851, remote-test capable. For use with DNR(W). *See DN-6935.*

**FST-851:** FlashScan thermal detector 135°F (57°C). *See DN-6936.*

**FST-851R:** FlashScan thermal detector 135°F (57°C) with rate-of-rise. *See DN-6936.*

**FST-851H:** FlashScan 190°F (88°C) high-temperature thermal detector. *See DN-6936.*

**FAPT-851:** FlashScan Acclimate Plus low-profile multi-sensor detector. *See DN-6937.*

**FSL-751:** FlashScan VIEW laser photo detector. See *DN-6886.*

**DNR:** InnovairFlex low-flow non-relay duct-detector housing (order FSP-851R separately). Replaces FSD-751PL/FSD-751RPL. *See DN-60429.*

**DNRW:** Same as above with NEMA-4 rating, watertight. *See DN-60429.*

**B224RB:** Low-profile relay base. *See DN-60054.*

**B224BI:** Isolator base for low-profile detectors. *See DN-60054.*

**B210LP:** Low-profile base. Standard U.S. style. Replaces B710LP. *See DN-60054.*

**B501:** European-style, 4" (10.16 cm) base. *See DN-60054.*

**B200S:** Intelligent programmable sounder base, capable of producing a variety of tone patterns including ANSI Temporal 3. Compatible with sychronization protocol. See DN-60054.

**B200S-LF:** Low-frequency version of B200S. See DN-60054.

**B200SCOA:** Based on B200SA, with added CO detector markings in English/French. For Canadian applications only.

**B200SR**: Sounder base, Temporal 3 or Continuous tone. *See DN-60054.*

**B200SR-LF**: Low-frequency version of B200SR. *See DN-60054.*

**FMM-1:** FlashScan monitor module. *See DN-6720.*

**FDM-1:** FlashScan dual monitor module. *See DN-6720.*

**FZM-1:** FlashScan two-wire detector monitor module. *See DN-6720.*

**FMM-101:** FlashScan miniature monitor module. *See DN-6720.*

**FTM-1:** Firephone Telephone Module connects a remote firefighter telephone to a centralized telephone console. Reports status to panel. Wiring to jacks and handsets is supervised. See DN-6989.

**FCM-1:** FlashScan control module. *See DN-6720.*

**FCM-1-REL:** FlashScan releasing control module. *See DN-60390.*

**FRM-1:** FlashScan relay module. *See DN-6720.*

**FDRM-1:** FlashScan dual monitor/dual relay module. *See DN-60709.*

**NBG-12LX:** Manual pull station, addressable. *See DN-6726.*

**ISO-X:** Isolator module. *See DN-2243.*

**ISO-6**: Six Fault isolator module. For Canadian applications order ISO-6A. *See DN-60844.*

**XP6-C:** FlashScan six-circuit supervised control module. *See DN-6924.*

**XP6-MA:** FlashScan six-zone interface module; connects intelligent alarm system to two-wire conventional detection zone. *See DN-6925.*

**XP6-R:** FlashScan six-relay (Form-C) control module. *See DN-6926.*

**XP10-M:** FlashScan ten-input monitor module. *See DN-6923.*

**SLC-IM:** SLC integration module, for VESDAnet detectors. *See DN-60755.*

### *Enclosures, Chassis, and Dress Plates*

**CAB-4 Series Enclosure:** NFS2-640 mounts in a standard CAB-4 Series enclosure (available in four sizes, "A" through "D"). Backbox and door ordered seperately; requires BP2-4 battery plate. A trim ring option is available for semi-flush mounting. *See DN-6857.*

**EQ Series Cabinets:** EQ series cabinets will house amplifiers, power supplies, battery chargers and control modules. EQ cabinets are available in three sizes, "B" through "D". *See DN-60229.* .

**CAB-BM Marine System:** Protects equipment in shipboard and waterfront applications. Also order **BB-MB** for systems using 100 AH batteries. For a full list of required and optional equipment, see *DN-60688.*

**CHS-4:** Chassis for mounting up to four APS-6Rs.

**CHS-4L:** Low-profile four-position Chassis. Mounts two AA-30 amplifiers or one AMG-E and one AA-30.

**DP-1B:** Blank dress panel. Provides dead-front panel for unused tiers; covers DAA2/DAX series or AA-series amplifier.

**NFS-LBB:** Battery Box (required for batteries larger than 26 AH).

**NFS-LBBR:** Same as above but red.

**CHS-BH1:** Battery chassis; holds two 12.0 AH batteries. Mounts one the left side of DAA2 chassis. See DN-7046.

**CA-1:** Chassis, occupies one tier of a CAB-4 Series enclosure. The left side accommodates one DVC-EM and a DVC-KD (optional); and the right side houses a CMIC-1 microphone and its well (optional). *See DN-7045.*

**CA-2:** Chassis assembly, occupies two tiers of a CAB-4 Series enclosure. The left side accommodates one DVC-EM mounted on a half-chassis and one NCA-2 mounted on a half-chassis. The right side houses a microphone/handset well. The CA-2 assembly includes CMIC-1 microphone. ADDR Series doors with two-tier visibility are available for use with the CA-2 configuration: ADDR-B4, ADDR-C4, ADDR-D4 (below).

**CFFT-1:** Chassis to mount firefighter's telephone and one ACS annunciator in a CAB-4 row. Includes TELH-1 firefighter's handset for the DVC-EM, chassis, phone well and mounting hardware. Order DP-CFFT dress panel separately.

**DP-CFFT:** CFFT-1 dress panel. Requires BMP-1 if no ACS annunciator is installed.

**ADDR-B4*:** Two-tier-sized door designed for use with the CA-2 chassis configuration. ADDR Series doors are similar to CAB-4 Series "DR" doors, but a clear window space exposes the top two tiers of the CAB-4 enclosure. Use an SBB-B4 backbox with the ADDR-B4. *See DN-7045, DN-6857.*

**ADDR-C4*:** Three-tier-sized door, designed for use with the CA-2 chassis configuration. ADDR Series doors are similar to CAB-4 Series "DR" doors, but a clear window space exposes the top two tiers of the CAB-4 enclosure. Use an SBB-C4 backbox with the ADDR-C4. *See DN-7045, DN-6857.*

**ADDR-D4*:** Four-tier-sized door designed for use with the CA-2 chassis configuration. ADDR Series doors are similar to CAB-4 Series "DR" doors, but a clear window space exposes the top two tiers of the CAB-4 enclosure. Use an SBB-D4 backbox with the ADDR-D4. *See DN-7045, DN-6857.*

*Use ADDR-B4/C4/D4 when CA-2 chassis is installed in top two rows with NCA-2 or BP-CA2. Use standard door when CA-2 is not installed in top two rows. For additional configuration information, see the DVC application guide on http://esd.notifier.com.

**DPA-1:** Dress panel, used with the CA-1 chassis when configured with a DVC-EM, DVC-KD, and CMIC-1. *See DN-7045.*

**DPA-2B:** Dress panel used with CA-2 chassis assembly.

**VP-2B:** Dress panel, required when CA-2 chassis is installed in the top two cabinet rows.

**DPA-1A4:** Dress panel, used with the CA-1 chassis when the CMIC-1 is not used. Provides mounting options on right two bays for two ACS annunciators, or for blank plates. *See DN-7045.*

**BP-CA2:** Blank plate for CA-2 chassis.

**BB-UZC:** Backbox for housing the UZC-256 in applications where the UZC-256 will not fit in panel enclosure. Black; for red, order BB-UZC-R.

**SEISKIT-CAB:** Seismic mounting kit. Required for seismic-certified applications with NFS2-640 and other equipment mounted in CAB-4 Series Enclosures. Includes battery bracket for two 26 AH batteries.

**SEISKIT-LBB:** Seismic kit for the NFS-LBB. Includes battery bracket for two 55 AH batteries.

### *Other Options*

**411:** Slave digital alarm communicator. See DN-6619.

**411UDAC:** Digital alarm communicator. See DN-6746.

**IPDACT-2/2UD, IPDACT Internet Monitoring Module:** Connects to primary and secondary DACT telephone output ports for internet communications over customer-provided Ethernet connection. Requires compatible Teldat VisorALARM Central Station Receiver. Can use DHCP or static IP. *See DN-60408.*

**IPCHSKIT:** IP Communicator Chassis Mounting Kit. For mounting an IPDACT-2/2UD onto the panel chassis or CHS-4 series chassis. Use IPENC for external mounting applications.

**IPSPLT:** Y-adapter option allow connection of both panel dialer outputs to one IPDACT-2/2UD cable input.

**IPENC:** External enclosure for IPDACT, includes IPBRKT mounting bracket; Red. For Black order IPENC-B.

**IPGSM-4G:** Internet and Digital Cellular Fire Alarm Communicator. Provides selectable configurable paths: cellular only, IP only, or IP primary with cellular backup. Connects to the primary and secondary ports of a DACT. For Canadian applications order IPGSM-4GC. *See DH-60769.*

***NOTE:** For other options including compatibility with retrofit equipment, refer to the panel's installation manual, the SLC manual, and the Device Compatibility Document.*

## System Specifications

### *System Capacity*

- Intelligent Signaling Line Circuits ............1 expandable to 2
- Intelligent detectors ........................................ 159 per loop
- Addressable monitor/control modules ............. 159 per loop
- Programmable software zones........................................ 99
- Special programming zones ............................................ 14
- LCD annunciators per CPU2-640/-640E and NCA-2 *(observe power)*............................................ 32
- ACS annunciators per CPU2-640/-640E ......................... 32 addresses x 64 points

- ACS annunciators per NCA-2.................................32 addresses x 64 or 96 points

***NOTE:*** *The NCA-2 supports up to 96 annunciator address points per ACM-24AT/-48A.*

### *Electrical Specifications*

- Primary input power:
  - CPU2-640 board: 120 VAC, 50/60 Hz, 5.0 A.
  - CPU2-640E board: 220/240 VAC, 50/60 Hz, 2.5 A.
- Current draw (standby/alarm):
  - CPU2-640(E) board: 0.250 A. Add 0.035 A for each NAC in use.
  - KDM-R2: 0.100 A.
  - LEM-320: 0.100 A.
- Total output 24 V power: 6.0 A in alarm.

***NOTE:*** *The power supply has a total of 6.0 A. of available power. This is shared by all internal circuits. See Installation Manual for a complete current draw calculation sheet.*

- Standard notification circuits (4): 1.5 A each.
- Resettable regulated 24V power: 1.25 A.
- Two non-resettable regulated 24V power outputs:
  - 1.25 A.
  - 0.50 A.
- Non-resettable 5V power: 0.15 A.
- Battery charger range: 18 AH – 200 AH. Use separate cabinet for batteries over 26 AH.
- Float rate: 27.6 V.

### *Cabinet Specifications*

- Systems can be installed in CAB-4 Series cabinets *(four sizes with various door options, see DN-6857)*. Requires BP2-4 Battery Plate.

### *Shipping Weight*

- CPU2-640/-640: 14.3 lb (6.49 kg).
- CPU2-640/-640E: 14.55 lb (6.60 kg).

### *Temperature and Humidity Ranges*

This system meets NFPA requirements for operation at 0 – 49°C/32 – 120°F and at a relative humidity 93% ± 2% RH (noncondensing) at 32°C ± 2°C (90°F ± 3°F). However, the useful life of the system's standby batteries and the electronic components may be adversely affected by extreme temperature ranges and humidity. Therefore, it is recommended that this system and its peripherals be installed in an environment with a normal room temperature of 15 – 27°C/60 – 80°F.

### *Agency Listings and Approvals*

The listings and approvals below apply to the basic NFS2-640 control panel. In some cases, certain modules may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL Listed:** S635.
- **ULC Listed:** S635.
- **FM Approved.**
- **MEA:** 128-07-E.
- **Fire Dept. of New York:** #6121.
- **CSFM:** 7165-0028:0243.
- **City of Chicago.**
- **City and County of Denver.**
- **CCCF listed.**

**Marine Applications:** Marine approved systems must be configured using components itemized in this document. (See Main System Components, in "Product Line Information.) Specific connections and requirements for those components are described in the installation document, PN 54756. When these requirements are followed, systems are approved by the following agencies:

- **US Coast Guard** 161.002/50/0, 161.002/55/0 (Standard 46 CFR and 161.002).
- **Lloyd's Register** 11/600013 (ENV 3 category).
- **American Bureau of Shipping** (ABS) Type Approval.

***NOTE:*** *For information on marine applications, see DN-60688.*

### *Standards*

The NFS2-640 complies with the following UL Standards and NFPA 72, International Building Code (IBC), and California Building Code (CBC) Fire Alarm Systems requirements:

- **UL 864, 9th Edition** (Fire).
- **UL 1076** (Burglary).
- **UL 2572** (Mass Notification Systems). (NFS2-640 version 20 or higher.)
- **LOCAL** (Automatic, Manual, Waterflow and Sprinkler Supervisory).
- **AUXILIARY** (Automatic, Manual and Waterflow) (requires TM-4).
- **REMOTE STATION** (Automatic, Manual, Waterflow and Sprinkler Supervisory) (requires TM-4).
- **PROPRIETARY** (Automatic, Manual and Waterflow).
  *Not applicable for FM.*
- **EMERGENCY VOICE/ALARM**.
- **OT, PSDN** (Other Technologies, Packet-switched Data Network).
- **IBC 2012, IBC 2009, IBC 2006, IBC 2003, IBC 2000** (Seismic).
- **CBC 2007** (Seismic).

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