Prescriptive and Performance-Based Fire and Life Safety Evaluation

FPE 596, Culminating Experience in Fire Protection Engineering

California Polytechnic State University, San Luis Obispo, CA

Orange Grove Library, Gulfport, Mississippi

David A. Boackle, P.E.

PO Box 1524, Jackson, MS 39215

601.918.6966

dboackle@gmail.com

2016-12-30

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Keywords:
Life Safety Analysis
Prescriptive Design
Performance-Based Design
Building Code
Fire Code Violation

Executive Summary

This report describes the analysis of the Orange Grove Library in Gulfport, Mississippi, using prescriptive and performance-based techniques to evaluate fire and life safety. The prescriptive analysis is broken down into four components: alarm, egress, structural and suppression. Prescriptive codes are written by consensus, such that adhering to these codes will produce a reasonable balance between cost, function and safety. The performance-based design analysis uses analytical tools to predict how this particular building would perform under specific fire conditions, chosen based on the actual building in place.

Life safety is the primary goal of this analysis. Achievement of this goal is measured by the ability of occupants to safely leave the building. This ability is quantified as the tenability criteria listed herein.

The findings of the prescriptive analysis indicate that this building fails to meet the prescriptive code for certain egress components. The egress analysis has revealed several areas of non-compliance with the code requirements. Related to the Communicating Space, these include the lack of smoke barriers, an obstructed view from the second floor and an exit path through the communicating space. There should not be an exit through the receiving area. Also, the placement of the egress illumination and exit signs do not correspond to the exit paths.

The performance-based design analysis also shows deficiencies in safety. FDS modeling shows that tenability due to loss of visibility begins to deteriorate very quickly, in under a minute for both fire sizes, 4'x4' and 2'x2'. However, the other tenability criteria, carbon monoxide and temperature, are not nearly as dangerous in the first few minutes. The secondary goal for this analysis is to consider the preservation of property. Under most circumstances, the protection

provided to the Secure Administrative Storage should be adequate to serve its function.

Upon inspection of the library, several fire code violations were observed. These include a blocked exit, maintenance of illumination devices, storage in exit enclosures and storage in mechanical room. Proper operational control can be achieved through education and training of the staff. For this purpose, a fire prevention plan is included here in the appendix.

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1. Introduction

This report has been prepared for the California Polytechnic State University course, FPE 596, Culminating Experience in Fire Protection Engineering, Winter/Spring 2016. The assigned task is to perform a comprehensive fire and life safety evaluation of a suitable project building.

The Orange Grove Library serves as the headquarters for the Harrison County Library System and houses 4 departments: a branch library (Orange Grove), administration, technical processing and information technology. The original headquarters library was located about 3 blocks from the Mississippi Sound and destroyed by Hurricane Katrina in 2005, requiring the construction of a new library. The new library at 12135 Old Hwy 49, Gulfport, MS 39503, is built approximately 7 miles inland at an elevation of 53 feet above sea level.

There is also a community meeting room attached to the library on the first floor. The building is configured with separate entrances into the library and meeting rooms, accessed off of the lobby. Each space can be used independently of the other.

This report discusses in detail the techniques and processes of performing both the prescriptive analysis and performance-based analysis. Discussions of the assumptions, techniques and methodologies are included along with the results. This building design contains deficiencies and thus fails to properly protect occupants.

Following the analysis of the two design methods, this report examines operational issues, including fire code violations that contribute to dangers to occupants. Included here are suggestions for corrective action to eliminate or minimize these operational risks.

Basis of Analysis

This analysis is designed to evaluate the safety of occupants of this building during fire situations. In order for all occupants to safely evacuate the building, the time required to exit the building must be greater than the time available to exit the building. Another way to express this is Available Safe Egress Time (ASET) must be greater than Required Safe Egress Time (RSET), plus a safety factor.

This analysis is done in two parts: the first method, called a prescriptive analysis, is based on compliance with established standards or codes. A building design that complies with these codes, by design of the code, should provide adequate egress time to allow all occupants to exit safely.

The second type of analysis is called a performance-based analysis. This builds on the concepts of the prescriptive codes and applies inputs specific to the building in question to determine an outcome unique to this building.

2. Building Design and Construction

The International Code Council authors a set of codes, including the International Building Code (IBC), which describes what protective features should be designed into a building. Libraries and community halls are classified as Assembly Group A-3 under Section 303.4 of the 2012 IBC.

IBC Section 202 Definitions

> ATRIUM. An opening connecting two or more stories other than enclosed stairways, elevators, hoistways, escalators, plumbing, electrical, air-conditioning or other equipment, which is closed at the top and not defined as a mall. Stories, as used in this definition, do not include balconies within assembly groups or mezzanines that comply with Section 505.

General requirements for an atrium are listed in IBC 2012, Section 404.1. Certain notable sections are listed below.

IBC Section 404.3 Automatic sprinkler protection.

> An approved automatic sprinkler system shall be installed throughout the entire building.

IBC Section 404.4 Fire alarm system.

> A fire alarm system shall be provided in accordance with Section 907.2.14.

IBC Section 404.5 Smoke control.

> A smoke control system shall be installed in accordance with Section 909.
> Exception: Smoke control is not required for atriums that connect only two stories.

IBC Section 404.6 Enclosure of atriums.

> Atrium spaces shall be separated from adjacent spaces by a 1-hour fire barrier constructed in accordance with Section 707 or a horizontal assembly constructed in accordance with Section 711, or both.
> Exception: A fire barrier is not required where a glass wall forming a smoke partition is provided.

Construction of this building began in 2011. There are approximately 32,000 square feet on two floors. The first floor consists of 17,000 square feet and the second floor is 15,000 square feet. This creates approximately 2,000 square feet of two-story opening. There are two protected egress stairs. There is also an accessory stair located in the atrium. The building is protected throughout by an automatic sprinkler system.

Atrium Ceiling Construction

Throughout the second floor, the ceiling is suspended four feet below the roof deck. In the area over most of the atrium communicating space, including over the atrium floor opening, the ceiling is constructed as suspended panels running north-south with large gaps (2 feet wide) between each ceiling panel. See Figures 3.6, 3.7 and 3.8.

During a fire, ceiling jets could be diverted off a ceiling panel and travel up into a gap, as opposed to spreading across a conventional smooth ceiling. Smoke will collect above the ceiling and go undetected until the space above the ceiling "fills up" with smoke, much like an upside-down bathtub.

3. Occupancy and Interior Photographs

There are a number of different classifications of occupancies within this building. The most prominent is the library space, which is classified as Assembly. Also, because this is a central hub for a number of other libraries, there are administrative offices and a large processing room for handling books. The office and processing space will be lightly populated and contain no special hazards, so they are considered a Business occupancy classification.

The community meeting room is located on the first floor and is used for a variety of events. Because of the multipurpose nature of this room, it is treated as a high-density Assembly occupancy, with only seven square feet per person.

The climate in south Mississippi is subtropical, requiring large air handling units to cool and dehumidify the building. The mechanical space required is larger than would be required if this building were located in a more temperate climate.

The open staircase in the interior of the building is not a means of egress but the square footage is included as service space for calculating the occupancy load. There is an occupancy load of 356 on the first floor and 134 on the second floor. See Figure A.1 for occupancy load calculation.

For color-coded occupancy classifications, see Figures 3.1 and 3.2. Photos of the building are included in Figures 3.3 through 3.9.

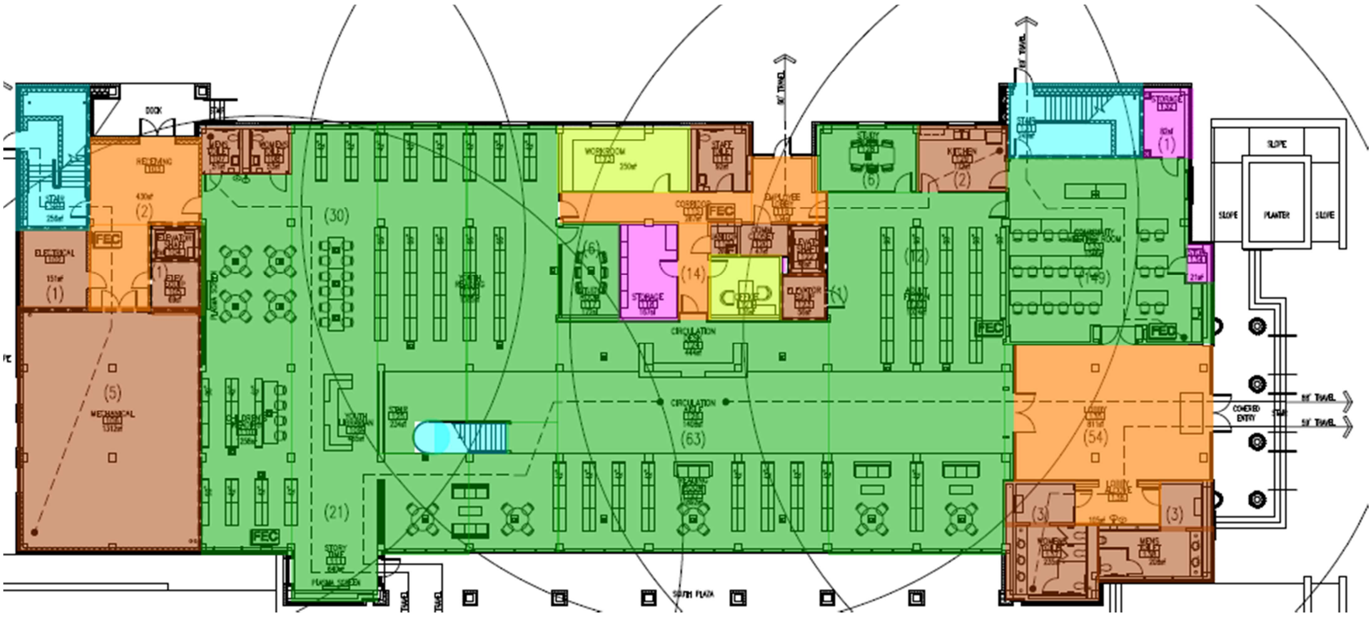


Figure 3.1 First floor occupancy classification. Orange=Exit Access, Blue=Vertical Exits, Green=Assembly, Yellow=Business, Brown=Service Space, Purple=Storage

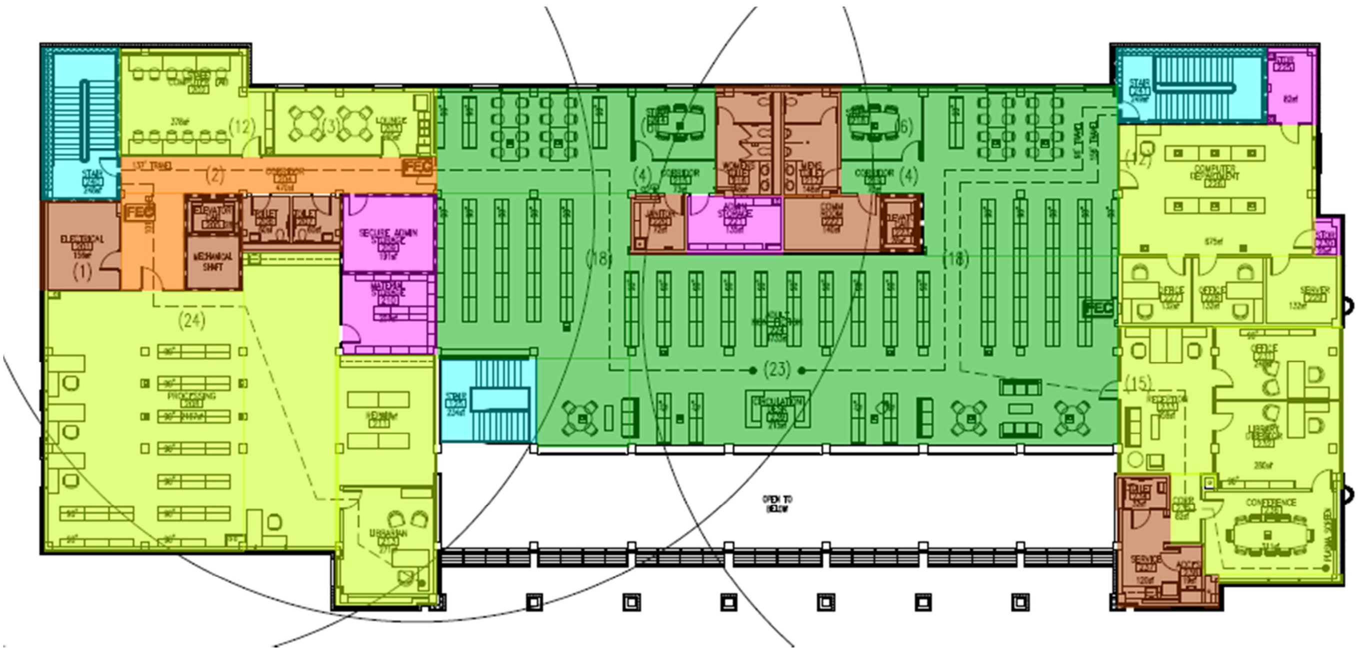


Figure 3.2 Second floor occupancy classification. Orange=Exit Access, Blue=Vertical Exits, Green=Assembly, Yellow=Business, Brown=Service Space, Purple=Storage

Figure 3.3 Second floor atrium space looking east

Figure 3.4 Second floor atrium space looking west

Figure 3.5 Second floor looking west

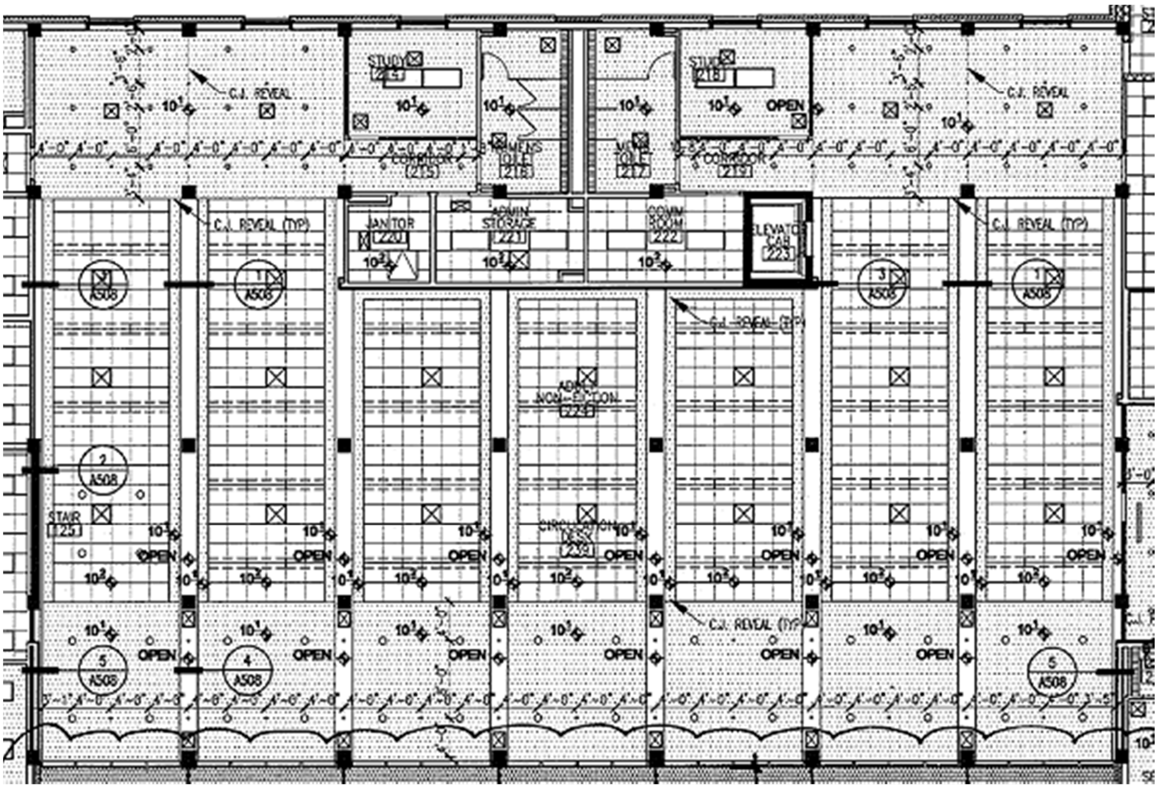


Figure 3.6 Second floor reflected ceiling plan

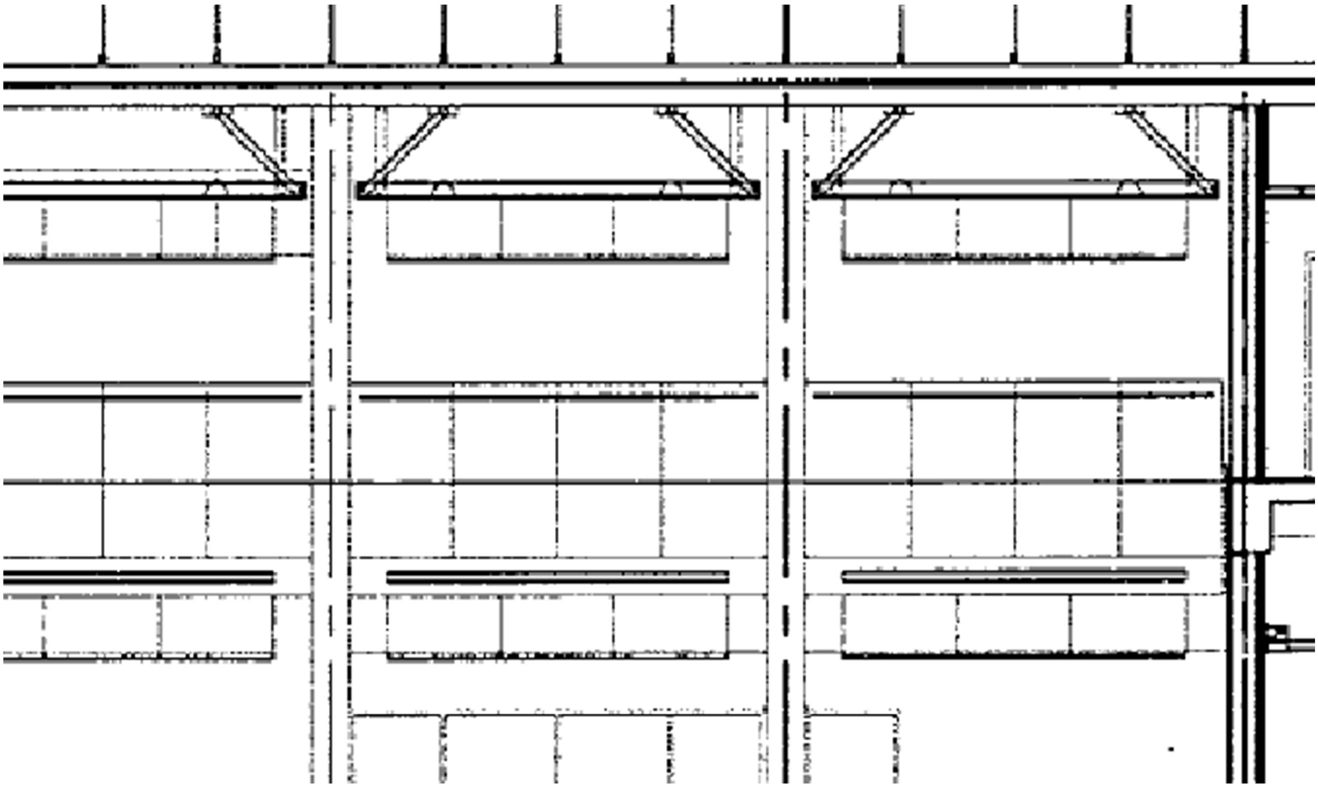


Figure 3.7 Section through atrium showing suspended ceiling

Figure 3.8 Second floor looking north, showing the gaps in the ceiling

Figure 3.9 Second floor looking south, showing the gaps in the ceiling

4. Floor Opening Classification and Smoke Control

The smoke control required is based on the classification of the floor opening. The building designer did not explicitly state how they classified and treated this opening. Therefore, several options are explored here.

Atrium

Atria are governed by the following code section, which requires active smoke control:

NFPA 101, Section 8.6.7 (5)

> For other than existing, previously approved atriums, an engineering analysis is performed that demonstrates that the building is designed to keep the smoke layer interface above the highest unprotected opening to adjoining spaces, or 6 ft. (1830 mm) above the highest floor level of exit access open to the atrium, for a period equal to 1.5 times the calculated egress time or 20 minutes, whichever is greater.

There is no active smoke control and none is required because the building is only two stories. Therefore, this is not an atrium.

Mezzanine

Mezzanine must comply with the following two sections:

NFPA 101, Section 8.6.10.2.1

> The aggregate area of mezzanines located within a room, other than those located in special-purpose industrial occupancies, shall not exceed one-third the open area of the room in which the mezzanines are located. Enclosed

> space shall not be included in a determination of the size of the room in which the mezzanine is located.

First floor open space is 8,666 square feet and second floor open space is 5,312 square feet. There is an additional 1,248 square feet of enclosed space on the second floor, containing two study rooms, bathrooms and service space. This is the appropriate ratio:

5,312 square feet / 8,666 square feet = 60.3% or around 2/3

This upper floor area exceeds that allowed for a mezzanine, which is 1/3.

NFPA 101, Section 8.6.10.3.1

> All portions of a mezzanine, other than walls not more than 42 in. (1065 mm) high, columns, and posts, shall be open to and unobstructed from the room in which the mezzanine is located, unless the occupant load of the aggregate area of the enclosed space does not exceed 10.

The shelves on the upper level are 90" tall. Therefore, the view of a growing fire would be blocked. Also the occupant load inside an enclosure exceeds 10 in the two study rooms located on the mezzanine.

Based on the two sections above, this building cannot be considered a mezzanine.

<u>Communicating Space</u>

By eliminating options, the only choice left is to classify this as Communicating Space under NFPA 101 Section 8.6.6. The examination of this building proceeded under this basis.

Based on the classification as Communicating Space, this library uses passive smoke control only. There are smoke detectors in the air handling system—one in the return and one in the supply. These duct smoke detectors are used to shut down the air handling system. See Section 7. Prescriptive - Egress Analysis for further discussion of required smoke control.

5. Prescriptive Analysis

This building was designed using the prescriptive approach, in which certain codes should have been followed. Mississippi did not have statewide codes at the time of design, so the codes listed by the designer may have been locally adopted by the City of Gulfport or the experience and discretion of the designer.

These codes were noted by the architect on the Life Safety plans:
- International Building Code (IBC) of 2003
- International Plumbing Code of 2003
- International Fire Code of 2003
- Americans with Disabilities Act of 1994
- Code of Ordinances of the City of Gulfport

The following aspects of prescriptive safety are listed below with the corresponding codes used by the author for analysis:
- Alarm, analyzed using the National Fire Protection Association (NFPA) 72 (2010) National Fire Alarm and Signaling Code
- Egress, analyzed using the NFPA 101 (2012) Life Safety Code
- Structural Fire Protection, analyzed using the IBC (2012)
- Suppression, analyzed using the NFPA 13 (2010) Standard for the Installation of Sprinkler Systems

Note that the codes used by the original designer are different versions than those used in this analysis.

6. Prescriptive - Alarm Analysis

A fire alarm system can give all occupants notice of a fire or other emergency situation simultaneously, so they can all exit the building soon enough to reach safety. The system must be designed to react quickly to the byproducts of combustion but robust enough to avoid nuisance alarms, which may desensitize occupants.

Code Requirement for a Fire Detection and Alarm System

The International Building Code (IBC) describes what protective features are required, while NFPA 72 describes how these features are installed and must function.

IBC Section 404.4 Fire alarm system.

> A fire alarm system shall be provided in accordance with Section 907.2.14.

IBC Section 907.2.14 Atriums connecting more than two stories.

> A fire alarm system shall be installed in occupancies with an atrium that connects more than two stories with smoke detection installed throughout the atrium. The system shall be activated in accordance with Section 907.5. Such occupancies in Group A, E or M shall be provided with an emergency voice/alarm communication system complying with the requirements of Section 907.5.2.2.

Since this building is only two stories, this reduces the requirements for the fire alarm system. There are still detectors provided for certain specific needs, such as elevator recall.

Fire Alarm System

The specification for this project is to be of non-coded, analog addressable, microprocessor-based control panels, remote annunciators, addressable alarm initiating devices, visual and audio/visual alarm devices and a fully supervised wiring system for a complete and operational Fire Detection and Alarm System. The general design of the initiating and notification devices was laid out by the electrical engineer in the drawings.

The Fire Alarm Control Panel (FACP) is located in a communications closet with the telecommunications backboard. Remote annunciators are located by the front door used by the public and by the back door to the north used by the employees. The FACP is a bid item which may be provided by the following approved system manufacturers:

a. Simplex/Grinnell
b. Siemens (Cerberus/Pyrotronics)
c. Edwards Systems Technology (EST)
d. Notifier
e. Fire Control Instruments, Inc. (FCI)
f. Secutron

The entire system must be from the same manufacturer. There are control/monitor modules to interface with other systems such as the elevators. Operating characteristics are discussed in a later section of this report.

Type and Location of Initiating Devices

Initiating devices include:

a. Manual Pull Stations are provided and connected at all exterior exit doors and in each corridor where required to limit spacing between devices to 200 feet.

Where shown at exit doorways, pull stations shall be mounted within 5 feet of the edge of the door.

b. Smoke Sensors (aka Detectors) are ceiling or wall mounted. Sensors shall not be located in direct air flow or within 36 inches of an air supply diffuser.

c. Thermal Sensors are ceiling or wall mounted and fixed temperature and rate-of-rise sensing, 135 F.

d. Duct Mounted Smoke Sensors with remote alarm and test station.

The specifications call for the Smoke Sensors to be of the photoelectric type.

Location, Spacing and Placement of the Fire Detection Devices

The specifications require the contractor to comply with NFPA 72.

There are smoke sensors in the air-handling system. There are heat detectors in the elevator shafts and other service spaces where the environment is not conducive to a smoke detector.

Additional protection could be gained by making the detectors in the building a dual type sensor, photoelectric and ionization. Also, a beam detector across the upper atrium opening would reduce the time to detect a fire.

Disposition of Alarm, Supervisory and Trouble Signals

Actuation of any initiation device or interface device shall cause the following actions:

a. Activate general alarms (audible and visual).

b. Display individual initiating device address and description at control panel(s) and remote annunciators.

c. Provide activation signals and interfaces to other systems as herein specified.

d. Transmit signal over telephone lines to central fire reporting station via

communicator.

e. Record the event in the historical log.

The System shall monitor the connected devices and associated circuitry and shall initiate a supervisory or trouble notification as required by NFPA 72 for the wiring classification specified. A supervisory or trouble signal shall initiate the associated audible and visual alarms at the associated FACP and remote annunciator(s) and shall record the event in the historical log.

Type and Location of Alarm Notification Devices

There are both audible and visual notification devices throughout the building. Every bathroom and most meeting rooms have an audio/visual device. There is also a horn/strobe in the large mechanical room on the first floor. See Figures 6.1 and 6.2 for locations of notification devices.

See NFPA 72, TABLE A.18.4.3 Average Ambient Sound Level According to Location.

Business occupancies and Places of assembly are both 55 dBA. Adding 15 dBA gives a required 70 dBA. The librarian's office, adjacent to the processing room is 60 feet away from a device. Assuming a Sound Pressure Level (SPL) of 110 dBA at 10 feet and using the 6 dBA rule, 104 dBA at 20 feet, 98 dBA at 40 feet and 92 dBA at 80 feet. Assuming the door to the office is of light construction, this should meet the requirements for SPL.

Divided into imaginary rooms, no space exceeds 60 feet by 60 feet, which can be satisfied by a 135 candela (cd) light. Therefore, it appears the visual notification appliance spacing meets the current code.

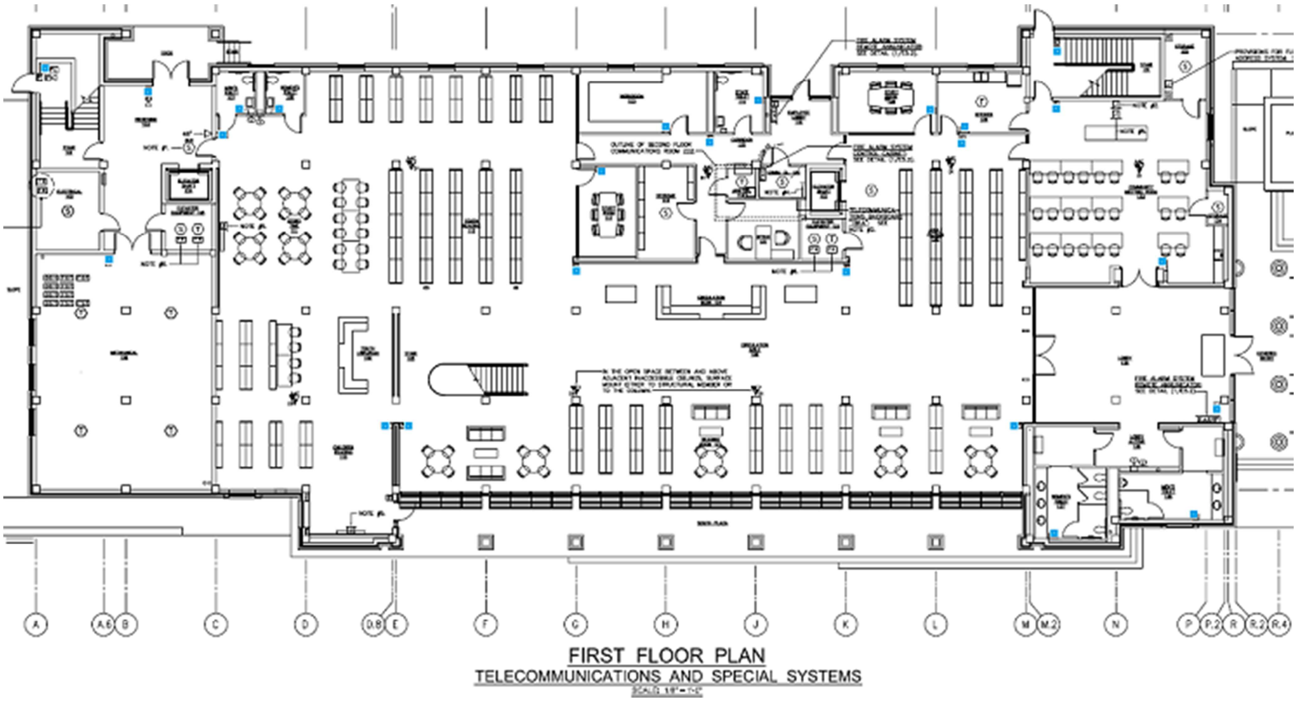


Figure 6.1 First floor notification devices marked in blue

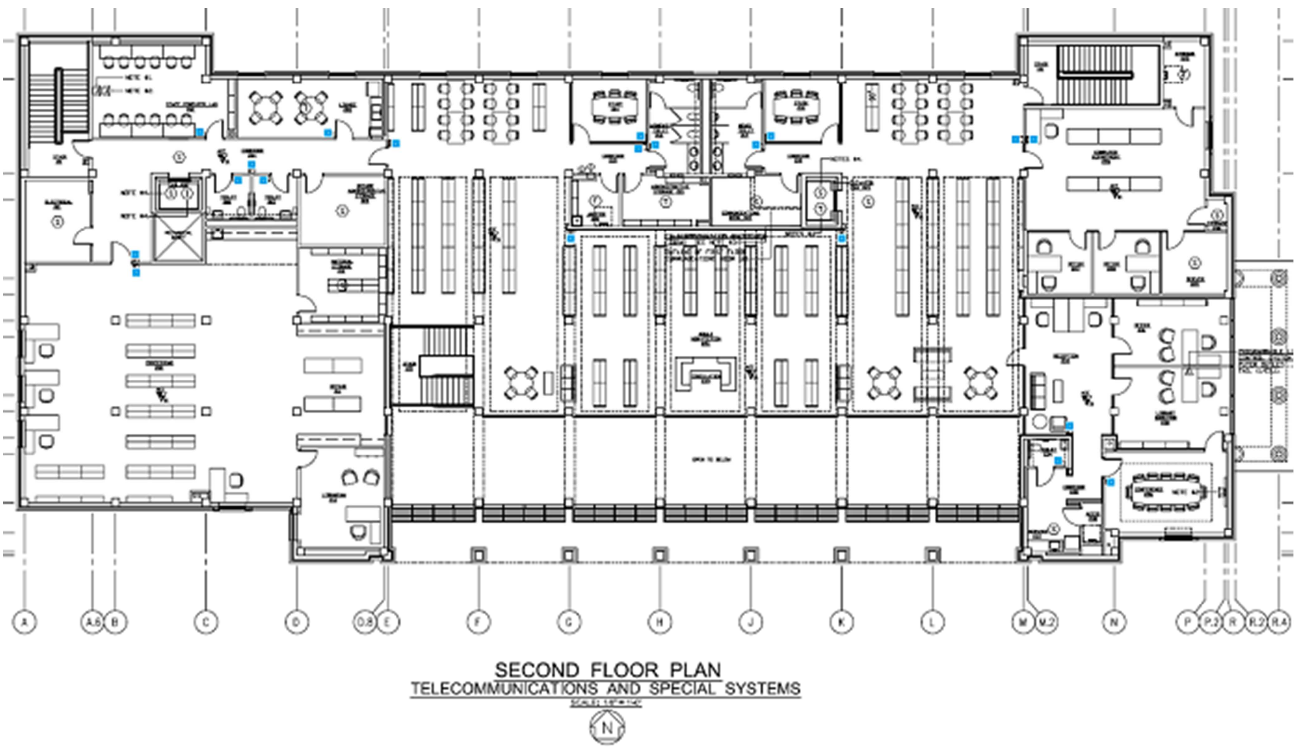


Figure 6.2 Second floor notification devices marked in blue

Expected Performance of Notification Appliances

The calculation for determining the time until smoke detector activation is performed in the two-story atrium space, since this is the most severe fire scenario with a ceiling height of 26 feet. The reason for this being so severe is that the higher the plume height, the more fresh air is entrained into the plume. For these calculations, it is assumed smoke detectors are placed at a maximum spacing of 30 feet between devices.

These calculations are made using the DETACT model with a Response Time Index (RTI) of 2. The low numbers are indicative of the quick response of a smoke detector. Assume a temperature gradient of 7.2 degrees C to drive the combustion products to the detector by buoyancy and use a T-squared fire.

Activation of the detector occurs at 82 seconds with a Heat Release Rate (HRR) of 324 kW. To put that into perspective, NFPA 92B, Standard for Smoke Management Systems, Table B.5.3(a) Maximum Heat Release Rates from Fire Detection Institute Analysis, indicates a furnished living room (heat at open door) has a heat release rate of 4,000 - 8,000 Btu/sec (approximately 4,000 - 8,000 kW).

To better illustrate why this HRR is so small, we can examine the Heskestad equation [SFPE, eqn 51.27] in Figure 6.3.

$$\dot{m} = 0.071\dot{Q}_c^{1/3} z^{5/3} + 0.0018\dot{Q}_c$$

Figure 6.3 Heskestad equation, where m-dot is mass flow rate, Q-dot is HRR and z is clear flame height

In this equation, the HRR (Q-dot) and flame height (z) are inversely proportional. This means that for a given mass flow rate (m-dot), if the flame height (z) increases, then the HRR (Q-dot) will be lower. The ceiling height (z) in this library atrium is quite a bit taller than the ceiling of a typical one-story living room. This explains why the HRR value of 324 kW is so small.

The subscript "c" on the HRR (Q-dot_c) stands for convection, as the radiative fraction is not relevant in this formula. The Heskestad formula was used here for illustrative purposes only. See Table 6.1 and Figure 6.4 for further information about this calculation.

Table 6.1 DETACT model inputs spreadsheet

3	INPUT PARAMETERS			CALC. PARAMETERS	
4	Ceiling height (H)	7.32	m	R/H	1.2486339
5	Radial distance (R)	9.14	m	dT(cj)/dT(pl)	0.2587207
6	Ambient temperature (To)	20	C	u(cj)/u(pl)	0.1662139
7	Actuation temperature (Td)	27.2	C	Rep. t2 coeff.	k
8	Response time index (RTI)	2	(m-s)1/2	Slow	0.003
9	Fire growth power (n)	2	-	Medium	0.012
10	Fire growth coefficient (k)	0.047	kW/s^n	Fast	0.047
11	Time step (dt)	1	s	Ultrafast	0.400

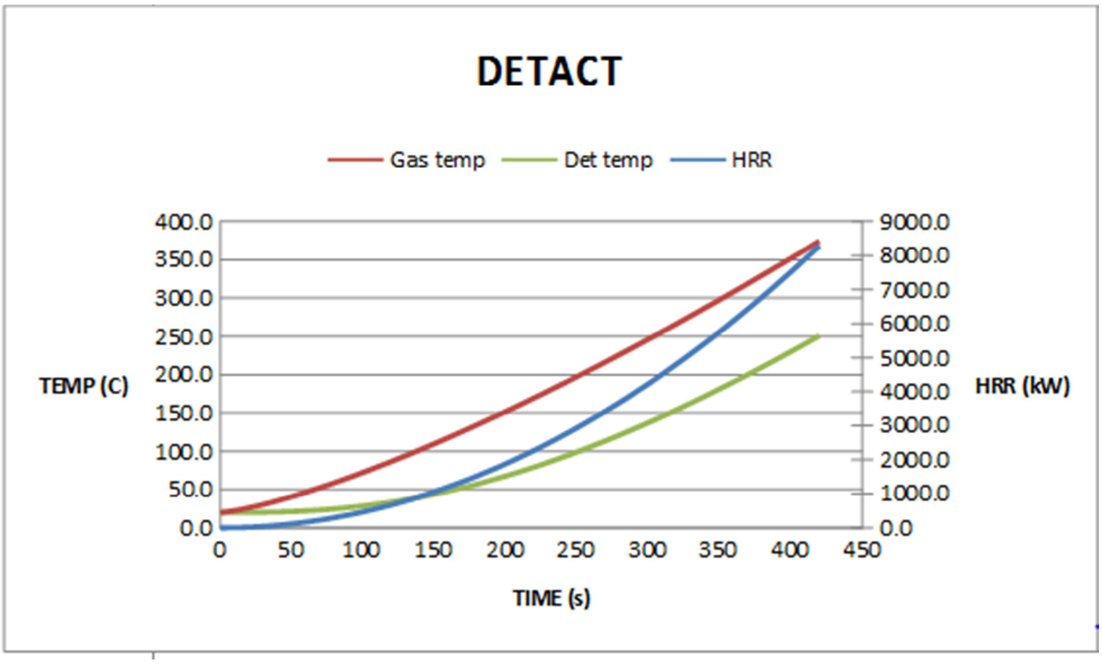


Figure 6.4 DETACT Graph

Secondary Power Supply Requirements

The specifications for this project call for a battery standby power supply capable of carrying the full load plus 25 percent Factor of Safety (FOS). The batteries must last for 24 hours in standby mode with 5 minutes of alarm operation at the end of that period. The batteries are supervised, so any failure should result in a trouble condition.

Battery Calculation for Illustrative Purposes

Author does not have the actual specifications for the installed devices. Therefore, this is an example to illustrate the methodology of calculating the battery capacity. Assume the following:

> total current for all appliances during standby: 0.50 amp

> total current draw for all appliances during alarm: 3.0 amp

24 hours * 0.05 amp = 1.2 amp hour

(5 min * 1 hour / 60 min) * 3.0 amp = 0.25 amp hour

Total of 1.45 amp hour * 1.25 FOS = 1.83 amp hour battery required.

A similar illustrative example for Voltage Drop:

VD = 2 * L * R * I / 1,000

where L = one-way length of conductor (ft)

R = conductor resistance (ohm/ft)

I = load current (amp)

Inspection, Testing and Maintenance

The specifications for this building require the fire alarm contractor to perform extensive testing and documentation. A System Record of Completion as required and published in NFPA 72 shall be completed by the installing contractor and submitted to the owner and a copy of the report shall be included with the close-out documents.

A "FIRE ALARM SYSTEM INSPECTION/TEST REPORT" is included in the Specifications. The fire alarm contractor is required to complete this document for the building owner.

Selected requirements from NFPA 72:

- Section 14.1.1 The inspection, testing, and maintenance of systems, their initiating devices and notification appliances shall comply with the requirements of this chapter.
- Section 14.1.3 Procedures that are required by other parties and that exceed the requirements of this chapter shall be permitted.
- Section 14.2.1.1.2 Inspection, testing and maintenance programs shall verify correct operation of the system.
- Section 14.2.2.3 Inspection, testing or maintenance shall be permitted to be done by the building or system owner or a person or organization other than the building or system owner if conducted under a written contract.

- EXHIBIT 14.2 Checklist for Required System Testing Documentation.

Fire Alarm System Record of Completion
Point-to-Point Wiring Diagrams
Individual Device Interconnection Drawings
As-Built (Record) Drawings
Copy of Original Equipment Submittals
Operational Manuals
Manufacturer's Proper Testing and Maintenance Requirements
Device Address List/Conventional Device Location List

- Section 14.2.5.5 Testing shall include verification that the releasing circuits and components energized or actuated by the fire alarm system are electrically monitored for integrity and operate as intended on alarm.

- TABLE 14.3.1 Visual Inspection Frequencies. Additional information in the code. The specifications require the contractor to test the system in parts and conduct a full test. They also require that the engineer conduct selected testing at his discretion. The specifications further state that if the engineer needs to make more than one re-check to verify issues have been corrected, then the contractor shall be charged for the engineer’s work.

Conclusion Fire Alarm

This building meets the IBC and NFPA 72 code requirements. The smoke detector located in the atrium communicating space is for the purpose of elevator recall (also called elevator capture), wherein if the detector senses smoke on the second floor, the elevator car can return to the ground floor level for fire department use.

7. Prescriptive - Egress Analysis

Several of the occupancy types in this building share a common exit access. Therefore, the NFPA 101 requires the building to be treated as a mixed occupancy without having the option to separate the occupancies. NFPA 101 Sections 6.1.14.1 and also 6.1.14.3, Multiple Occupancies, will be applied in the Egress analysis.

IBC Section 404.6 Enclosure of atriums.

> Atrium spaces shall be separated from adjacent spaces by a 1-hour fire barrier constructed in accordance with Section 707 or a horizontal assembly constructed in accordance with Section 711 or both.
> Exception: A fire barrier is not required where a glass wall forming a smoke partition is provided.

The green boundaries shown in Figures 7.1 and 7.2 indicate the location of a required smoke partition that does not exist. The darkened walls indicate a 1-hour fire rated partition. The number in parenthesis is the area occupant load as calculated by the designer.

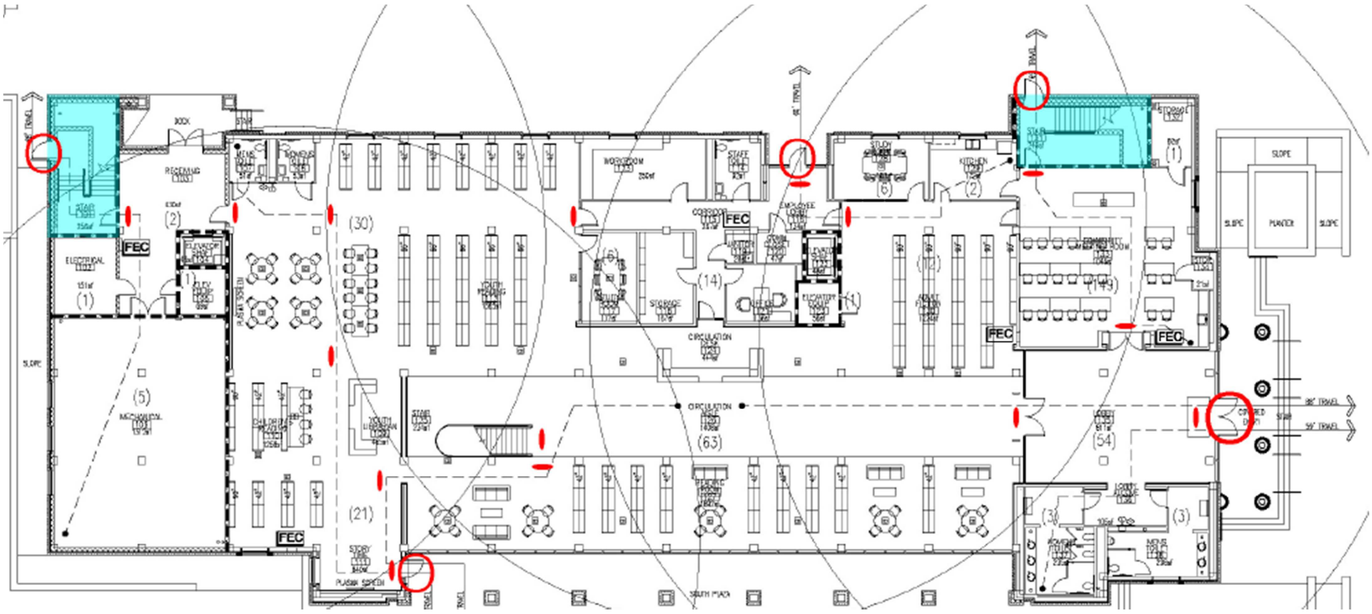


Figure 7.1 First floor egress plan showing 1-hour fire rated barrier in bold black and area occupant load in parenthesis. The egress path is shown as a dashed line.

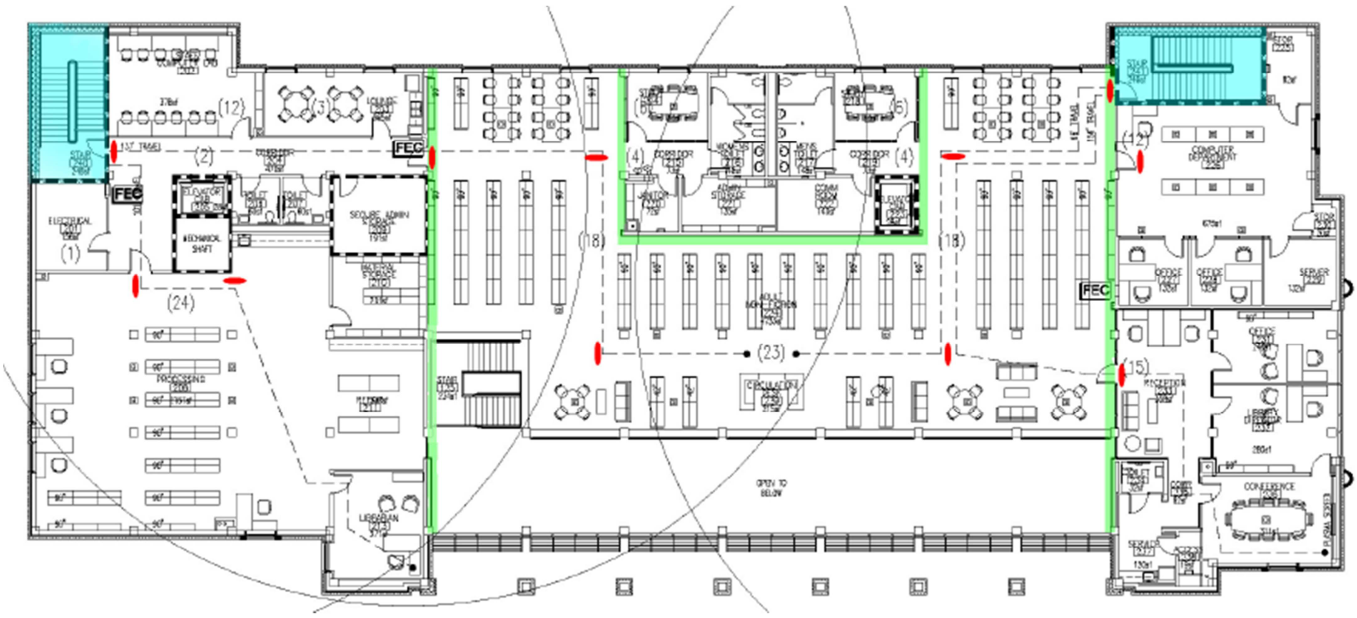


Figure 7.2 Second floor egress plan showing 1-hour fire rated barrier in bold black and area occupant load in parenthesis. There are smoke barriers. However, the plan here is marked in green where smoke barriers should be located. The egress path is shown as a dashed line.

Exit Capacity

Buildings must be designed such that egress capacity is greater than the occupant load. The types of occupancies and square footage were determined from the plans. See Appendix A.1 for calculations.

To perform this analysis, we determine the total occupant load using Occupant Load Factors from NFPA 101 Table 7.3.1.2. The results here are close to what the designer calculated for total occupancy. However, there are differences in the egress capacity. The Capacity Factor from NFPA 101 Table 7.3.3.1 requires 0.2 inch per person exiting horizontally and 0.3 inch per person exiting vertically by way of stairs. The length in inches refers to width of the exit. The designer used 0.15 inch per person for both horizontal and vertical exits. However, enough of a margin of safety was provided that the building still has adequate exit capacity for not only the second floor occupants alone but also the building's total occupant load. See Appendix A.1 for calculations.

Number and Arrangement of Exits

There are 134 persons on the second floor who have access to the two protected stairs. The building exits are remote from each other, and the two protected stairs are at opposite ends of the building. If one exit should be blocked, then the remaining exits still represent more than half the needed capacity.

IBC Section 1015.2.1 Two exits or exit access doorways.

> Where two exits or exit access doorways are required from any portion of the exit access, the exit doors or exit access doorways shall be placed a distance apart equal to not less than one-half of the length of the maximum overall diagonal dimension of the building or area to be served measured in a straight line between exit doors or exit access doorways. Interlocking or scissor stairs shall be counted as one exit stairway.

Maximum overall diagonal dimension in this building is 220 feet, so the exits are required to be a minimum of 110 feet apart. The actual distance is 164 feet apart on the second floor, which meets this requirement.

<u>Exit Through Receiving Area</u>

IBC Section 1018.6 Corridor continuity.

> Fire-resistance-rated corridors shall be continuous from the point of entry to an exit and shall not be interrupted by intervening rooms.

In this building, an exit is marked through the receiving area. Because some goods received may be of a flammable nature and because these goods may block the exit path through the receiving area, this route should not be used or marked as an exit. See Figure 7.3.

Figure 7.3 Marked exit through receiving area on first floor

<u>Horizontal Exits and Fire Resistance Ratings</u>

NFPA 101 Section 12.3.6, Corridors, Paragraph (2) states, "Corridor and lobby protection shall not be required in buildings protected throughout by an approved, supervised automatic sprinkler system in accordance with Section 9.7."

There are no horizontal exits in this building. Firewalls surround mechanical and electrical spaces, elevator shafts and stairs.

NFPA 101 Section 7.2.4.3.4

> Where fire barriers serving horizontal exits, other than existing horizontal exits, terminate at outside walls, and the outside walls are at an angle of less than 180 degrees for a distance of 10 ft. (3050 mm) on each side of the horizontal exit, the outside walls shall have a minimum 1-hour fire resistance rating, with opening protectives having a minimum 3⁄4-hour fire protection rating for a distance of 10 ft. (3050 mm) on each side of the horizontal exit.

The east stair exterior wall is partly protected where the angle with the adjacent north wall is less than 180 degrees. See Figure 7.4.

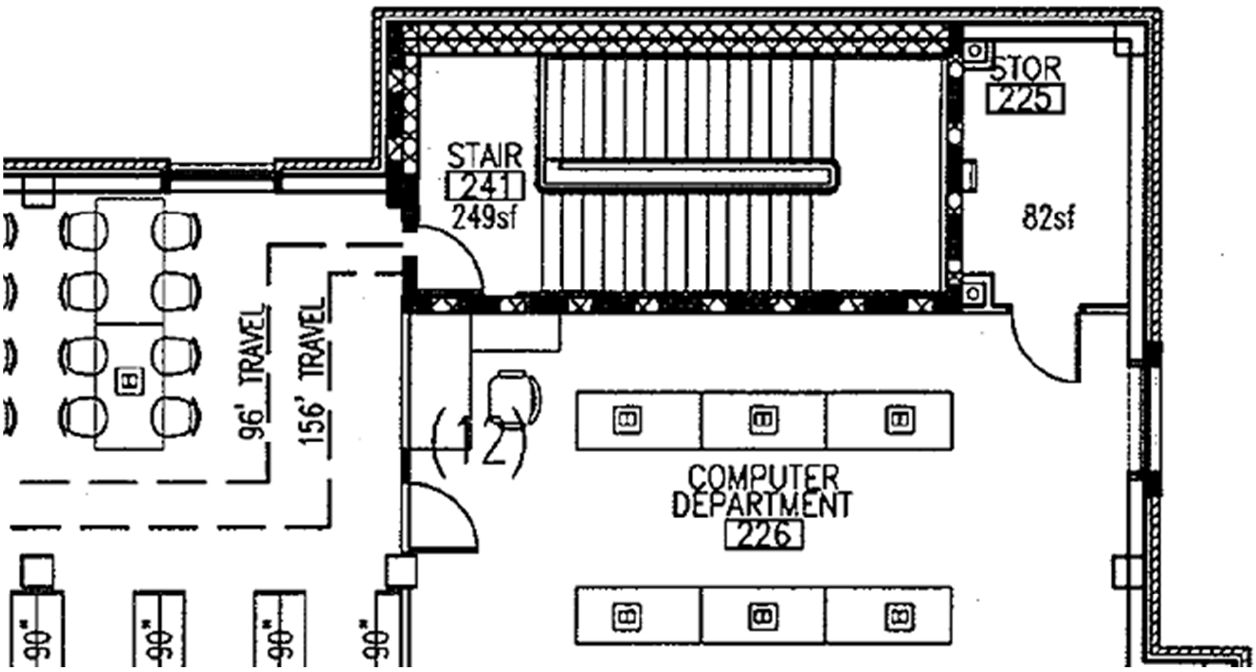


Figure 7.4 Protected Exterior Wall

Exit Signs and Illumination

NFPA 101 Section 7.10.1.2.1

> 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.

The central staircase in the interior of the building is not counted towards the egress capacity because it is not protected and its use might lead occupants down and into a fire on the first floor. Therefore, there are no exit signs on the second floor directing occupants to use this stair. However, there is a possibility this stair might be used during an emergency and, in such case, signs would be needed on the first floor to direct them out of the building. See Figure 7.1.

NFPA 101 Section 7.8.1.1

> Illumination of means of egress shall be provided in accordance with Section 7.8 for every building and structure where required in Chapters 11 through 43. For the purposes of this requirement, exit access shall include only designated stairs, aisles, corridors, ramps, escalators, and passageways leading to an exit. For the purposes of this requirement, exit discharge shall include only designated stairs, aisles, corridors, ramps, escalators, walkways and exit passageways leading to a public way.

In this building, there are emergency exit signs as well as battery-backup lighting. However, these signs and lights are placed over the paths contemplated by the original design of the furniture layout.

Much of the actual furniture layout does not correspond to the original design. Therefore, some parts of the building do not comply with code requirements for exit signs and illumination to show occupants a clear path to safety. For an example, see Figure 7.5 below.

Figure 7.5 Emergency lighting and exit signs over bookshelves

Interior Finish Requirements

NFPA 101 Section 12.3.3.2 Corridors, Lobbies, and Enclosed Stairways.

Interior wall and ceiling finish materials complying with Section 10.2 shall be Class A or Class B in all corridors and lobbies and shall be Class A in enclosed stairways.

NFPA 101 Section 12.3.3.3 Assembly Areas.

Interior wall and ceiling finish materials complying with Section 10.2 shall be Class A or Class B in general assembly areas having occupant loads of more than 300 and shall be Class A, Class B, or Class C in assembly areas having occupant loads of 300 or fewer.

NFPA 101 Section 12.3.3.5.2

Interior floor finish in exit enclosures and exit access corridors and in spaces not separated from them by walls complying with 12.3.6 shall be not less than Class II.

Issues Relating to Atrium Communicating Space

IBC Section 404.9 Travel distance.

In other than the lowest level of the atrium where the required means of egress is through the atrium space, the portion of exit access travel distance within the atrium space shall be not greater than 200 feet (60 960 mm). The travel distance requirements for areas of buildings open to the atrium and where access to the exits is not through the atrium shall comply with the requirements of Section 1016.

The Life Safety Plans drawn by the architect show a travel distance for the office suite of 156 feet. However, these occupants must travel through the atrium.

IBC Section 1018.4 Dead ends.

Where more than one exit or exit access doorway is required, the exit access shall be arranged such that there are no dead ends in corridors more than 20 feet (6096 mm) in length.

This building complies with the code above.

Equivalency

The designer must provide a safe building. Because an atrium is inherently more challenging to protect from fire than a one-story opening, they have additional safety requirements. However, the designer has flexibility in how they meet the requirement to provide for safety. The designer could have chosen to provide active smoke and treated this building according to NFPA 101 Section 8.6.7 (Atriums).

Instead they attempted to use the alternate method described in NFPA 101 Section 8.6.6 (Communicating Space). The provisions of NFPA 101 Section 8.6.6 are often referred to as the "mini-atrium" requirements. The three conditions listed below (#3, #4 and #8) are violated.

NFPA 101 Section 8.6.6 Communicating Space.

> Unless prohibited by Chapters 11 through 43, unenclosed floor openings forming a communicating space between floor levels shall be permitted, provided that the following conditions are met:
>
> (3) The entire floor area of the communicating space is open and unobstructed, such that a fire in any part of the space will be readily obvious to the occupants of the space prior to the time it becomes an occupant hazard.
>
> (4) The communicating space is separated from the remainder of the building by fire barriers with not less than a 1-hour fire resistance rating, unless one of the following is met:
> (a) In buildings protected throughout by an approved automatic sprinkler system in accordance with Section 9.7, a smoke barrier in accordance with Section 8.5 shall be permitted to serve as the separation required by 8.6.6(4).

(8) Each occupant not in the communicating space has access to not less than one exit without having to enter the communicating space.

In regards to NFPA 101 Section 8.6.6(3), an occupant on the second floor might have a hard time seeing a fire developing due to the configuration of the opening, the suspended ceilings and the tall shelving units. The appendix for this section states:

> ... judging sufficient openness can be difficult. Through the use of the equivalency concept addressed in Section 1.4, some authorities having jurisdiction have permitted complete automatic smoke detection systems with proper occupant notification features to be substituted for the openness and unobstructedness required by 8.6.6(3) for awareness and early warning purposes.

The ceiling panels above the atrium space run north-south and a ceiling jet may rise up in between the suspended ceiling panels. An occupant on the east end of the second floor would not be able to see a fire plume or ceiling jet of a fire developing on the west end of the building and vice versa.

In regards to NFPA 101 Section 8.6.6(4a), the building plans show firewalls around mechanical and electrical spaces, elevator shafts and stairs, but not around the atrium space. The walls shown adjacent to the atrium space are not barrier walls of any type, fire or smoke. The proper protection is shown in the Figure 7.2 above with required smoke barriers marked in green.

In regards to NFPA 101 Section 8.6.6(8), second floor occupants located in the office suite and study rooms will have to enter and traverse the atrium space in order to reach an exit.

Conclusion Egress

The egress analysis has revealed several areas of non-compliance with the code requirements. Related to the communicating space, these include the lack of smoke barriers, obstructed view from the second floor and exit path through the communicating space. There should not be an exit through the receiving area. Also, the placement of the egress illumination and exit signs do not correspond to the exit paths.

8. Prescriptive - Structural Analysis

Chapter 3 of the IBC covers Use and Occupancy Classification. Specifically, libraries and community halls are classified as Assembly Group A-3 under Section 303.4.

Construction Type

The building structure is cast-in-place concrete. The concrete columns are exposed in the interior. The first floor/foundation is slab on grade with strip footings and spread footings at column locations. The second floor and lower roof slab are structural concrete slab. The upper roof is metal deck on light gage steel trusses.

Exterior material include the following: hand-formed brick, architectural precast panels, lintels and columns, glass fiber reinforced concrete panels, copings, and pediment, cementitious stucco soffits, aluminum storefront and curtainwall. Roofing systems include both low-slope modified bitumen and sloped prefinished metal standing seam.

The height of the building is approximately thirty-eight feet (38’). Additionally, the building is surrounded by sidewalks or yard. There is at least sixty feet (60’) of land on all sides of the building, including the parking lots.

Permissible Construction Types

IBC Table 503, ALLOWABLE BUILDING HEIGHTS AND AREAS in the IBC lays out the permissible construction types. The building in question has a first floor area exceeding 15,500 square feet. However, there are increases allowed for frontage and the sprinkler system.

Checking this building's number of stories and overall height against IBC Table 503 for an A-3 occupancy, it could be Construction Type I (A or B), Type II (A or B), Type III (A or B), Type IV or Type V-A.

The building is surrounded by a public way or open space leading to a public way. For frontage increase, use IBC Equation 5-2: $I_f = (F/P - 0.25) * W / 30$
where

I_f = Area increase due to frontage.
F = Building perimeter that fronts on a public way or open space having 20 feet (6096 mm) open minimum width (feet). In this case, the entire building has open space.
P = Perimeter of entire building (feet).
W = Width of public way or open space (feet) in accordance with IBC Section 506.2.1.

F = P, so F/P = 1.0
so, $I_f = (1.0 - 0.25) * 30 / 30 = 0.75 = 75\%$

IBC Section 506.3 Automatic sprinkler system increase allows for an increase an additional 200 percent for multi-storied buildings, so $I_s = 2.0$

Total increase is $A_a = A_t + (A_t * I_f) + (A_t * I_s)$
where
A_a = allowable building area per story (square feet)
A_t = Tabular building area per story in accordance with IBC Table 503 (square feet)

So, testing the floor area against the least stringent construction type this building might qualify for, Type V yields the following:

A_a = 11,500 square feet + (11,500 square feet * 0.75) + (11,500 square feet * 2)

A_a = 43,125 square feet

Therefore, it is possible this building could be built with Type V-A construction. The actual construction type is not known.

IBC Table 601, FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS of the IBC requires the following for Type V-A construction, given in hours:

Primary structural frame - 1

Bearing walls, Exterior - 1

Bearing walls, Interior - 1

Nonbearing walls and partitions, Exterior - see below

Nonbearing walls and partitions, Interior - 0

Floor construction and secondary members - 1

Roof construction and secondary members - 1

IBC Table 602, FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON FIRE SEPARATION DISTANCE of the IBC requires no fire protection based on a fire separation distance greater than thirty feet (30’).

Per the specification, penetrations through rated walls must comply with ASTM E-814, "Standard Method of Fire Tests of Through Penetration Fire Stops" (July 1997).

Conclusion Structural

The plans and specifications only generically state that the building shall comply with the IBC. They do not list any fire protection ratings for the structural members to be used or their expected performance. The designer has effectively

put the burden of compliance on the contractor to make a determination of the requirements for compliance with the code.

Most of the material specified on this project is inherently non-combustible. However, the author was unable to determine compliance due to lack of information about the construction of the building.

9. Prescriptive - Suppression Analysis

Purpose of Fire Sprinklers

The Available Safe Egress Time (ASET) must be greater than the Required Safe Egress Time (RSET). A water-based fire suppression system can be used to increase the ASET for any given building. A suppression system can also help protect property.

The NFPA (National Fire Protection Association) 13, Standard for the Installation of Sprinkler Systems is used as the standard to design, install, test and maintain this system. NFPA 13 is based on the assumption of a single source of ignition. See Figures 9.1 and 9.2.

Figure 9.1 Fire sprinkler riser located in the mechanical room on the west end of first floor

Figure 9.2 Fire sprinkler riser, valves and tamper switches

Occupancy

The classification is "light hazard" as called out by the architect in the Specifications, Section 15330 - WET-PIPE SPRINKLER SYSTEM. This agrees with NFPA 13, Section 5.2 Light Hazard Occupancies.

Water Supply

Shop drawings from the fire protection contractor show a flow test from a nearby fire hydrant: static 50 psi, residual 47 psi, flow 1190 gpm on 2010-11-22. See Appendix D.3 and D.4.

Fire Department Connection

The International Fire Code (IFC), Section 912 Fire Department Connections (FDC), requires a sprinklered building to have an FDC installed.

IFC Section 912.2.1 Visible location.

> Fire department connections shall be located on the street side of buildings, fully visible and recognizable from the street or nearest point of fire department vehicle access or as otherwise approved by the fire chief.

IFC Section 912.3 Access.

> Immediate access to fire department connections shall be maintained at all times and without obstruction by fences, bushes, trees, walls or any other fixed or moveable object. Access to fire department connections shall be approved by the fire chief.

Code requirements regarding the FDC are meant to ensure an auxiliary water supply to a water-based suppression system, such as is installed in this building. The FDC allows the fire department to either boost pressure within the building or to pump water off their truck. See Figures 9.3 and 9.4.

This building does not comply with code requirements for the FDC.

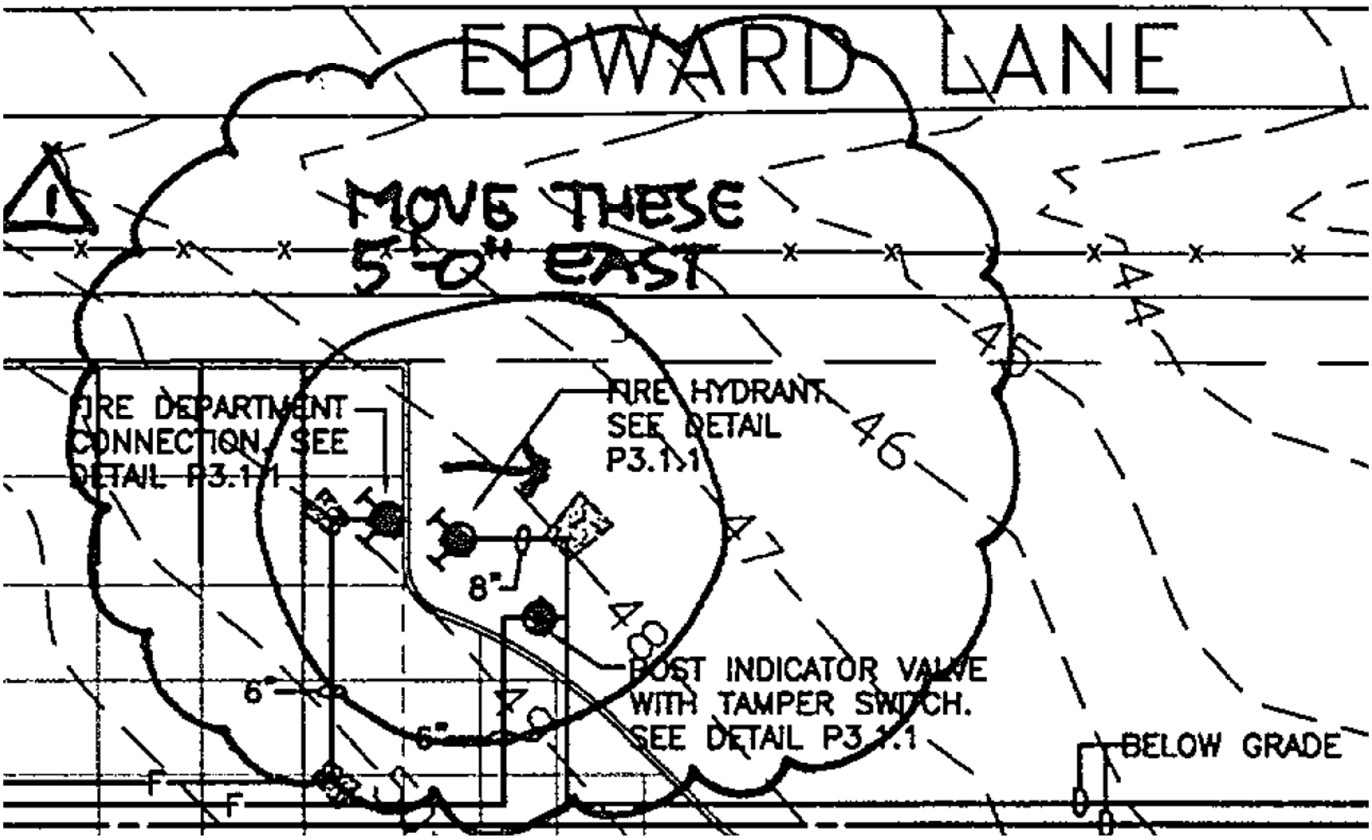


Figure 9.3 Plan showing FDC, fire hydrant and post indicator valve on engineering plans

Figure 9.4 In this picture, the fire hydrant is painted yellow and the post indicator valve is painted red. Both are barely visible through the vegetation. According to the engineering plans, the FDC is also located in this area

Type of Suppression System

The type of water-based fire suppression system in this building is a mostly wet pipe sprinkler system. The only exception is the loading dock area, which has dry pendants concealed in the ceiling. All pipe, 1-1/2 inch and larger, is schedule 10. See Appendix D.1 and D.2 for shop drawings.

Shop drawings were developed by a fire protection contractor using NFPA 13, 2007. The shop drawings contain the following notes:

1. Construction consists of slab on grade with steel columns supporting metal beams, steel bar joists and non-combustible roof deck

2. Sprinkler design is in accordance with NFPA 13 11-2.3.2 for area/density method
3. Piping to conform with NFPA 13 6.3 (ASTM A-135 Black Steel Schedule 10/40)
4. Fittings to conform with NFPA 13 6.4 and are to be combination of threaded, drilled, welded and/or grooved
5. Hangers to conform with NFPA 13 6.6 and are to consist of ATR, swivel ring and upper attachment
6. Mains and branch lines are cut dimensions with mains indicating center to center weld-o-lets.
7. Center of tile installation is required by contract documents. Representation is made for the sprinklers to be located in the center of the ceiling tiles. Sprinkler locations for this project are to conform with NFPA 13. Deviations from this plan for aesthetic will result in extra compensation.

Types of Sprinklers

All sprinklers provided to this job are made by Reliable. An exterior loading dock is protected by two dry pendants, which are the only two standard response sprinklers in this building. Except for those mentioned above, all other sprinklers are of the quick response type.

Hydraulic Calculations

This building has an area which appears to be the most hydraulically remote based on the distance from the system riser. There is another area on the second floor with higher K-value heads which may be more hydraulically demanding, based on flow volume. In order to test which one is more demanding, calculations must be done on each area. See Appendix B.1 thru B.3.

Hydraulic Calculations - Office & Reading Room

By distance, the second floor office suite is the most remote area. The fire protection contractor sized the system for a 1,500 square foot design area.

NFPA 13, Section 11.2.3.2.3.1 states: Where listed quick-response sprinklers, including extended coverage quick response sprinklers, are used throughout a system or portion of a system having the same hydraulic design basis, the system area of operation shall be permitted to be reduced without revising the density as indicated in Figure 11.2.3.2.3.1 when all of the following conditions are satisfied:

(1) Wet pipe system
(2) Light hazard or ordinary hazard occupancy
(3) 20 ft. (6.1 m) maximum ceiling height
(4) There are no unprotected ceiling pockets as allowed by 8.6.7 and 8.8.7 exceeding 32 ft2 (3 m2)

This more remote area of this building is an office space and meets this criteria with 10-foot ceilings, which allows for a 40 percent reduction in the design area. That means that only 900 square feet (sf) must be protected and will require 6 sprinklers. The calculations performed here will take advantage of this.

900 sf / 6 heads = 150 sf/head * 0.1gpm/sf = 15 gpm
P = MAX[7 psi, (Q1/K)^2] > P = MAX[7 psi, 7.175 psi] > use 7.175 psi for the office

A reduction in the design area should not be considered in this space for two reasons. First, the ceilings are over the maximum 20 feet high and secondly because this area is in an atrium. This area is closer to the water source than the

offices above, but because of the higher K and larger area (1,500 sf vs. 900 sf), this may have a higher hydraulic demand.

1,500 sf / 6 heads = 250 sf/head * 0.1 gpm/sf = 25 gpm
P = MAX[7 psi, (Q1/K)^2] > P = MAX[7 psi, 9.766 psi] > use 9.766 psi for the reading room

The calculated equations above, the office requires 7.175 psi and the office requires 9.766 psi.

Hose Stream Allowance

NFPA 13, TABLE 11.2.3.1.2 Hose Stream Allowance and Water Supply Duration Requirements for Hydraulically Calculated Systems specifies a flow of 100 gpm for 30 minutes. In this application, there is a large (8") main that connects to a fire hydrant in the yard. From that point, the water supply is carried to the Base of Riser (BOR) by a 6 inch main.

Outcome of Hydraulic Calculations

The reading room on the second floor is the most remote area in the building, both by water flow (gpm) and by pressure (psi) requirements. An outline of the building is attached which shows the areas which were analyzed. See Appendix B for calculations.

Because the test data was obtained at the tie-in with the municipal water supply, these calculations are carried back from the Base Of Riser (BOR) to the tie-in with municipal system. There is a note on the attached calculations denoting the conditions at the BOR. The available water supply meets the required water demand. See Figure 9.5.

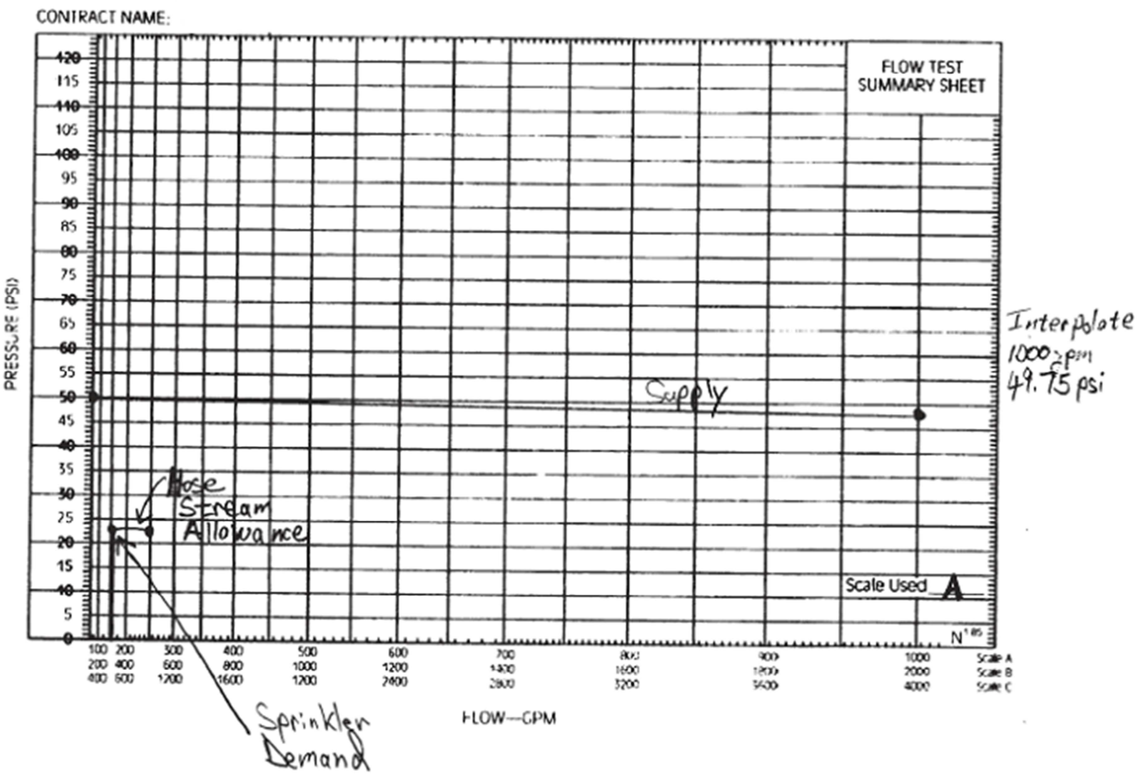


Figure 9.5 Hydraulic graph showing supply from utility

<u>Inspection, Testing and Maintenance</u>

NFPA 25, Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems is used here. The abbreviation ITM is sometimes used. The information below is from the 2011 Edition. Some of the items in the code have been removed because they do not apply to the building under consideration. Of particular note is the lack of a backflow preventer. The only protection for the municipal water supply appears to be swing check valves at the Base of Riser (BOR) in the mechanical room.

Selected information from NFPA 25, Table 6.1.1.2 Summary of Standpipe and Hose Systems Inspection, Testing and Maintenance (Item Frequency Reference)

Inspection:
Control valves Table 13.1
Piping Annually 6.2.1
Gauges Weekly 6.2.2
Hydraulic design information sign Annually 6.2.3

Test:
Water flow alarm devices Table 13.1
Valve supervisory alarm devices Table 13.1
Supervisory signal devices (except valve supervisory switches) Table 13.1
Pressure control valve Table 13.1
Pressure reducing valve Table 13.1
Hydrostatic test 5 years 6.3.2
Flow test 5 years 6.3.1
Main drain test Table 13.1

Maintenance:
Valves (all types) Annually/as needed Table 13.1

Selected information from Table 13.1.1.2 Summary of Valves, Valve Components, and Trim Inspection, Testing and Maintenance (Item Frequency Reference)

Inspection:
Control Valves
Sealed Weekly 13.3.2.1
Locked Monthly 13.3.2.1.1
Tamper switches Monthly 13.3.2.1.1

Alarm Valves
Exterior Monthly 13.4.1.1
Interior 5 years 13.4.1.2
Strainers, filters, orifices 5 years 13.4.1.2

Check Valves
Interior 5 years 13.4.2.1
Fire Department Connections Quarterly 13.7.1

Testing:
Main Drains Annually/quarterly 13.2.5, 13.2.5.1, 13.3.3.4
Water flow Alarms Quarterly/semiannually 13.2.6
Control Valves
Position Annually 13.3.3.1
Operation Annually 13.3.3.1
Supervisory Semiannually 13.3.3.5
Full flow Annually 13.4.3.2.2

Conclusion Water Suppression

In conclusion, the design of the water suppression system inside the building is in compliance with NFPA 13. The system outside the building appears from the plans to have been built correctly and also in compliance with NFPA 13.

However, the vegetation around this outside equipment is not being maintained properly and thus completely conceals parts of the outdoor system. This constitutes a fire code violation under the International Fire Code (IFC).

10. Prescriptive - General Conclusion

The analysis finds that this building fails to meet the prescriptive code for the egress components. The atrium communicating space lacks proper protection.

The occupants of the second floor offices and second floor study area will be exposed to fire products as they move to the exits, located at the protected stair entrances. They will likely not be able to see the location of the fire or, because of the lack of smoke partitions, to shelter in place while awaiting rescue.

11. Performance-Based Analysis

This section discusses the performance-based analysis. This type of analysis builds on the concepts of the prescriptive codes and applies the inputs specific to this building to arrive at a predicted outcome for a specific assumed fire. The desired outcome is primarily measured as Available Safe Egress Time (ASET) vs Required Safe Egress Time (RSET).

12. Performance - Design Brief

Goals

The primary goal of the performance based analysis is to evaluate the safety of life of the building occupants from fire dangers. A secondary goal for this analysis is to consider the preservation of property. Records for the district are kept in the secure administrative storage room on the second floor of the building.

Objectives

NFPA 101 Section 4.2.1 Occupant Protection.

> A structure shall be designed, constructed, and maintained to protect occupants who are not intimate with the initial fire development for the time needed to evacuate, relocate, or defend in place.

NFPA 101 Section 4.2.2 Structural Integrity.

> Structural integrity shall be maintained for the time needed to evacuate, relocate, or defend in place occupants who are not intimate with the initial fire development.

NFPA 101 Section 4.2.3 Systems Effectiveness.

> Systems utilized to achieve the goals of Section 4.1 shall be effective in mitigating the hazard or condition for which they are being used, shall be reliable, shall be maintained to the level at which they were designed to operate and shall remain operational.

Primary Performance Criteria - Tenability Requirements

The performance criteria used to measure achievement of the life safety goals of the performance-based analysis are collectively referred to as tenability requirements, which are necessary for egress. Tenability requirements are a set of values that are the most severe that an occupant can endure and still escape safely.

Fire fatalities are usually caused by inhaling the products of combustion. However, poor visibility and high temperatures of a fire may disorient occupants and prevent them from escaping a fire.

Maintaining tenability throughout the facility will allow for a timely evacuation of all occupants, either to the public way (outside the building) or to an area of refuge, such as a stairwell.

Here, safe tenability limits are established for visibility, temperature and exposure to carbon monoxide (CO). The actual values for these limits will be different for each fire scenario and depend on the type of building, any special hazards, the physical limitations of the occupants, etc. For instance, in this building, one would expect some of the occupants are elderly or young; these classes of occupants would be expected to be less tolerant of a fire environment than a healthy adult. See Table 12.1.

Table 12.1, Tenability Criteria

Criteria	Value	Source
Visibility	10m (30ft)	SFPE HB, Table 63.5
Carbon Monoxide	1706 ppm for 4 minutes for Fractional Effective Dose (FED) of 0.3	NFPA 130, Table B.2.1.2
Temperature	60 C (140 F)	SFPE HB, p, 2382

These values may be more conservative (safer) than would be used in other circumstances, due to the inclusion of certain vulnerable persons in the building population, such as children, handicapped and the elderly.

Secondary Performance Criteria - Administrative Storage

This building contains a secured storage area which holds records for itself and other libraries in the county. Plans show a 1-hour rated fire partition around the administrative storage room located on the second floor.

13. Scenarios

Scenario Used for FDS

The most obvious fire scenario to use in this building to test the limits of fire protection is a fire starting in the four chairs located on the first floor, centered under the atrium floor opening. Since the chairs are movable and occupants have been observed moving the chairs, the power cords are vulnerable to being crushed under the legs of these chairs. The first fuel ignited is the chair, as a result of the frayed power cord.

Smoke production is proportional to the 5/3 power of the fire plume height. Therefore, placing the test fire under the atrium floor opening will provide the tallest ceiling and therefore, the largest amount of smoke generation. The additional smoke is generated through entrainment of ambient air into the fire plume. This ambient air cools the fire plume and also the ceiling jet, delaying the activation of the fire suppression system (sprinklers).

This fire scenario is the most severe because occupants in the southeast corner of the building will have to travel through the atrium space to reach an exit. This will expose them to whatever products of combustion may be present.

Other Scenarios Considered

The second scenario considered involved the community meeting room, which is counted as a high density occupancy at only 7 square feet per person. A fire could start in one of the adjacent small storage rooms and if it reached flashover, it is possible to overwhelm the sprinkler system in the community meeting room. However, this scenario was not pursued as both storage rooms have fire sprinklers and smoke detectors.

The last scenario considered is a fire in the main entrance lobby. This would require bringing in outside combustible material, such as from a health fair with tables and booths. However, blocking this door would still leave 3 exit doors from the interior of the library on the ground level, including one on the opposite side of the community meeting room.

14. Performance - Fire Dynamics Simulator (FDS)

The mesh wall boundaries used in the FDS model are inside the green marks on the second floor, where there should be a 1-hour smoke partition, as required by IBC Section 404.6 Enclosure of atriums and NFPA 101 Section 8.6.6(4). See Figure 14.1.

While these walls are not actually constructed as smoke partitions, they are solid walls from floor to ceiling and all of the connecting doors through these walls have automatic closers which should, at least initially, make this FDS model reasonably accurate in regard to the walls. The mesh walls on the first floor are set to match the second floor and closely approximate the atrium communicating space on the first floor.

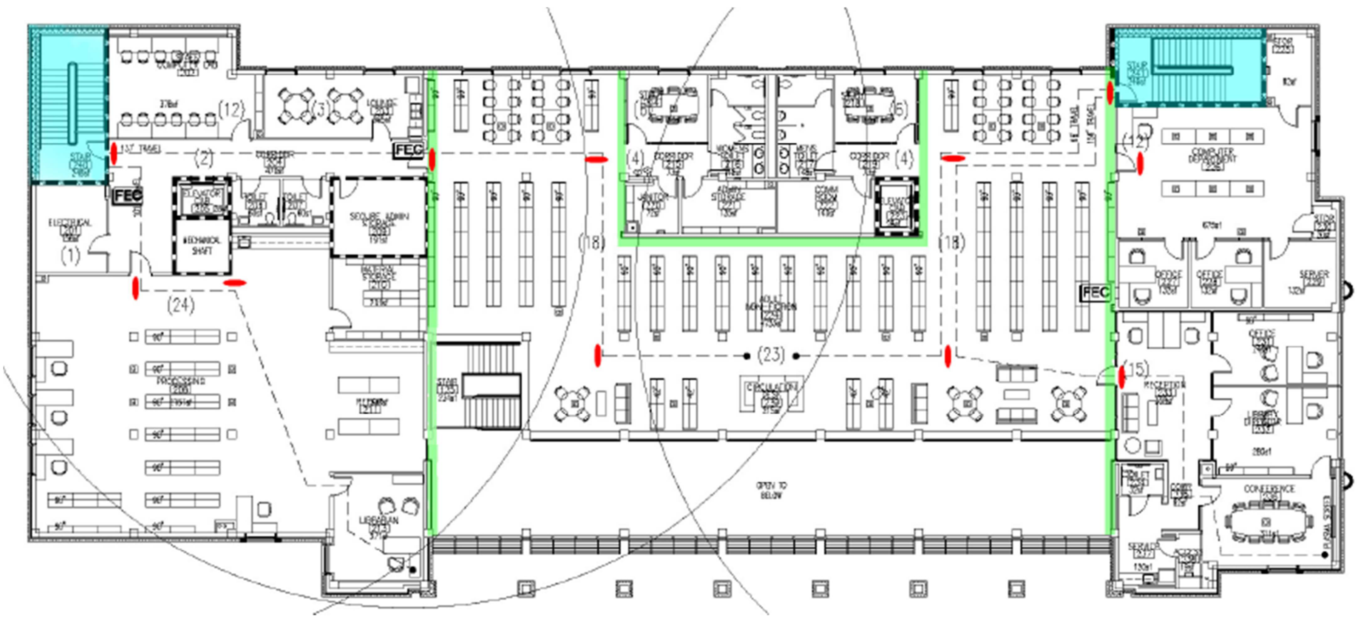


Figure 14.1 Second floor plan view, showing required 1-hour smoke partitions

In this case, the ceiling being suspended with gaps between the panels creates a very complex modeling environment. The void space or area above the ceiling

may be fairly open in certain places and somewhat blocked in other places, such as by environmental air ducts.

Therefore, it is expected that the results from this FDS model are inherently less accurate than normally expected from a building that closely matches the equations used to develop FDS.

Smoke Detector in Second Floor Atrium

There is only one smoke detector located in the atrium space, approximately 38 feet to the north of the nearest point in the atrium floor opening and 99 feet from the furthest point in the atrium communicating space.

Fire Sprinklers

This building is equipped with automatic fire sprinklers throughout. For the FDS model, a fire sprinkler has been placed directly over the seat of the fire. This is a close approximation to the actual location.

Activation of the first sprinkler head is assumed to provide fire suppression. This means a sharp reduction of the rate of heat release of a fire and prevention of regrowth.

Design Fire

The other materials in the first floor atrium space consisted mainly of cellulosic material, either books or magazines. The upholstered chairs provided the more challenging fire. Also, the upholstered chairs have a built-in ignition source, in the form of electrical outlets on the side of each chair, fed by individual cords running to a floor box. See Figure 14.2 for the layout.

The chairs on the first floor are assumed to be made of Polyurethane PM27 material. The Heat Release Rate per Unit Area (HRRPUA) is 88.0551 Btu/(s·ft^2) [1,000 kW/m^2] from PyroSim standard library.

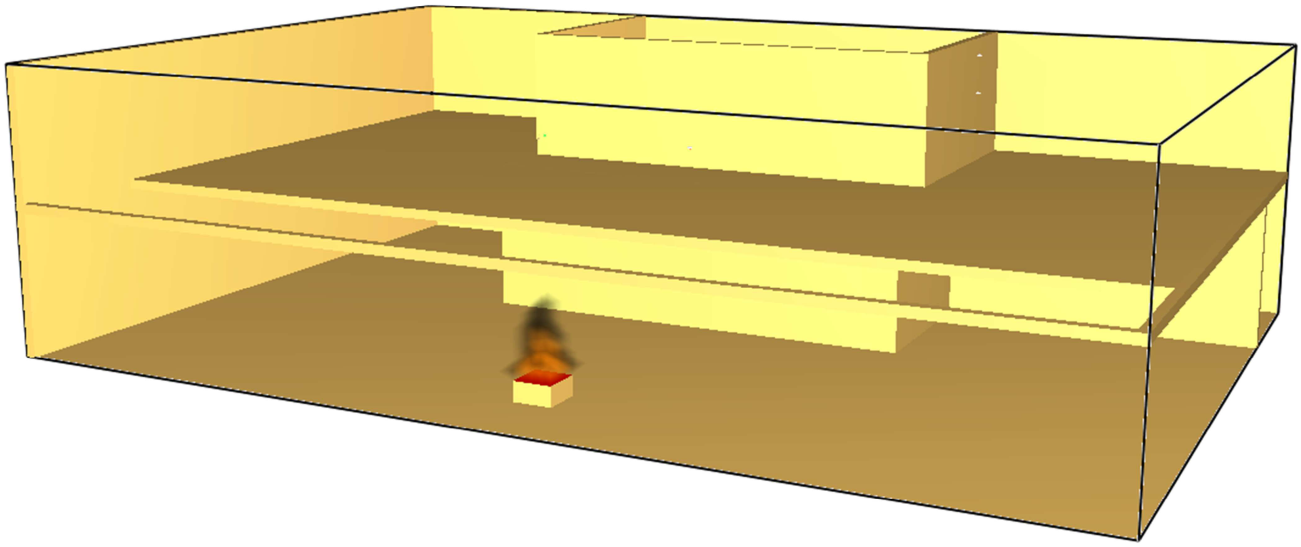


Figure 14.2 Perspective view of 4'x4' atrium design fire

Sensitivity Analysis

Part of the performance-based evacuation design process for fire scenarios is to examine and evaluate different scenarios. In this case, the first fuel ignited is an upholstered chair located under the floor opening of the atrium on the first floor. There are four chairs grouped together, with each chair approximately 2'x2' for a total of 4'x4' area. Modeling was done using an ultra-fast fire growth profile.

Because the chairs are movable, it is not possible to reliably predict their physical arrangement at the time of ignition. FDS fire was set to both a 4'x4' model as the "Fire Vent" and again with "Fire Vent" size of 2' x 2'.

15. Performance - FDS Sprinkler Activation

Heat Release Rate (HRR) and fire growth are capped by the fire suppression system. So, once the HRR grows until the time of the first sprinkler activation, then the HRR remains constant for the balance of the simulation.

For the FDS model, a fire sprinkler head is placed directly above the group of four chairs located in the atrium space on the first floor. The actual temperature rating is not known. An activation temperature of 165 F (73.9 C) is assumed.

The sprinkler failed to activate in the 2'x2' model, reaching a peak temperature of 145 F (62.7 C) at 146 seconds. It should also be noted that in the 4'x4' fire, the peak temperature reached was 165.2 F (74.0 C), which is just 0.2 F (0.1 C) above the activation temperature. After the activation temperature is reached at this single time step, the temperature drifts back down and never again reaches the activation temperature for the duration of the 300-second simulation. So, even this one sprinkler head may not reliably activate given real world variability.

The large volume of the space helps dilute the products of combustion. This is both an advantage and a disadvantage. The advantage of the large volume space is that the resulting smoke is less toxic, less dense and at a lower temperature. However, this dilution of the smoke also causes fire plume and ceiling jet temperatures not to be hot enough to activate the sprinkler in a timely manner.

Fire sprinkler activation results are provided in Section 18 of this report along with a discussion of sensitivity analysis.

16. Performance - FDS Smoke Detector Activation

Suggested constants for unidentified ionization and photoelectric detectors came from the FDS User Guide, p.169, Table 15.1. ACTIVATION_OBSCURATION is the threshold value in units of %/m. The threshold can be set according to the setting commonly provided by the manufacturer. The default setting is 3.24 %/m (1 %/ft.). Smoke detector activation results are provided in Section 18 of this report along with a discussion of sensitivity analysis.

17. Performance - Egress time

Pre-Movement Activities and Movement Times

In the event of an evacuation there may be a delay while parents gather their children. Students would want to pack up their possessions, such as laptop computers. These activities would tend to add to pre-movement time. Use an assumed delay of 2 minutes.

The distances to the nearest exit are all relatively short. According to the architectural drawings, the longest one is 156 feet for the office area in the southeast corner of the second floor.

Movement time itself may be longer because the main staircase, which is in the atrium, may be blocked. While there are two other exits from the second floor and four exits from the first floor, not including the front door, there will be a tendency for occupants to leave the way they entered. In the event this open stair is blocked, the occupants on the second floor will have to back-track and locate one of the two protected stairs. This would likely be their first time to use those alternate exits.

Density

The NFPA Handbook, Section 4, Chapter 2 says, "Flow and density have a more complex relationship. At low densities, the rate of flow is small, as there are few people in the stream. Flow rates again are slow at high densities where there is little movement. Optimal flow is achieved at a density of approximately 2.0 persons per square meter." This is equal to 0.186 person per square foot.

Calculations of density are based on assumptions about the number of patrons exiting through each doorway and, as discussed earlier in this report, the front entrance does not have a corridor per se. Based on the limited information here, the density in all lobbies is either very low or around the optimum density for maximum flow rate. Crowding should not be an issue.

Building Evacuation Time

Required Safe Egress Time (RSET), aka Evacuation time = Delay time + Travel time where

Delay time = Time to notification + Reaction time + Pre-evacuation activity time

This calculation assumes occupants know to use one of the two protected stairs and go directly there. Handicapped persons who reached the second floor by elevator will have to wait in the stairwells for rescuers to reach them. Their safety depends on the integrity of the fire wall surrounding the stairwell. It should be noted that the east stairwell borders the atrium communicating space.

Notification time should be fairly short given the modern standards used in the design of this building. However, because systems do fail, defenses should be built in layers. Assume notification occurs 60 seconds after the fire starts.

Corridor occupant density on the ground floor is fairly low because some areas exit directly to the outside. The second floor has only one corridor on the west end, connecting business-classified spaces with very low occupant load. However, it would be advisable to have an additional corridor on the east side of the building to address the issue of those occupants being forced to enter the communicating space of the atrium to exit.

Movement is through a total of five exterior doors. Both stairwells have both an exterior door and an interior or "entrance" door where occupants use the lower level of the staircase as a protected exit access passageway. This adds more variables into how occupants might choose to exit the building under any given emergency scenario.

Assumptions for travel time calculation:

1. The stairwell usage is uniform and will accept the maximum specific flow (optimum evacuation).
2. All occupants start egress at the same time.
3. 30 seconds is added for occupants to get to the entrance into the stairwell at their level.
4. The stairs are 7" rise and 11" run.
5. The 44" stairs has 48" x 8' landings at the door and intermediate landing.
6. The exit discharge doors at the bottom of the stairwells are the same size as the doors serving the stairwell.
7. Queuing will occur, and the maximum specific flow at the control location will dictate the egress time.

The largest capacity exit is the set of double doors at the east end of the building beside the community meeting Room. Calculate evacuation time based on this exit being blocked and all occupants having to exit by way of the remaining four exit doors. The doors are more restrictive than the stairs. Total occupants are 490. So, 123 persons leave each exit at a rate of 56 persons per minute. This takes 2.20 minutes. Calculations are provided in Appendix A.

Total evacuation time includes 2.0 minutes of delay, plus 0.5 minute to reach the exit, plus 2.20 minutes of flow through the doors, yielding a total evacuation time of 4.70 minutes (RSET). Considering the largest exit was "blocked" in this calculation, the evacuation times are relatively short. However, this calculation is

just a rough estimate and the occupants may not act in accordance with the stated assumptions. In particular, a majority of the second floor occupants are likely to try to use the open stair and the front door because those are familiar.

18. Performance - Conclusion

Uncertainty Due to Ceiling

Analysis results for a building with an ordinary flat ceiling have some amount of uncertainty. Given the unusual nature of this ceiling with gaps in between the panels, the uncertainty increases both for hand calculations and for FDS results.

Smoke movement above the suspended ceiling panels depends on the amount and placement of materials in this space. For instance, if the gap runs north-south and a large duct runs north-south as well, the smoke is impeded from migrating east-west. If a large duct runs east-west, smoke rising through the gap could move east-west, freely in the space above the suspended ceiling and below the roof deck.

Results of FDS Model

Below are the results for fire detection devices in the FDS simulation. The shortest detection time for the model fire scenario was the beam detector. See Figures 18.1 and 18.2.

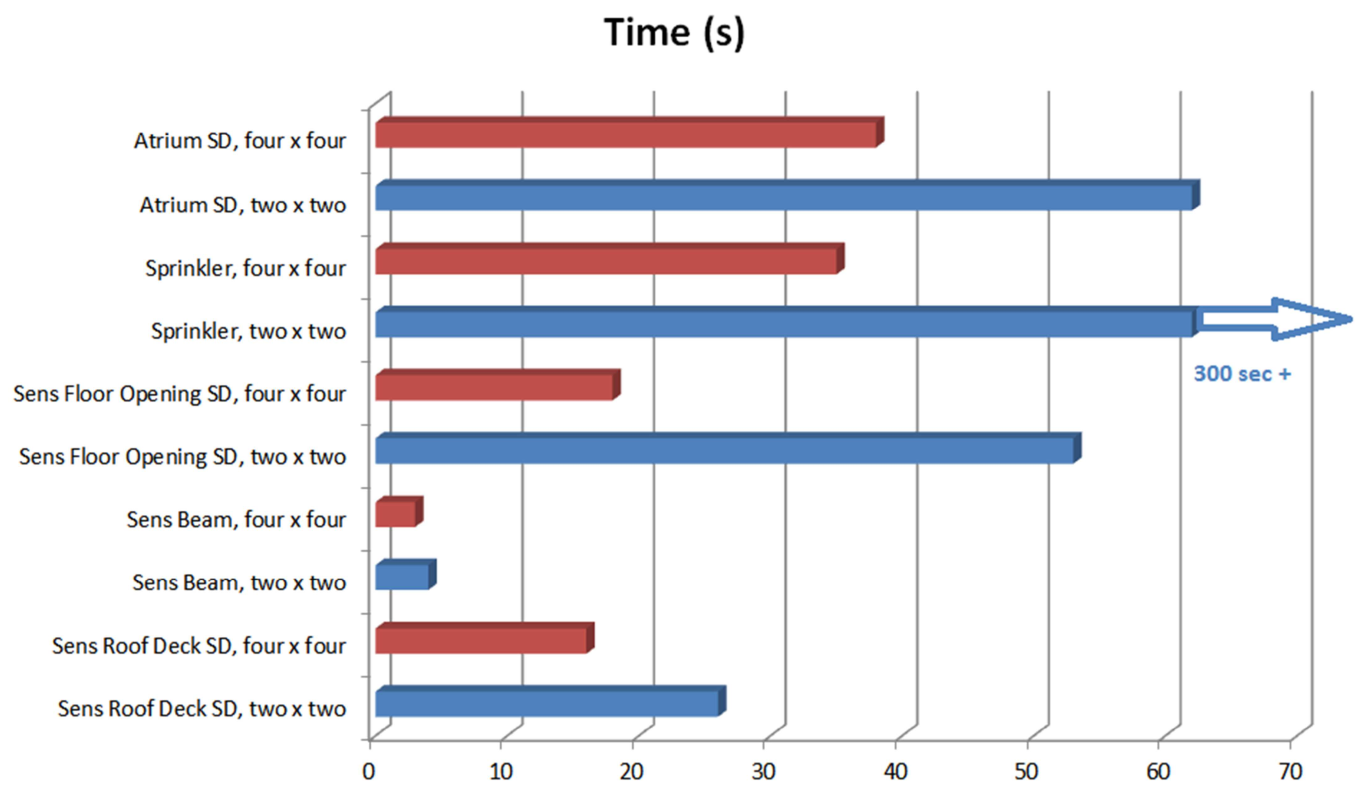


Figure 18.1 Device activation times, FDS models with 4'x4' "Fire Vent" in red, 2'x2' "Fire Vent" in blue. "Sens" devices used in the sensitivity analysis

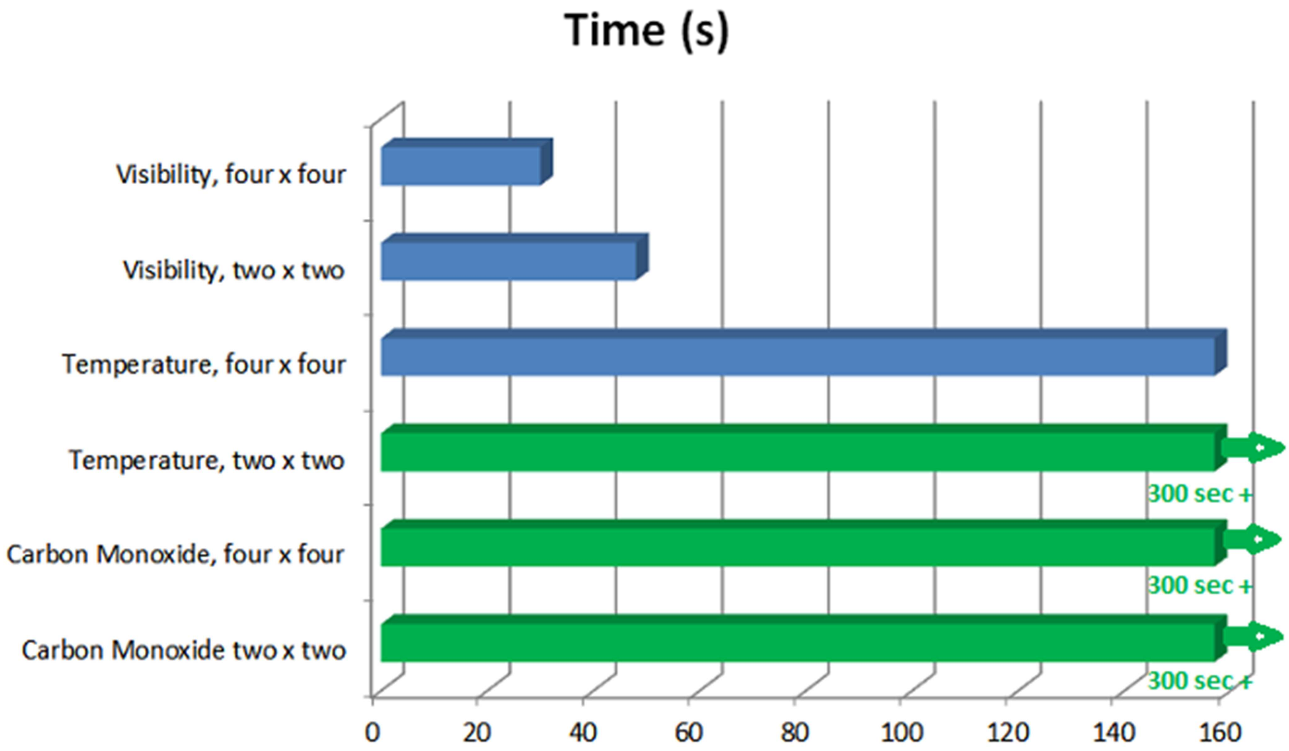


Figure 18.2 Tenability results showing initial deterioration of conditions

19. Overall Conclusions

Available Safe Egress Time vs. Required Safe Egress Time

FDS modeling shows that tenability due to loss of visibility begins to deteriorate very quickly, in under a minute for both fire sizes, 4'x4' and 2'x2'. However, the other tenability criteria, carbon monoxide and temperature are not nearly as dangerous in the first few minutes.

In 300 seconds, the temperature only rises above tenability limits with the 4'x4' fire model and only in certain locations on the second floor. In the 2'x2' fire model, the temperature remains below the tenability limits all the way out to the end of the simulation period at 300 seconds.

Based on visibility loss of less than a minute, the Available Safe Egress Time (ASET) is less than the Required Safe Egress Time (RSET) of 4.7 minutes. Calculation shown in Section 17.

In Figure 18.2 presented above, the three FDS models shown in blue result in loss of tenability which occurs in less than the 4.7 minutes RSET for this building. The three FDS models show in green result in ASET greater than RSET.

Secure administrative storage

Inspection of this room by the author confirmed a listed door and matching door frame. Also, there were no obvious sources of ignition in the room. The door was closed and locked at the time of inspection.

The author discussed response time with Kevin Lundy, the Deputy Fire Chief for the Gulfport Fire Department and learned the following. The first due engine

company is 1.3 miles away from the Orange Grove Library. For a fire at the library, they will be sending 4 engines, 2 command units, and a truck company. The stations that these units are coming from are 1.3 miles away, 1.7 miles away, 3.7 miles away, and 4.6 miles away. They can have a full complement of personnel on scene (17 firefighters) in approximately 5-6 minutes.

The conditions of the building and fire would dictate how long it would take to get to the second floor. Typically, the first due engine company would be making entry into the structure to start the fire attack within two minutes of arriving on scene. Under most circumstances, the protection provided to the secure administrative storage area should be adequate to serve its function.

Furniture

The severity of fire encountered could be reduced by furnishing the library, especially under the atrium opening, with furniture compliant with California Technical Bulletin 133 or comparable standard and remove additional ignition sources.

20. Design Retrofit Recommendations

Information up to this point in the report has been analysis of the design. On several points this building fails to meet safe design criteria when analyzed based on both prescriptive analysis and performance-based analysis.

Below are listed a number of moderate or low-effort actions to correct some of these deficiencies:

1. Remove vegetation from around the Fire Department Connection (FDC).
2. Remove the exit sign leading to the receiving area.
3. Move existing exit signs and emergency illumination to coincide with exit paths.
4. Add a beam smoke detector.

Adding a beam smoke detector across the east-west orientation of the atrium opening would add considerable protection to the occupants by reducing the time to detect a fire. The basic alarm equipment is already in place, so the cost of a beam detector would be relatively small compared to the increased protection for occupants.

Certain other issues are not be practical to correct, such as providing an exit for second floor occupants without entering the atrium communicating space.

21. Operational Analysis and Code Violations

What follows is a discussion of operational issues discovered upon inspection of the building. These issues constitute code violations.

<u>Blocked Exit</u>

IBC Section 1015.2 Exit or exit access doorway arrangement.

> Required exits shall be located in a manner that makes their availability obvious. Exits shall be unobstructed at all times. Exit and exit access doorways shall be arranged in accordance with Sections 1015.2.1 and 1015.2.2.

The library has erected a steel wire barrier in front of the exit in the southeast corner of the building to prevent children from leaving the building. However, this prevents proper use of this exit and constitutes a fire code violation. See Figures 21.1 and 21.2.

Figure 21.1 Paper decorations hung from the ceiling obstruct the exit sign

Figure 21.2 Exit at first floor southeast corner, adjacent to children's area

Maintenance of Illumination Devices

IBC Section 1006.1 Illumination required.

> The means of egress, including the exit discharge, shall be illuminated at all times the building space served by the means of egress is occupied.

Most of the lights along the path in front of the main circulation desk on the first floor are not operating, although the battery charging lights can be seen. See Figures 21.3 and 21.4.

Figure 21.3 First floor emergency egress lighting is not functioning

Figure 21.4 Emergency light charging indicator

Storage in Exit Enclosures

NFPA 101 Section 7.1.3.2.3

> An exit enclosure shall not be used for any purpose that has the potential to interfere with its use as an exit and, if so designated, as an area of refuge. (See also 7.2.2.5.3.)

At the time of inspection, both protected exit stairs were being used for storage of combustible items. See Figures 21.5, 21.6 and 21.7.

Figure 21.5 East stair enclosure second floor used for storage

Figure 21.6 East stair enclosure first floor used for storage

Figure 21.7 West stair enclosure first floor used for storage. Note: stairs continue down from first floor to ground level outside

Storage in Mechanical Room

International Fire Code (IFC) Section 315.3.3 Equipment rooms.

> Combustible material shall not be stored in boiler rooms, mechanical rooms or electrical equipment rooms. See Figures 21.8, 21.9 and 21.10.

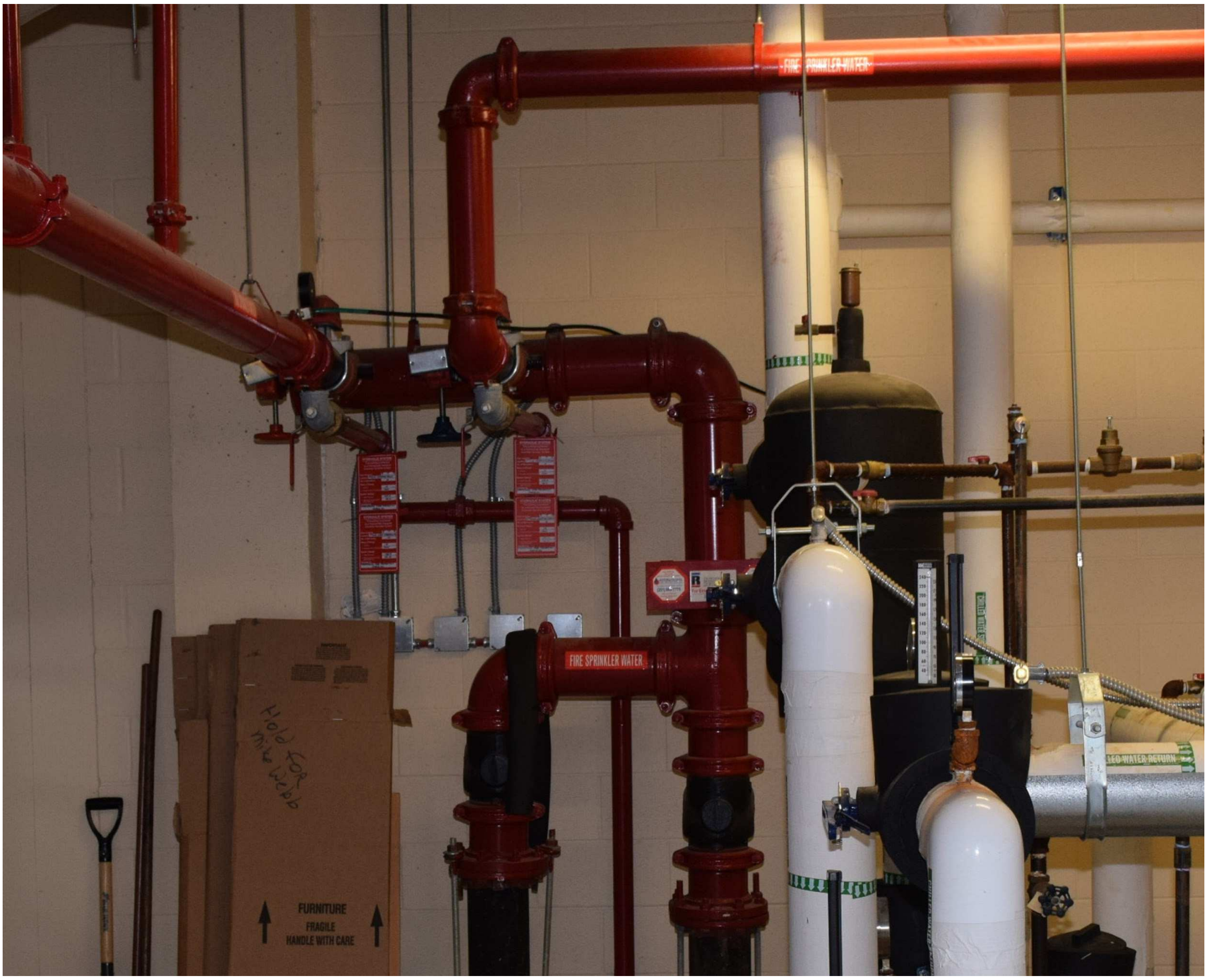


Figure 21.8 Fire sprinkler riser in mechanical room

Figure 21.9 Carpet tile adhesive stored in mechanical room

Figure 21.10 Corrosive material and paint stored in mechanical room

Conclusion and Recommendations

1. Clear the exit near the children's reading area.
2. Remove the decorations blocking the exit sign near the children's reading area.
3. Perform maintenance on the emergency egress lighting to restore functionality.
4. Remove the storage from staircases. Remove shelving and repair holes in fire-rated walls to restore protection.
5. Remove combustible materials from the mechanical room.
6. Train staff on a fire prevention plan. See example located in Appendix E.

22. References

[SFPE] Society of Fire Protection Engineers Handbook, 5th edition, 2015

[NFPA HB] National Fire Protection Association Handbook, 20th

[NFPA Glossary] National Fire Protection Association Glossary of Terms, 2016

[IBC] International Building Code 2012

[IFC] International Fire Code 2012

[NFPA 72] National Fire Protection Association 72 (2010)

[NFPA 101] National Fire Protection Association 101 (2012)

[NFPA 13] National Fire Protection Association 13 (2010)

Appendix A - Egress calculations

Occupancy, First Floor	Area (sf)	Occupancy Load Factor (sf/person)	Occupancy Load (person)	
Assembly, Community Meeting Room	1,046	7	150	
Assembly, Lobby	811	15	55	
Assembly, Library Reading Areas	4,765	50	96	
Assembly, Library Stack Areas	4,111	100	42	
Business	386	100	4	
Corridor	430	0	0	
Vertical Exit	768	0	0	
Service	2,478	300	9	
Storage	270	300	1	
		Total First Floor:	356	
Occupancy, Second Floor	Area (sf)	Occupancy Load Factor (sf/person)	Occupancy Load (person)	
Assembly, Library Reading Areas	1,707	50	35	
Assembly, Library Stack Areas	3,531	100	36	
Business	5,753	100	58	
Corridor	407	0	0	
Vertical Exit	768	0	0	
Service	989	300	4	
Storage	270	300	1	
		Total Second Floor:	134	
Total building occupancy is 490 persons.				

	Capacity Factor from Table 7.3.3.1 (inch/person)	Person	Required Egress Capacity (inch)	Actual Egress Capacity (inch)
Horizontal, First and Second Floors	0.2	490	98	148
Vertical, Second Floor Only	0.3	134	40	64

Corridor	Person	Area (sf)	Density (person/sf)	
First Floor Near Community Meeting Room	105	811	0.129	
First Floor Near Loading Dock	13	430	0.030	
First Floor Employee Lobby and Corridor	50	401	0.125	
Second Floor Staff Area	26	470	0.055	

Travel Time Calculation	Effective Width (inch)	Effective Width (ft)	Max Specific Flow (person/min/ft)	Capacity (person/minute)
56" Stair	44	3.67	18.5	68
40" Door	28	2.33	24.0	56
			NFPA HB Table 4.2.8	

Figure A.1 Egress Calculations

Appendix B - Sprinkler Calculations

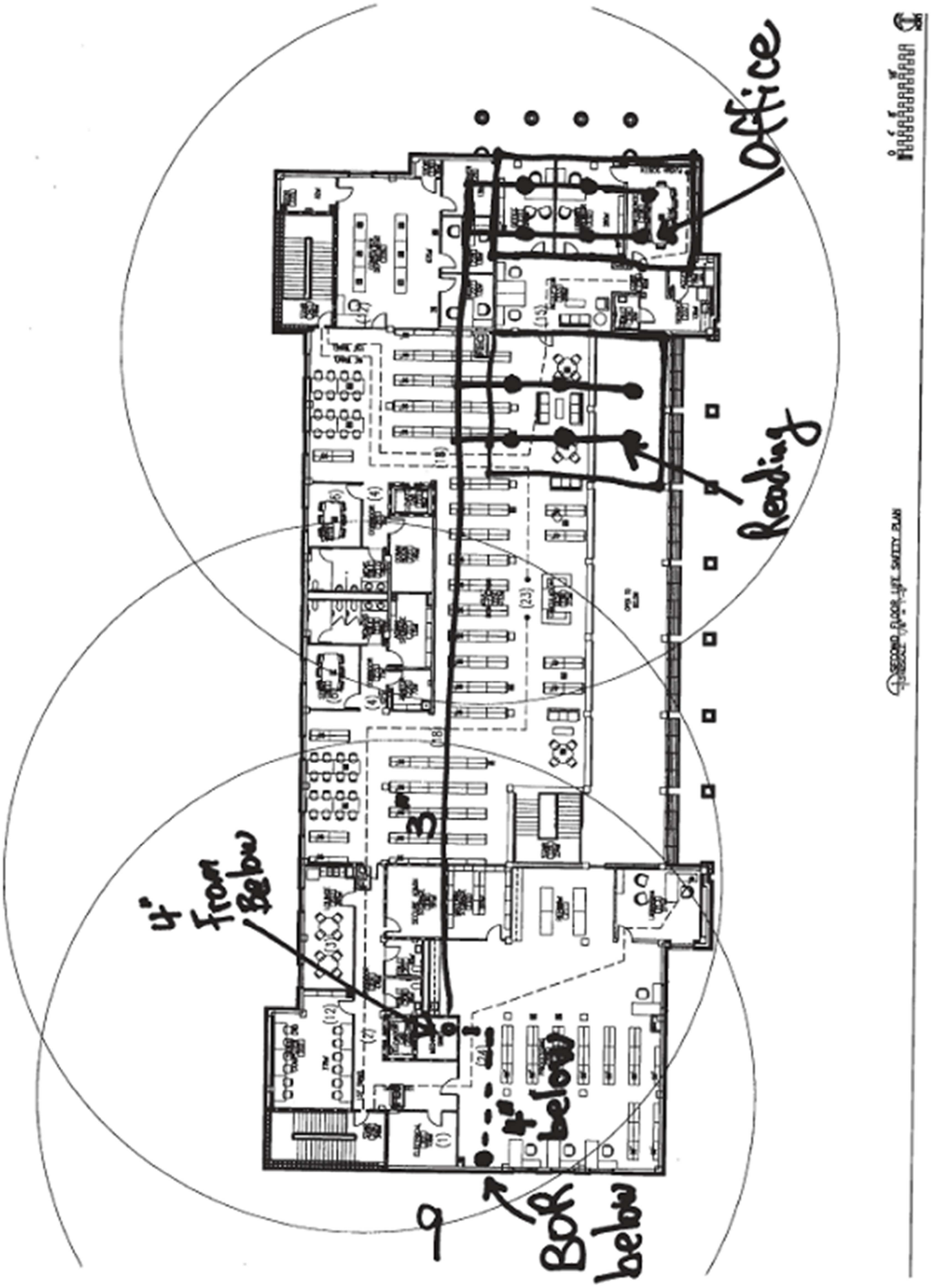
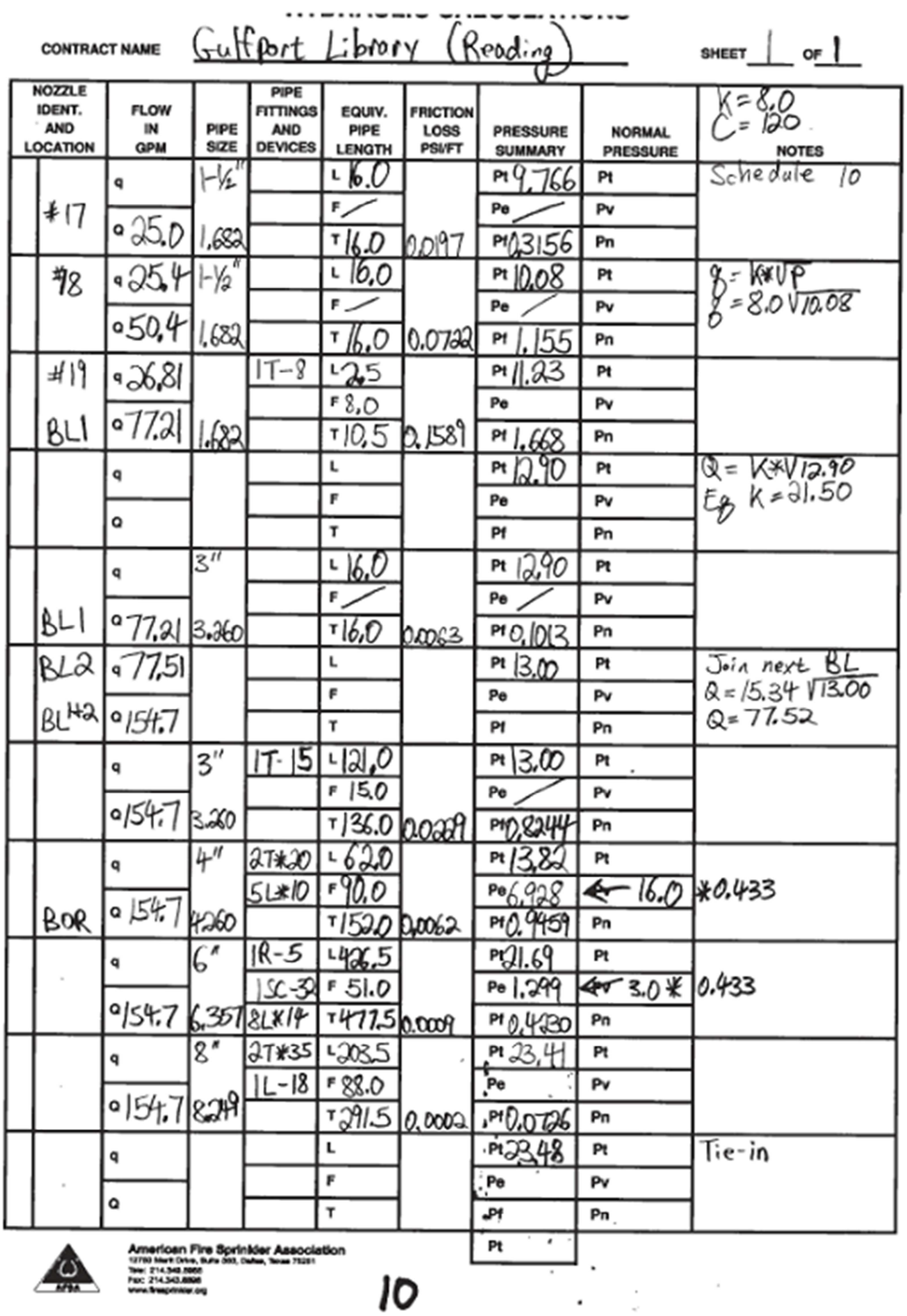


Figure B.1 Sprinklers Calculations Floor Plan



CONTRACT NAME Gulfport Library (Reading) 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	NOTES K=8.0 C=120
#17	q Q 25.0	1-1/2" 1.682		L 16.0 F — T 16.0	0.0197	Pt 9.766 Pe — Pf 0.3156	Pt Pv Pn	Schedule 10
#18	q 25.4 Q 50.4	1-1/2" 1.682		L 16.0 F — T 16.0	0.0722	Pt 10.08 Pe — Pf 1.155	Pt Pv Pn	q = K*√P q = 8.0√10.08
#19 BL1	q 26.81 Q 77.21	1.682	1T-8	L 2.5 F 8.0 T 10.5	0.1589	Pt 11.23 Pe Pf 1.668	Pt Pv Pn	
	q Q			L F T		Pt 12.90 Pe Pf	Pt Pv Pn	Q = K*√12.90 Eq K = 21.50
BL1	q Q 77.21	3" 3.260		L 16.0 F — T 16.0	0.0063	Pt 12.90 Pe — Pf 0.1013	Pt Pv Pn	
BL2 BL1+2	q 77.51 Q 154.7			L F T		Pt 13.00 Pe Pf	Pt Pv Pn	Join next BL Q = 15.34√13.00 Q = 77.52
	q Q 154.7	3" 3.260	1T-15	L 121.0 F 15.0 T 136.0	0.0229	Pt 13.00 Pe — Pf 0.8244	Pt Pv Pn	
BOR	q Q 154.7	4" 4.260	2T*20 5L*10	L 62.0 F 90.0 T 152.0	0.0062	Pt 13.82 Pe 6.928 Pf 0.9459	Pt Pv ← 16.0 Pn	*0.433
	q Q 154.7	6" 6.357	1R-5 1SC-32 8L*14	L 426.5 F 51.0 T 477.5	0.0009	Pt 21.69 Pe 1.299 Pf 0.4330	Pt Pv ← 3.0 * Pn	0.433
	q Q 154.7	8" 8.249	2T*35 1L-18	L 203.5 F 88.0 T 291.5	0.0002	Pt 23.41 Pe Pf 0.0726	Pt Pv Pn	
	q Q			L F T		Pt 23.48 Pe Pf	Pt Pv Pn	Tie-in
						Pt		

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Figure B.2 Sprinklers Calculations, Second Floor Reading Area

CONTRACT NAME Gulfport Library (offices) 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	NOTES
#1	q 15.0	1-½"		L 15.96		Pt 7.175	Pt	K = 5.6 C = 120 Schedule 10
				F /		Pe /	Pv	
	Q	1.682		T 15.96	0.0077	Pf 0.1224	Pn	
#2	q 15.13	1-½"		L 12.83		Pt 7.297	Pt	q = K√P
				F /		Pe /	Pv	q = 5.6 √7.297
1-2	Q 30.13	1.682		T 12.83	0.0279	Pf 0.3575	Pn	
#3	q 15.49	1-½"	1T-8	L 11.75		Pt 7.654	Pt	
				F 8		Pe /	Pv	
1-3	Q 45.62	1.682		T 19.75	0.0600	Pf 1.185	Pn	
	q			L		Pt 8.839	Pt	Equivalent BL
				F		Pe	Pv	45.62 = K√8.839
	Q			T		Pf	Pn EQ	K = 15.34
	q	3"	1T-8	L 11.0		Pt 8.839	Pt	
				F 8.0		Pe /	Pv	
BL 1	Q 45.62	3.260		T 19.0	0.0024	Pf 0.0454	Pn	
Pt 8	q			L		Pt 8.884	Pt	Join Next BL
				F		Pe	Pv	Q = 15.34√8.884
	Q			T		Pf	Pn BL2	Q = 45.74
BL 1+2	q	3"		L 169.0		Pt 8.884	Pt	
				F /		Pe /	Pv	
	Q 91.36	3.260		T 169.0	0.0086	Pf 1.461	Pn	
	q	4"	2T*20	L 62.0		Pt 10.34	Pt	
			5L*10	F 90.0		Pe 6.928	← 16.0*	0.433
BOR	Q 91.36	4.260		T 152.0	0.0023	Pf 0.3570	Pn	
	q	6"	1R-5	L 426.5		Pt 17.63	Pt	
			1SC-32	F 51.0		Pe 1.299	← 3.0*	0.433
	Q 91.36	6.357	8L*14	T 477.5	0.0003	Pf 0.1597	Pn	
	q	8"	2T*35	L 203.5		Pt 19.09	Pt	
			1L-18	F 88.0		Pe	Pv	
	Q 91.36	8.249		T 291.5	0.000...	Pf 0.0274	Pn	
	q			L		Pt 19.12	Pt	Tie-in
				F		Pe	Pv	
	Q			T		Pf	Pn	
						Pt		

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Figure B.3 Sprinklers calculations, second floor office area

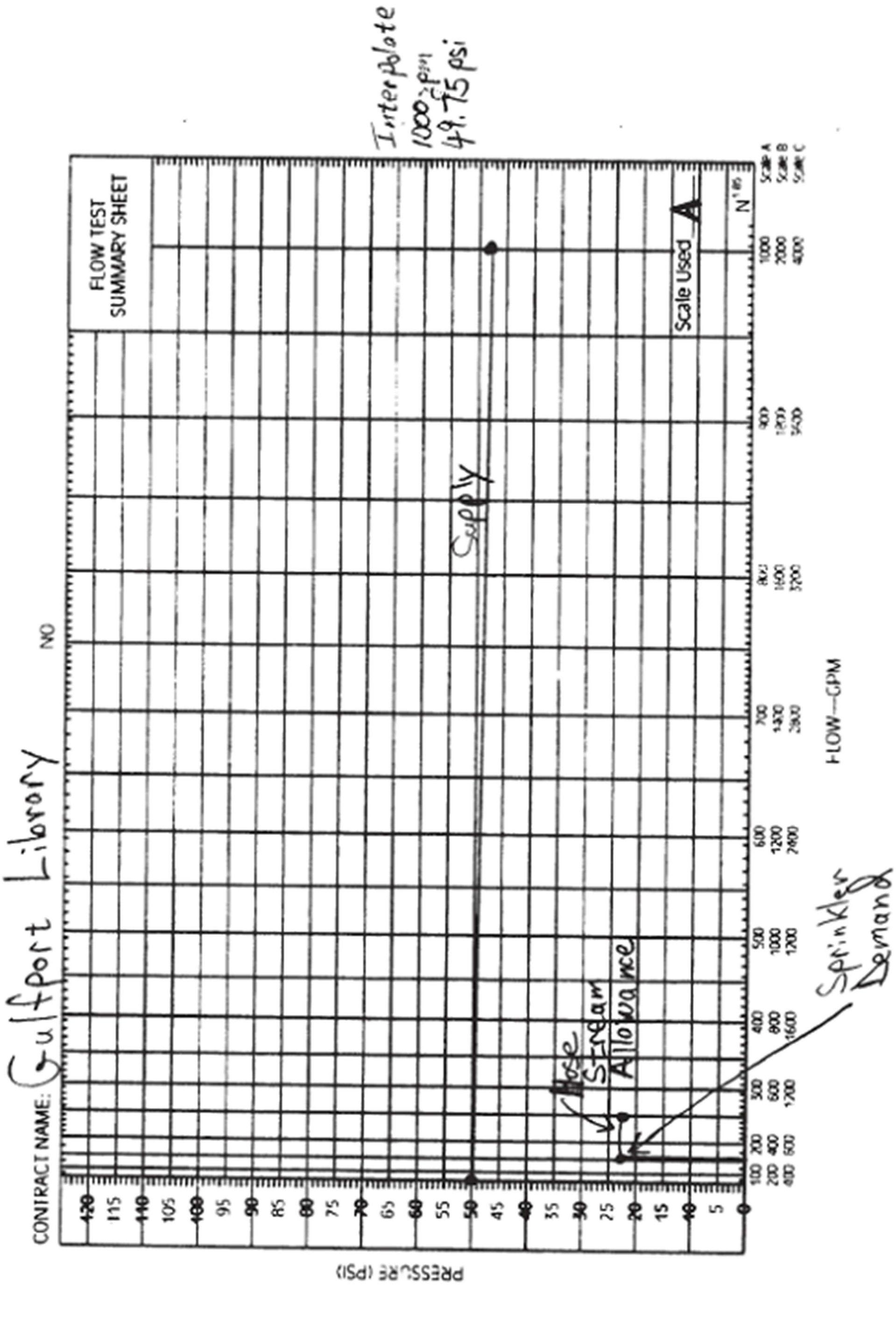

Figure B.4 Water supply graph

Appendix C - FDS Images

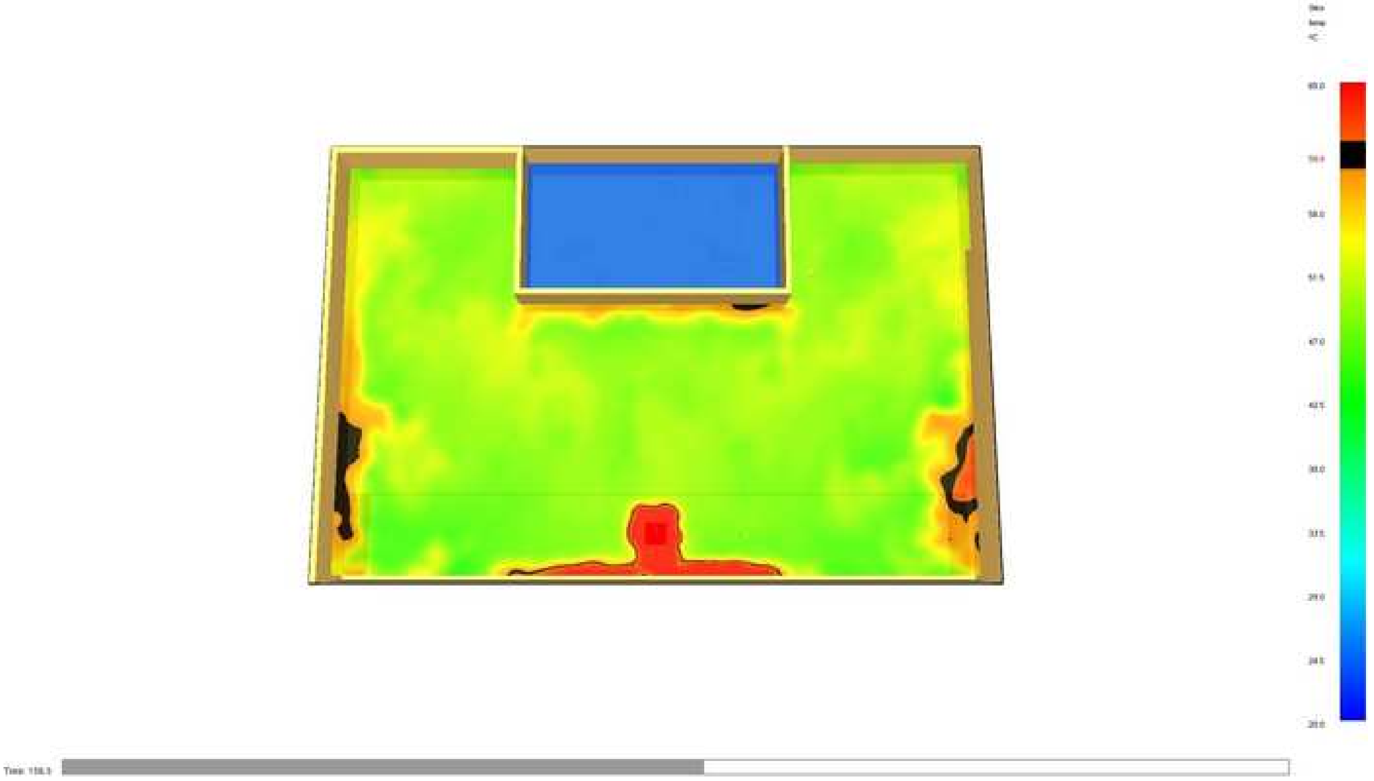

Figure C.1 - 4'x4' fire vent, minor loss of tenability due to temperature 157s

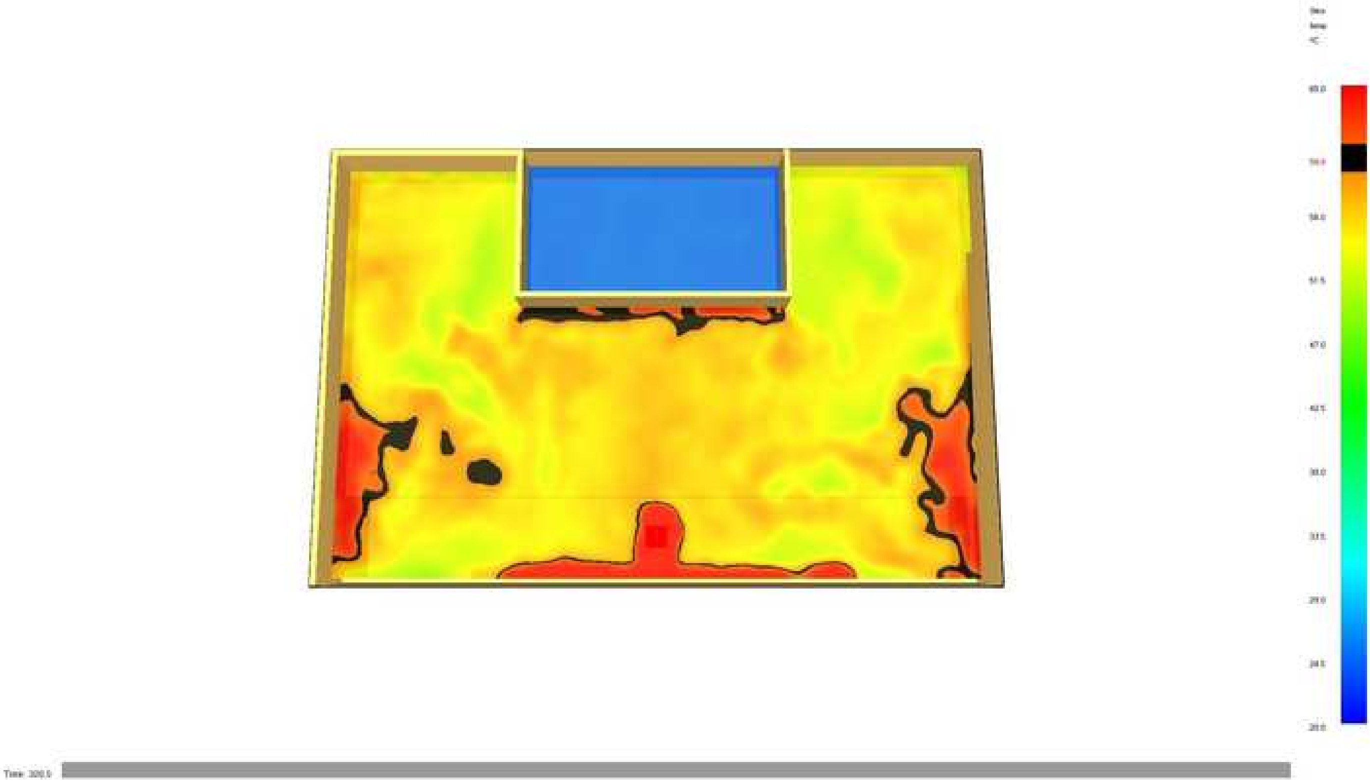

Figure C.2 - 4'x4' fire vent, still minor loss of tenability due to temperature at 300s

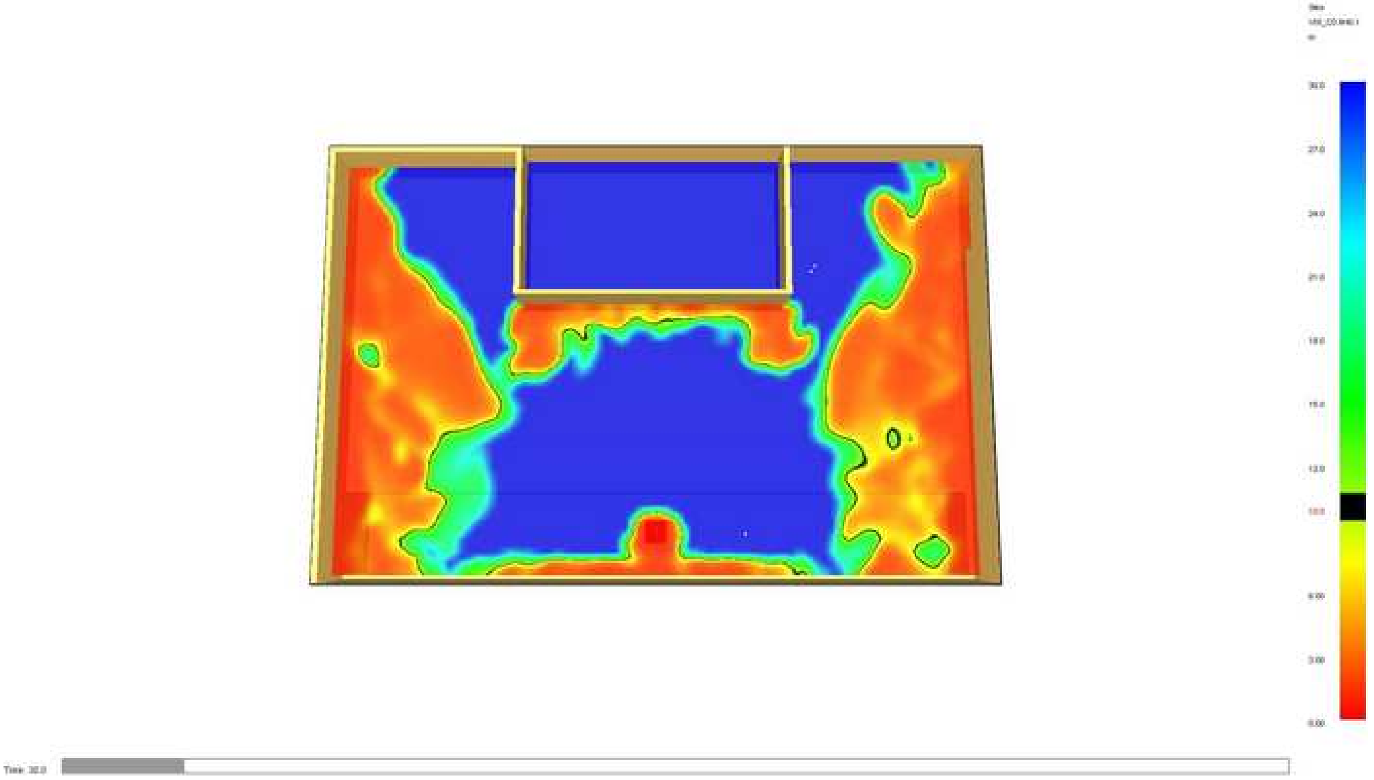

Figure C.3 - 4'x4' fire vent, minor loss tenability due to visibility at 30s

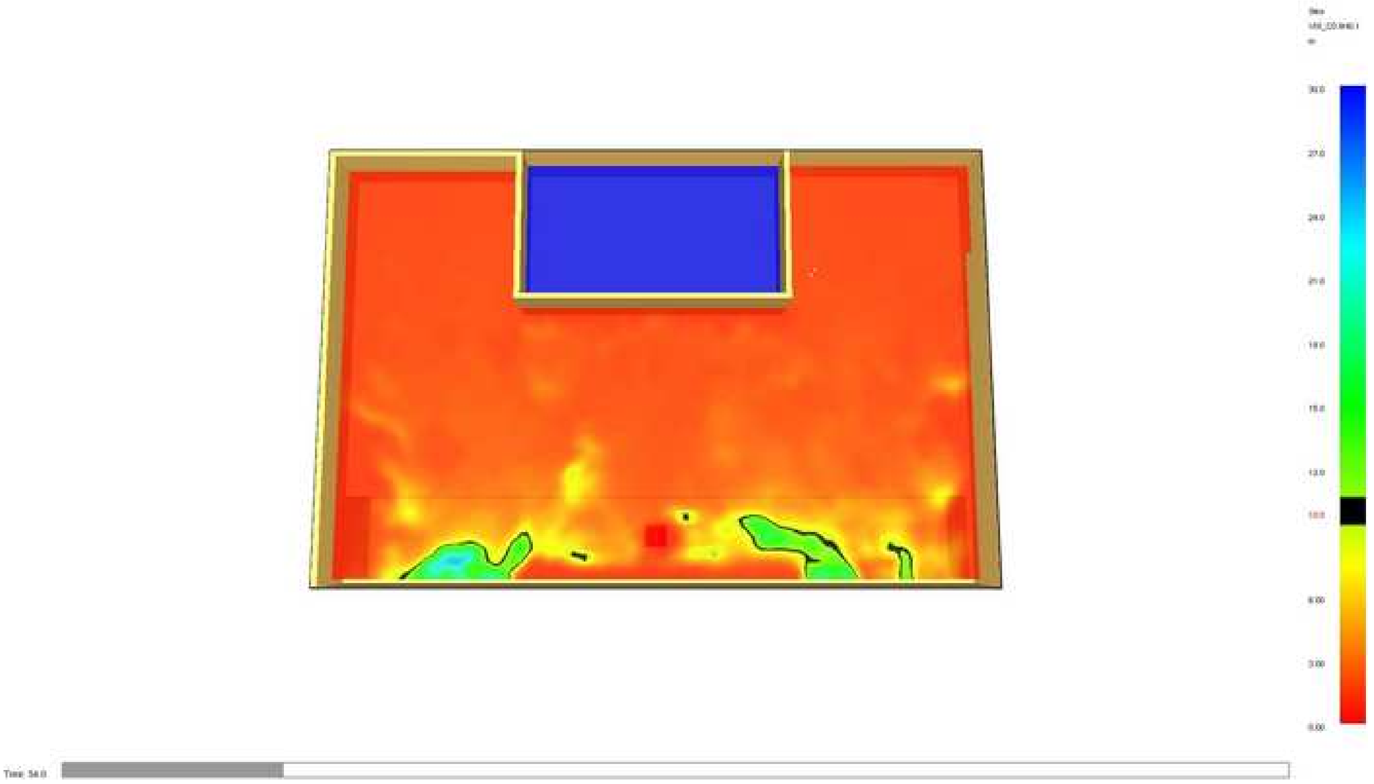

Figure C.4 - 4'x4' fire vent, complete loss tenability due to visibility 54s

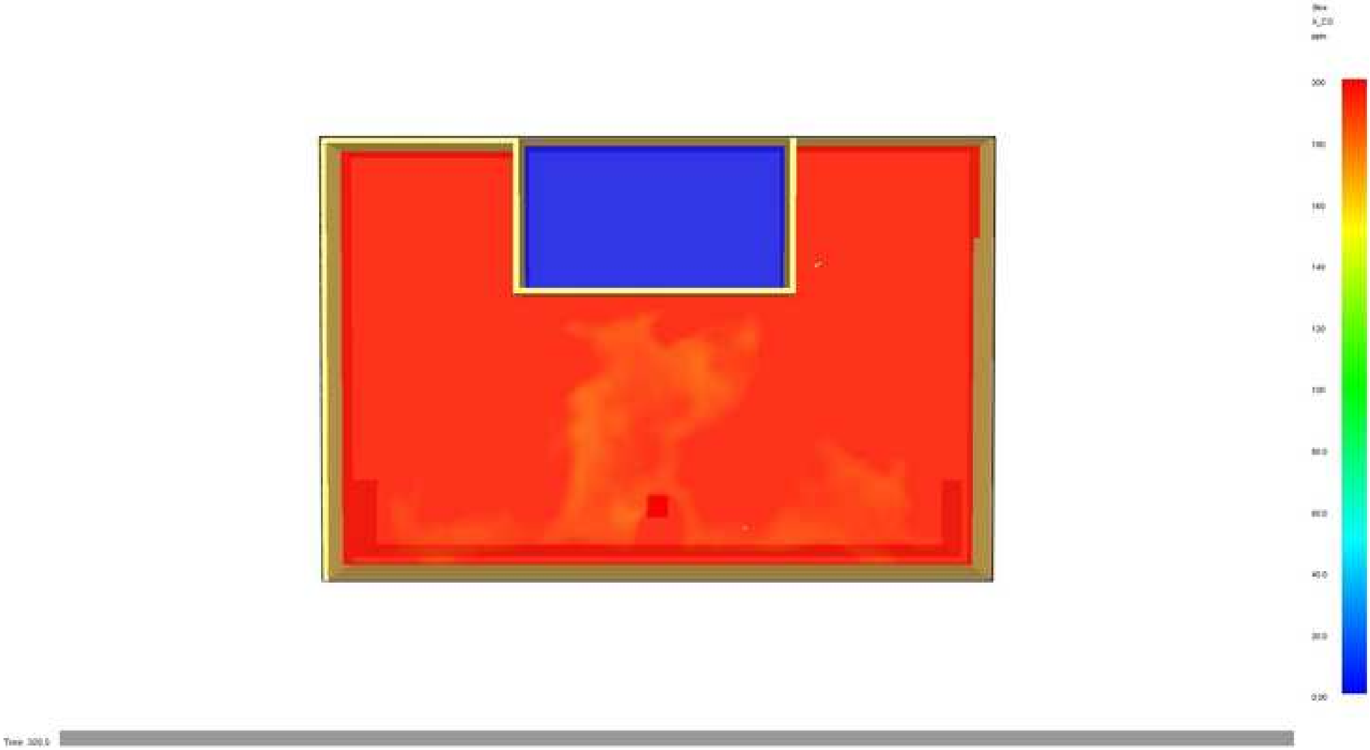

Figure C.5 - 4'x4' fire vent, Carbon Monoxide levels only reach 200 ppm at 300s

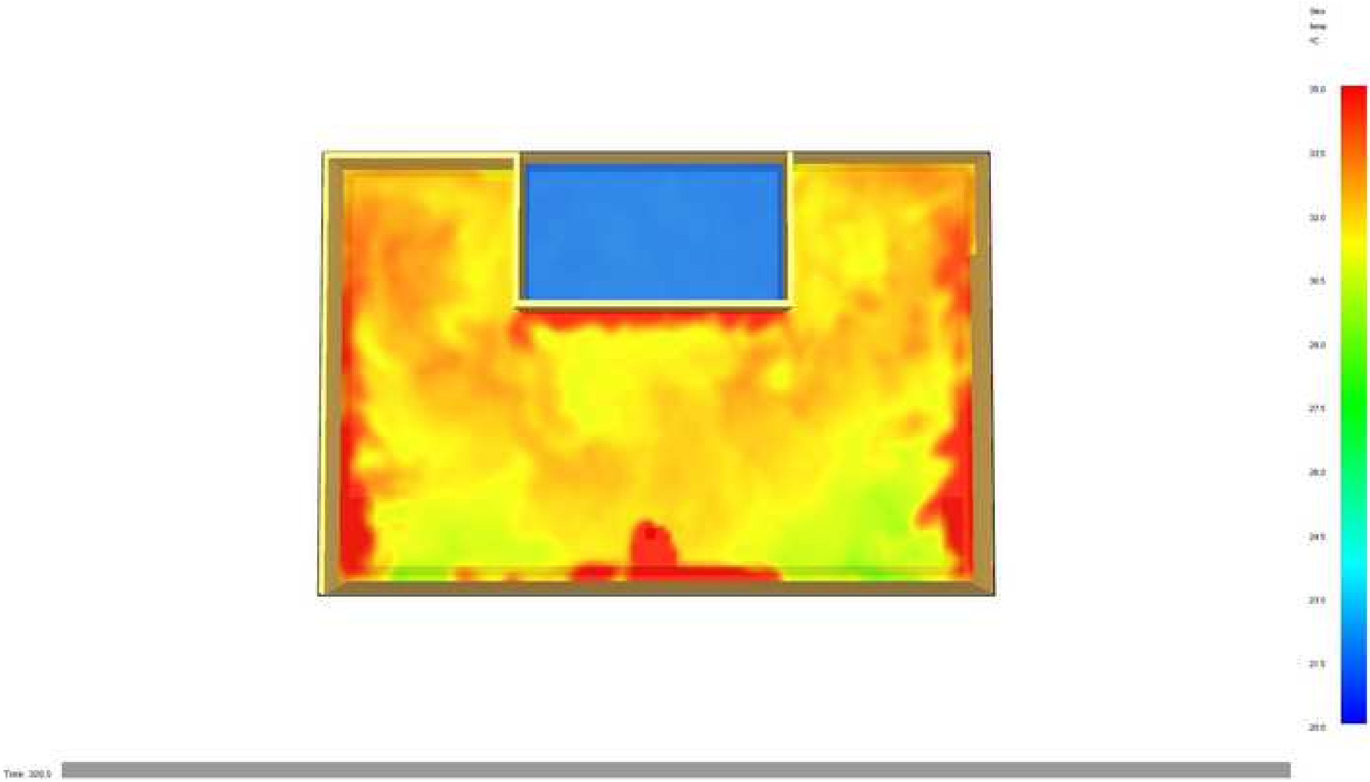

Figure C.6 - 2'x2' fire vent, temperature only reaches 35 C at 300s

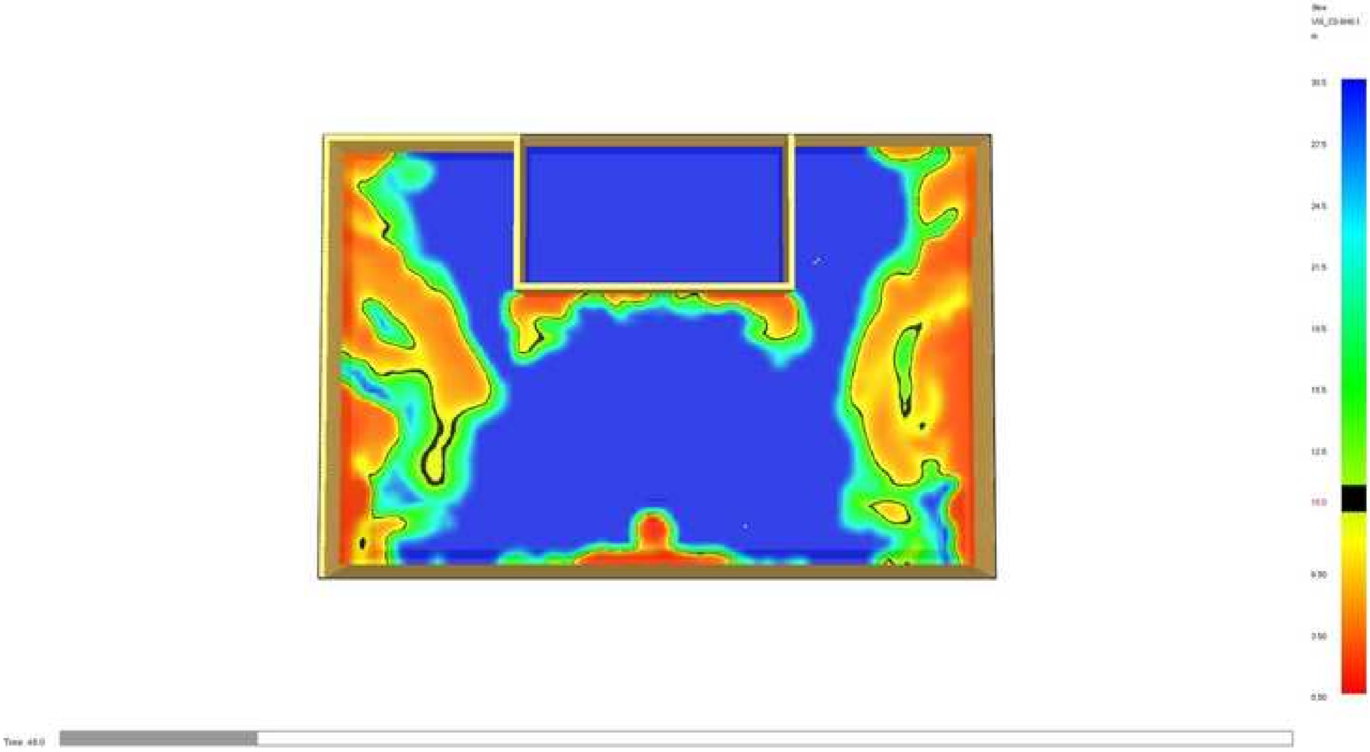

Figure C.7 - 2'x2' fire vent, minor loss tenability due to visibility at 48s

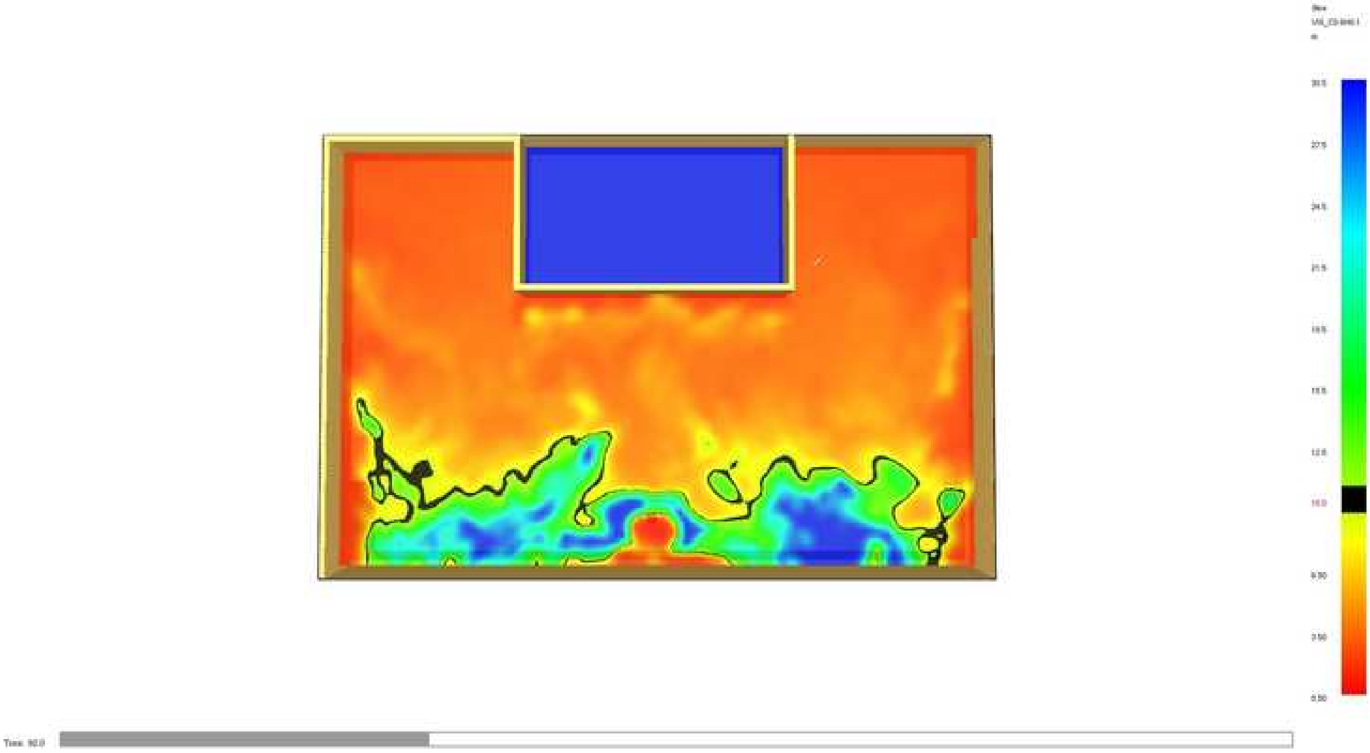

Figure C.8 - 2'x2' fire vent, complete loss tenability due to visibility at 90s

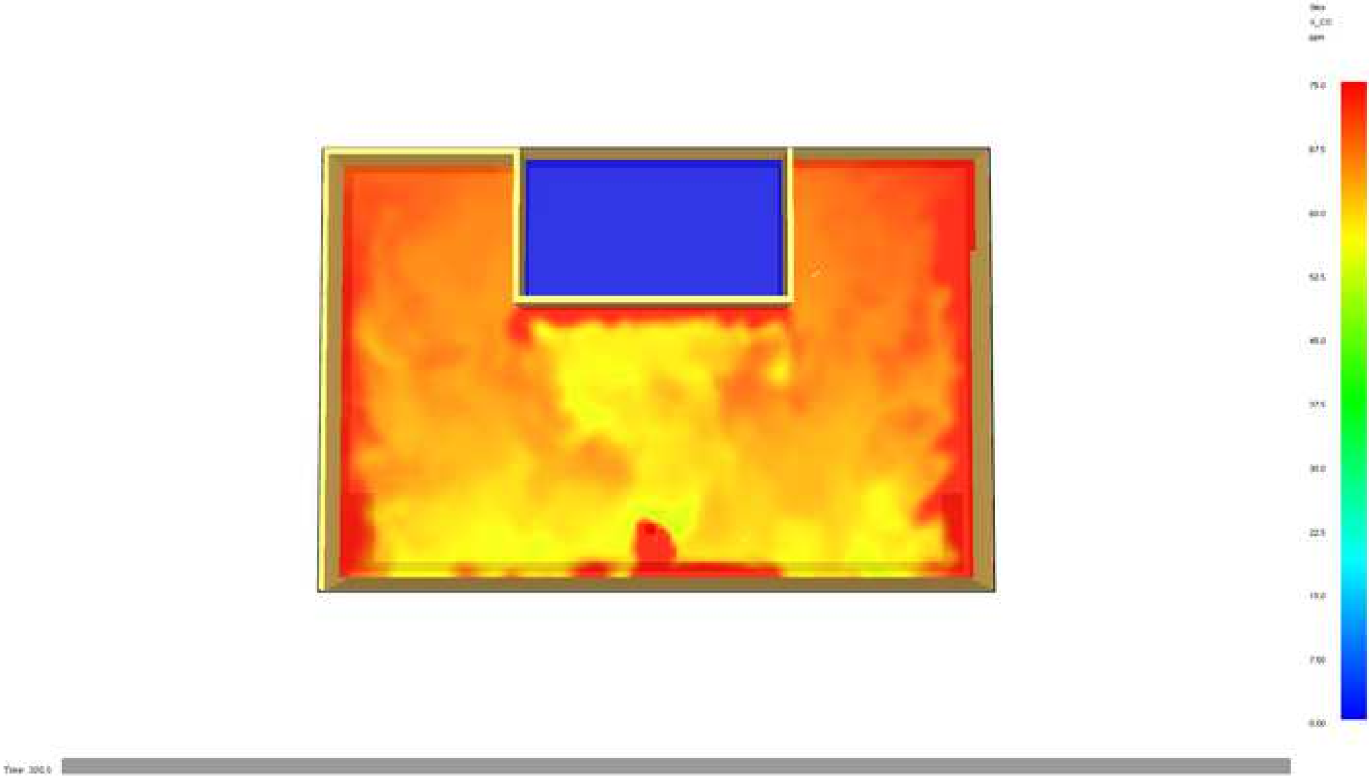

Figure C.9 - 2'x2' fire vent, carbon monoxide only reaches 75ppm at 300s

Appendix D - Fire Sprinkler Shop Drawings

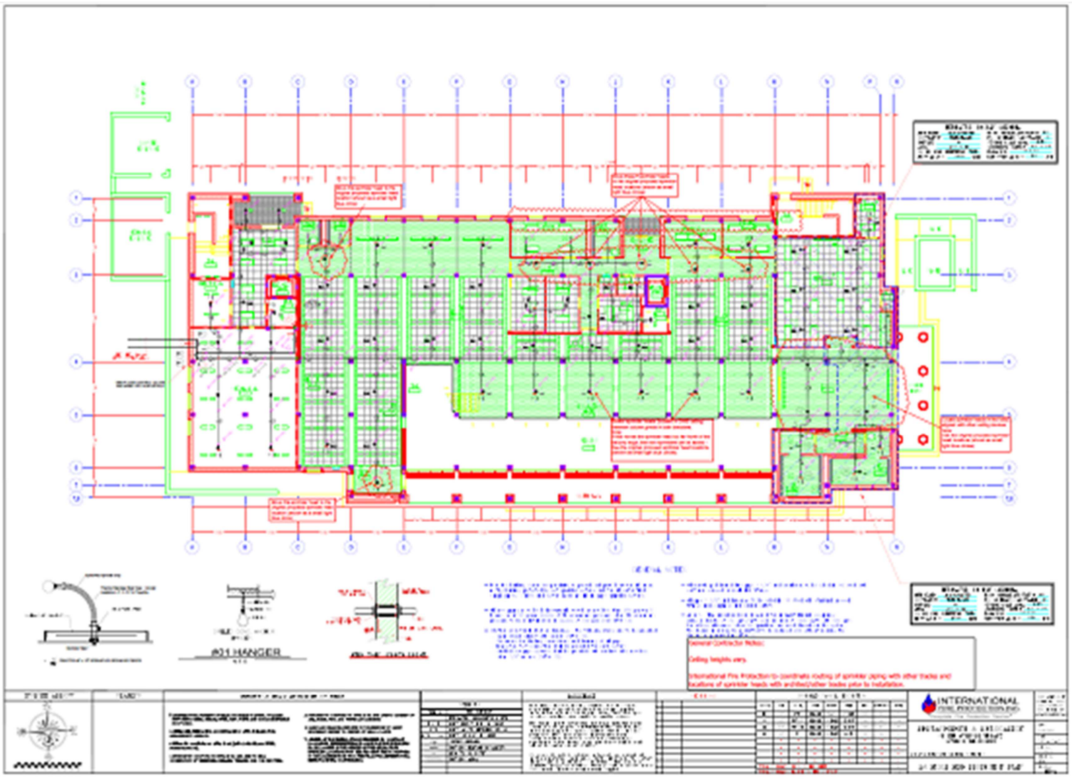

Figure D.1 Fire sprinkler shop drawing 1.

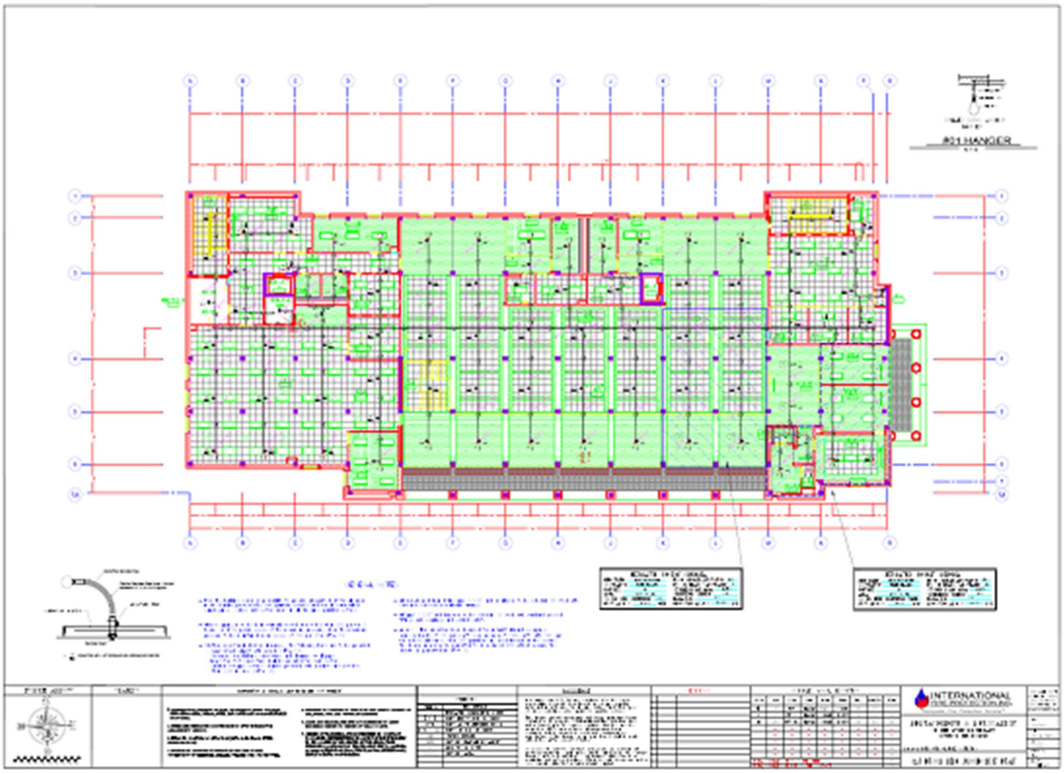

Figure D.2 Fire sprinkler shop drawing 2.

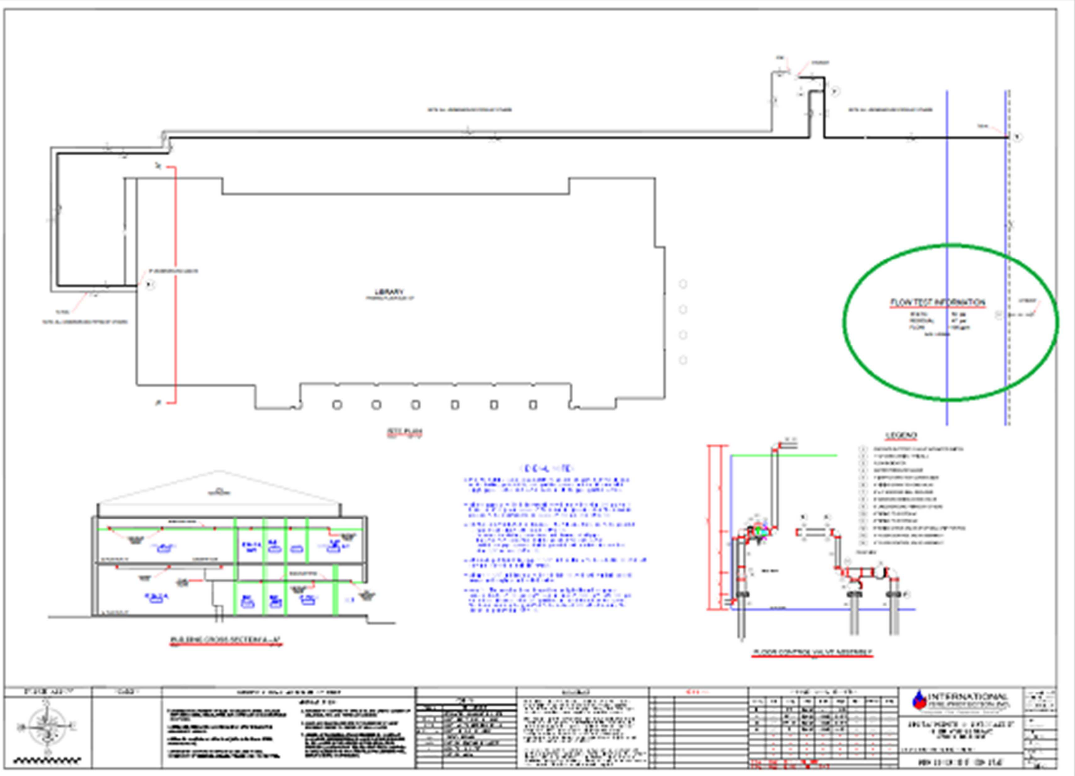

Figure D.3 Fire sprinkler shop drawing 3. Flow test data circled in green.

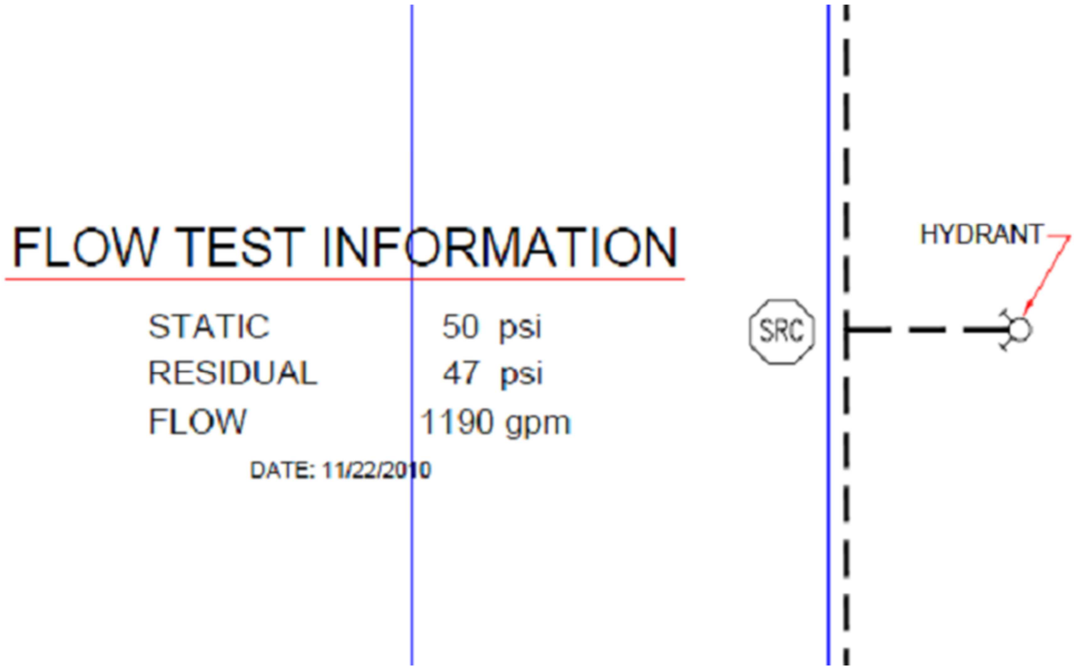

Figure D.4 Flow test data.

Appendix E - Fire Prevention Plan

1. Objective
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Prepared by

Date

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1. OBJECTIVE

The purpose of this Fire Prevention Plan, also sometimes called a Fire Safety Management Plan, is to eliminate the causes of fire and prevent loss of life and property by fire. It provides employees with information and guidelines that will assist them in recognizing, reporting and controlling fire hazards.

The Orange Grove Public Library's separate "Procedures & Guidelines on Safety, Security and Disaster Response" spells out the procedures for responding to fires and other issues. For more information or if any employee has questions about fire, they should contact the Branch Manager who will obtain additional information from the Gulfport Fire Department as necessary.

2. BACKGROUND

The Orange Grove Public Library is committed to minimizing the threat of fire to employees, visitors and property. The Orange Grove Public Library complies with all applicable laws, regulations, codes and good practices pertaining to fire prevention.

This Fire Prevention Plan serves to reduce the risk of fires at Orange Grove Public Library in the following ways:

A. identifies materials that are potential fire hazards and their proper handling and storage procedures;
B. distinguishes potential ignition sources and the proper control procedures of those materials;
C. describes fire protection equipment and/or systems used to control fire hazards;

D. identifies persons responsible for maintaining the equipment and systems installed to prevent or control ignition of fires;

E. identifies persons responsible for the control and accumulation of flammable or combustible material;

F. describes good housekeeping procedures necessary to insure the control of accumulated flammable and combustible waste material and residues to avoid a fire emergency; and

G. provides training to employees with regard to fire hazards to which they may be exposed.

3. ASSIGNMENT OF RESPONSIBILITY

Fire safety is everyone's responsibility. All employees should know how to prevent and respond to fires and are responsible for adhering to Orange Grove Public Library policies regarding fire emergencies.

A. Management

The Harrison County Library System determines the Orange Grove Public Library fire prevention and protection policies. Harrison County Library System will provide adequate controls to provide a safe workplace and will provide adequate resources and training to its employees to encourage fire prevention and the safest possible response in the event of a fire emergency.

B. Plan Administrator

The Branch Manager shall manage the Fire Prevention Plan for Orange Grove Public Library and shall maintain all records pertaining to the plan. The Plan Administrator shall also:

1. Develop and administer the Orange Grove Public Library fire prevention training program.
2. Ensure that fire control equipment and systems are properly maintained.
3. Control fuel source hazards.
4. Conduct fire risk surveys with the cooperation of the Gulfport Fire Department.

C. Supervisors

Supervisors are responsible for ensuring that employees receive appropriate fire safety training and for notifying the branch manager when changes in operation increase the risk of fire. Supervisors are also responsible for enforcing Orange Grove Public Library fire prevention and protection policies.

D. Employees

All employees shall:

1. Complete all required training before working without supervision.
2. Conduct operations safely to limit the risk of fire.
3. Report potential fire hazards to their supervisors.
4. Follow fire emergency procedures.

4. PLAN IMPLEMENTATION

A. Good Housekeeping

To limit the risk of fires, employees shall take the following precautions:

1. Minimize the storage of combustible materials.

2. Make sure that doors, hallways, stairs, and other exit routes are kept free of obstructions and combustible materials.
3. Dispose of combustible waste in covered, airtight, metal containers.
4. Use and store flammable materials in well-ventilated areas away from ignition sources.
5. Use only nonflammable cleaning products.
6. Keep incompatible (i.e., chemically reactive) substances away from each other.
7. Perform “hot work” (i.e., welding or working with an open flame or other ignition sources) in controlled and well-ventilated areas.
8. Keep equipment in good working order (i.e., inspect electrical wiring and appliances regularly and keep motors and machine tools free of dust and grease.
9. Ensure that heating units are safeguarded.
10. Report all gas leaks immediately. Branch manager shall ensure that all gas leaks are repaired immediately upon notification.
11. Repair and clean up flammable liquid leaks immediately.
12. Keep work areas free of dust, lint, sawdust, scraps and similar material.
13. Do not rely on extension cords if wiring improvements are needed, and take care not to overload circuits with multiple pieces of equipment.
14. Ensure that required hot work permits are obtained.
15. Turn off electrical equipment when not in use.

B. Maintenance

Branch manager will ensure that equipment is maintained according to manufacturer's' specifications. Orange Grove Public Library will also comply with requirements of the National Fire Protection Association (NFPA) codes for specific equipment. Only properly trained individuals shall perform maintenance work.

The following equipment is subject to the maintenance, inspection and testing procedures:

1. equipment installed to detect fuel leaks, control heating and control pressurized systems;
2. portable fire extinguishers, automatic sprinkler system and fixed extinguishing systems;
3. detection systems for smoke, heat or flame;
4. fire alarm systems; and
5. emergency backup systems and the equipment they support.

5. TYPES OF HAZARDS

The following sections address the major workplace fire hazards at Orange Grove Public Library's facilities and the procedures for controlling the hazards.

A. Electrical Fire Hazards

Electrical system failures and the misuse of electrical equipment are leading causes of workplace fires. Fires can result from loose ground connections, wiring with frayed insulation, or overloaded fuses, circuits, motors, or outlets.

To prevent electrical fires, employees shall:

1. Make sure that worn wires are replaced.
2. Use only appropriately rated fuses.
3. Never use extension cords as substitutes for wiring improvements.
4. Use only approved extension cords (i.e., those with the Underwriters Laboratory (UL) or Factory Mutual (FM) label).
5. Check wiring in hazardous locations where the risk of fire is especially high.
6. Check electrical equipment to ensure that it is either properly grounded or double insulated.
7. Ensure adequate spacing while performing maintenance.

B. Portable Heaters

All portable heaters shall be approved by branch manager. Portable electric heaters shall have tip-over protection that automatically shuts off the unit when it is tipped over. There shall be adequate clearance between the heater and combustible furnishings or other materials at all times.

C. Office Fire Hazards

Fire risks are not limited to Orange Grove Public Library's industrial facilities. Fires in offices have become more likely because of the increased use of electrical equipment, such as computers and fax machines. To prevent office fires, employees shall:

1. Avoid overloading circuits with office equipment.
2. Turn off nonessential electrical equipment at the end of each workday.
3. Keep storage areas clear of rubbish.
4. Ensure that extension cords are not placed under carpets.
5. Ensure that trash and paper set aside for recycling is not allowed to accumulate.

D. Cutting, Welding and Open Flame Work

Branch Manager(s) will ensure the following:

1. All necessary hot work permits have been obtained prior to work beginning.
2. Cutting and welding are done by authorized personnel in designated cutting and welding areas whenever possible.
3. Adequate ventilation is provided.

4. Torches, regulators, pressure-reducing valves, and manifolds are UL listed or FM approved.
5. Oxygen-fuel gas systems are equipped with listed and/or approved backflow valves and pressure-relief devices.
6. Cutters, welders, and helpers are wearing eye protection and protective clothing as appropriate.
7. Cutting or welding is prohibited in sprinklered areas while sprinkler protection is out of service.
8. Cutting or welding is prohibited in areas where explosive atmospheres of gases, vapors, or dusts could develop from residues or accumulations in confined spaces.
9. Cutting or welding is prohibited on metal walls, ceilings or roofs built of combustible sandwich-type panel construction or having combustible covering.
10. Confined spaces such as tanks are tested to ensure that the atmosphere is not over ten percent of the lower flammable limit before cutting or welding in or on the tank.
11. Small tanks, piping or containers that cannot be entered are cleaned, purged and tested before cutting or welding on them begins.
12. Fire watch has been established.

E. Flammable and Combustible Materials

Branch manager shall regularly evaluate the presence of combustible materials at Orange Grove Public Library.

Certain types of substances can ignite at relatively low temperatures or pose a risk of catastrophic explosion if ignited. Such substances obviously require special care and handling.

1. Class A combustibles.

These include common combustible materials (wood, paper, cloth, rubber, and plastics) that can act as fuel and are found in non-specialized areas such as offices.

To handle Class A combustibles safely:

a. Dispose of waste daily.
b. Keep trash in metal-lined receptacles with tight-fitting covers (metal wastebaskets that are emptied every day do not need to be covered).
c. Keep work areas clean and free of fuel paths that could allow a fire to spread.
d. Keep combustibles away from accidental ignition sources, such as hot plates, soldering irons or other heat- or spark-producing devices.
e. Store paper stock in metal cabinets.
f. Store rags in metal bins with self-closing lids.
g. Do not order excessive amounts of combustibles.
h. Make frequent inspections to anticipate fires before they start.

Water, multi-purpose dry chemical (ABC), and halon 1211 are approved fire extinguishing agents for Class A combustibles.

2. Class B combustibles.

These include flammable and combustible liquids (oils, greases, tars, oil-based paints, and lacquers), flammable gases, and flammable aerosols.

To handle Class B combustibles safely:

a. Use only approved pumps taking suction from the top to dispense liquids from tanks, drums, barrels or similar containers (or use approved self-closing valves or faucets).

b. Do not dispense Class B flammable liquids into containers unless the nozzle and container are electrically interconnected by contact or by a bonding wire. Either the tank or container must be grounded.
c. Store, handle, and use Class B combustibles only in approved locations where vapors are prevented from reaching ignition sources such as heating or electric equipment, open flame or mechanical or electric sparks.
d. Do not use a flammable liquid as a cleaning agent inside a building (the only exception is in a closed machine approved for cleaning with flammable liquids).
e. Do not use, handle or store Class B combustibles near exits, stairs or any other areas normally used as exits.
f. Do not weld, cut, grind or use unsafe electrical appliances or equipment near Class B combustibles.
g. Do not generate heat, allow an open flame or smoke near Class B combustibles.
h. Know the location of and how to use the nearest portable fire extinguisher rated for Class B fire.

Water should not be used to extinguish Class B fires caused by flammable liquids. Water can cause the burning liquid to spread, making the fire worse. To extinguish a fire caused by flammable liquids, exclude the air around the burning liquid. The following fire-extinguishing agents are approved for Class B combustibles: carbon dioxide, multi-purpose dry chemical (ABC), halon 1301, and halon 1211. (NOTE: Halon has been determined to be an ozone-depleting substance and is no longer being manufactured. Existing systems using halon can be kept in place.)

F. Smoking

Smoking is prohibited in all Orange Grove Public Library buildings. Certain outdoor areas may also be designated as no smoking areas. The areas in which smoking is prohibited outdoors are identified by NO SMOKING signs.

6. TRAINING

The branch manager shall present basic fire prevention training to all employees upon employment and shall maintain documentation of the training, which includes the following:

A. review of 29 CFR 1910.38, including how it can be accessed;
B. this Fire Prevention Plan, including how it can be accessed;
C. good housekeeping practices;
D. proper response and notification in the event of a fire;
E. instruction on the use of portable fire extinguishers (as determined by company policy in the Emergency Action Plan); and
F. recognition of potential fire hazards.

Supervisors shall train employees about the fire hazards associated with the specific materials and processes to which they are exposed and will maintain documentation of the training. Employees will receive this training:

A. at their initial assignment;
B. annually; and
C. when changes in work processes necessitate additional training.

7. PROGRAM REVIEW

Branch manager shall review this Fire Prevention Plan at least annually for necessary changes.