Fire Protection Engineering

CALIFORNIA POLYTECHNIC SLO

FIRE PROTECTION ENGINEERING PROGRAM

CULMINATING PROJECT

SUMMER 2014

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Statement of Disclaimer

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

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Overview:

The following report will analyze a mixed-use hotel occupancy for compliance with the minimum fire safety standards. This report outlines the design is compliant with the referenced standards –with the exception of the performance based equivalency- but should not be considered an all-inclusive design. A performance-based evaluation was required to determine if a fire resistance barrier is essential across the exit access corridor serving the guest rooms.

The subject of the report will be evaluated under the standards set forth by the State of Georgia. Georgia mandates the minimum fire safety standard in the Rules and Regulations of The Safety Fire Commissioner, also referred to as Chapter 120-3-3. This document establishes which fire standard edition is adopted and also establishes a hierarchy of precedence when two standards address the same topic.

Abstract

The State of Georgia modifies the International Building Code through State amendments, to require a fire resistance rating between residential occupancies and all other occupancies. This fire and life safety analysis report will substantiate the necessity for the barrier in a mixed-use hotel occupancy. The first-half of the report addresses the prescriptive-based code requirements, reporting a compliant design was presented. Then the performance portions primary objective was established, maintain a tenable environment for egressing guest room occupants. Three conditions were evaluated to define a tenable environment, carbon monoxide levels, temperature, and visibility limits. Selecting the location of the fire required analyzing the fuel load while referring to Section 5.5 of the Life Safety Code, *Design Fire Scenarios*. The fire scenario selected was an ultrafast developing fire open to the primary means of egress with the interior doors open. A significant fuel load was located near the area requiring fire resistance separation, the storage room equipped with stacked cushioned chairs. Referencing fire test data the stackable chairs do present an ultrafast developing fire scenario. The storage room opens directly into the corridor serving as the exit access for the guest rooms on the main level. Through hand calculations and fire modeling using NIST's Fire Dynamic Simulator (FDS) the report concludes that a barrier must be established or another equivalency must be implemented to provide an acceptable design.

Framework:

- Overview
- Abstract
- Project Description
- Code Summary
- Prescriptive Code Analysis
  - Structural
  - Water Based Fire Suppression System
  - Fire Alarm
  - Egress
- Performance Based Alternative
  - RSET: Required Safe Egress Time
    - Egress Time Analysis- Hand Calculation Method
    - Egress Time Analysis- Computer Based Method
  - ASET: Available Safe Egress Tim
    - Fire Model
    - Tenability
    -
- Equivalencies
- Summary
- Annex

Contents:

Introduction:

This report will assess the fire protection features of a six-story hotel through both prescriptive and performance based designs. The subject structure is a 105 room hotel with over 2,000 square feet (sf.) of meeting space and a 3,500 sf. restaurant/lobby combination on the main level. An aerial view of the building presents a non-symmetrical “T” shape footprint spanning 242 feet long and 155 feet across. If the main level was omitted from the aerial the building would present an “L” shape footprint. With all 6-stories raising above grade the tallest architectural feature reaches an elevation of 75 feet; however, the highest occupied floor is slightly over 50 feet above grade. All floors except the main level are typically 8’-8” from floor to floor, the main level has a floor to floor dimension of 13’-4”. The main level of the hotel consists of hotel rooms, a restaurant, fitness area, swimming pool, meeting rooms and guest services. Levels 2-6 are typical floor plans with an interior common corridor connecting the two stairwells on each end of the building. Guest rooms are located on either side of the common corridor. The total floor plan covers approximately 107,542 sf. with a 21,587 sf. main level and all other levels typically consisting of 17,191 sf.

STRUCTURAL

Use and Occupancy Classification:

In accordance with Section 302 of the International Building Code (IBC), structures with multiple uses shall comply with Section 508. Section 508 addresses structures that are comprised of multiple occupancies, identified as a Mixed Occupancy. Mixed Occupancies are considered "Separated" if fire barriers are present between each occupancy as required by Table 508.3.3 otherwise, they are considered "Non-Separated". This analysis will be for a non-separated mixed occupancy comprised of three occupancies, A-2, A-3, and R-1 (assembly and residential). Other incidental uses are present such as storage rooms and laundry facilities are considered accessory uses. Accessory use areas are limited to 10 percent of the area of the story (unless the height and area table is abided for the particular occupancy).

The construction type is dictated by the occupancy with the most stringent requirements when evaluated as a non-separated mixed occupancy. In accord with the occupancy classification definitions the residential portion of the structure is classified as Group R-1 for hotel use with guest who are transient in nature. Transient is defined as occupancy of a dwelling unit for less than 30 days. The assembly portion is comprised of two Groups, the restaurant is considered A-2 and the meeting rooms are A-3. Table-1 presents the allowable number of stories, the maximum area per story (square feet), and the maximum overall height (feet) for the three different occupancy types. All values shown in the table are before any consideration is made for fire sprinkler or street frontage increases.

Type of Construction:

The values presented in Table-1 conclude that the most stringent of the occupancies listed is Assembly, both A-2 and A-3 has the same limitations. Considering the proposed structure will be 6 stories it is apparent that the number of stories will be our most limiting factor. All the Assembly Occupancies are on the main level therefore the residential becomes the most restrictive due to the number of stories. The only construction types eligible are Type IA and IB, the selected construction is Type IB. Section 504.2 IBC allows the height of the building to be increased by 1 story and the overall height to be increased by 20 feet if the building is equipped with an approved automatic fire sprinkler system. Without any allowable increases for fire sprinkler or road frontage, both Residential and Assembly occupancies are permitted to be 11 stories in height with an unlimited area per story if constructed as a Type IB building. The addition of a fire sprinkler system to the Type IB building allows the Hotel to be of an unlimited area up to a maximum of 12 stories. In Type I and II construction all structural framing, bearing walls, floor construction, and roof construction are required to be non-combustible.

Table-1: Height and Area

	Type of Construction					
	I-A	I-B	II-A	II-B	III-A	III-B
Height	UL	160	65	55	65	55
Occupancy Classification	Allowable number of stories/ Maximum Area per story					
Residential R-1	UL/UL	11/UL	4/24000	4/16000	4/24000	4/16000
Assembly A-2	UL/UL	11/UL	3/15500	2/9500	3/14000	2/9500
Assembly A-3	UL/UL	11/UL	3/15500	2/9500	3/14000	2/9500

*Referencing IBC Table 503- Allowable Height and Building Area

IBC's Fire Resistance Rating:

Section 602 IBC states that building elements shall have a fire-resistance rating no less than the specified rating in Table 601 and exterior walls shall have a fire-resistance rating no less than the specified rating in Table 602. Table-2 below is a replica of Table 601 referenced above listing the required fire resistance ratings for each structural element for Type IB construction.

Table-2: Fire-Resistance Rating for Building Elements

CONSTRUCTION TYPE IB – SPRINKLERED FIRE RESISTANCE RATINGS (TABLE 601) *		
COMPONENT		REQUIRED FIRE RATING
STRUCTURAL FRAME		2 HOURS
EXTERIOR BEARING PARTITIONS		2 HOURS
INTERIOR BEARING PARTITIONS		2 HOURS
EXTERIOR NON-BEARING PARTITIONS (IN ACCORDANCE WITH THE REQUIREMENTS OF TABLE 602)	(LESS THAN 5' FIRE SEPARATION DISTANCE – R1 / A2)	1 HOUR
	(LESS THAN 5' FIRE SEPARATION DISTANCE – S2)	1 HOUR
	(30'+ FIRE SEPARATION DISTANCE)	0 HOUR
FLOOR CONSTRUCTION INCLUDING SUPPORTING BEAMS AND JOISTS		2 HOURS
ROOF CONSTRUCTION INCLUDING SUPPORTING BEAMS AND JOISTS		1 HOUR
FIRE WALLS		NOT APPLICABLE
VERTICAL SHAFT AND STAIR ENCLOSURES		2 HOURS
TENANT SEPARATION		1 HOUR
EXIT PASSAGEWAY ENCLOSURES		1 HOUR

SITE:

Figure-1 below presents the Site Plan for the proposed structure. As shown, the building is bordered on two sides by public right of way, one side is a private roadway and the fourth side is the parking lot. Referencing Table-602 IBC for the required fire resistance rating of non-load bearing walls the two long sides of the building are not required to be rated by obtaining a minimum 30 ft. separation distance from adjacent structures. Close attention to Figure-1 reveals that a future restaurant is proposed to the plan-east side of the structure and must be considered. Because the exterior wall is also a bearing wall, the wall is required to have a 2-hour fire resistive rating and will allow the restaurant to be built within 5 ft. The rated wall design, adjacent to the future restaurant, has excluded all openings except the openings to accommodate the main level exit corridor discharge and the stairwell exit discharge. The plan-right side of the building shall be evaluated to determine if the building is at least 30 ft. from the center line of the private roadway, if so, a rating is not required for the separation requirements.

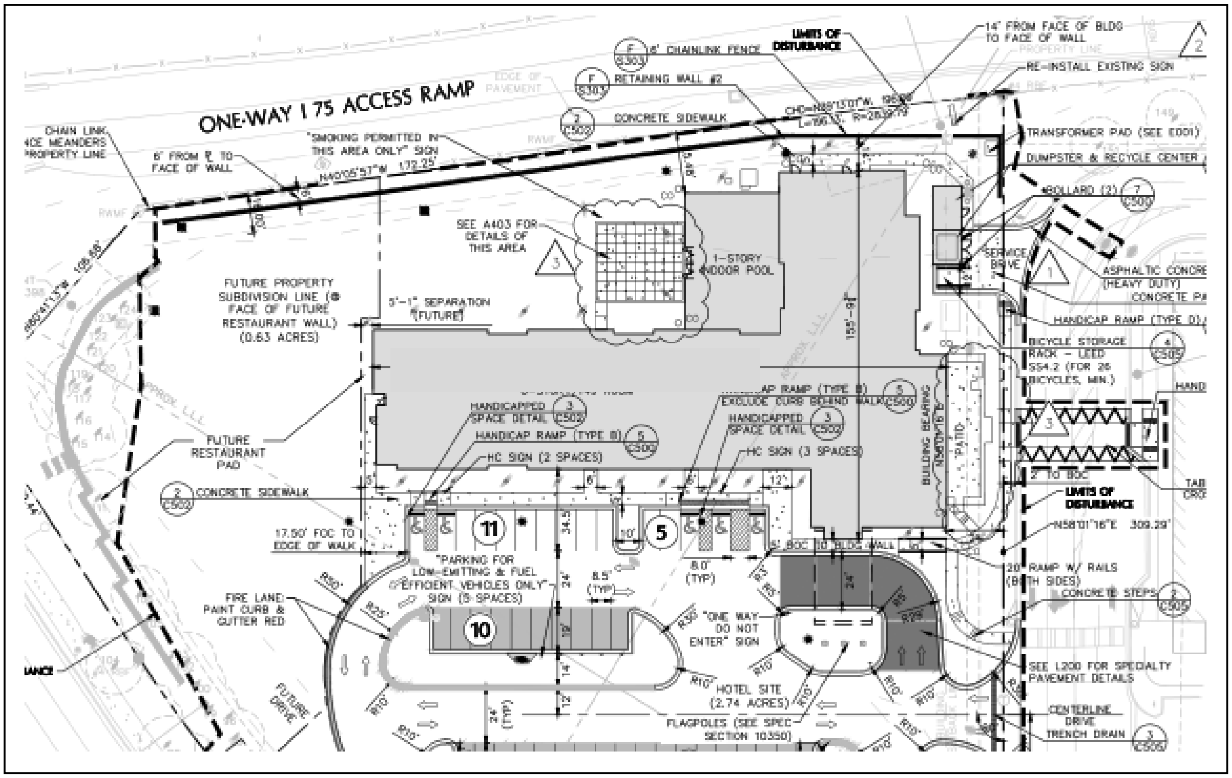


Figure-1: Site Plan

PARAPET WALL:

A parapet wall is not required when the exterior wall is not required to be fire resistance rated in accordance with Table-602 IBC. However, because Type IB construction requires all exterior load bearing walls to be rated a parapet is provided around the entire parameter of the roof of the same fire resistance rating as the supporting exterior wall.

Construction:

Figure-2 below presents the live loads, wind loads, seismic category, and snow loads that are incorporated into the structural design of the Hotel.

DESIGN LOADS:

1. LIVE LOADS
   40 PSF – GUESTROOMS AND CORRIDORS
   100 PSF – PUBLIC ROOMS AND CORRIDORS SERVING PUBLIC ROOMS.
   100 PSF – STAIRS AND EXITS
   20 PSF – ROOF
   125 PSF – STORAGE
2. WIND LOADS
   90 MPH BASIC WIND VELOCITY – I=1.0, EXPOSURE B. GCpi = +/–0.18
3. SEISMIC:
   BUILDING OCCUPANCY CATEGORY II, I=1.0 SEISMIC DESIGN CATEGORY = B
   SITE CLASS – C
   Ss = 0.246, SI = 0.088, SDS = 0.197, SD1 = 0.100
   SEISMIC FORCE RESISTING SYSTEM – INTERMEDIATE REINFORCED CMU SHEAR WALLS
   R = 3.5, Ω = 2–1/2, CD = 2–1/4
   DESIGN PER EQUIVALENT LATERAL FORCE PROCEDURE
   IBC 2006, SECTION 1615
4. GROUND SNOW LOAD Pg = 10PSF.

Figure-2: Design Loads

HIGH-RISE:

The Hotel is not required to meet the requirements of Section 403 IBC: High-Rise Building. A High-Rise Building is defined as a building with an occupied floor located more than 75 feet above the lowest fire department vehicle access. Figure-3 is an elevation drawing of the Hotel with a clear depiction of the architectural feature that protrudes to a maximum elevation of 75 ft.; however, the architectural feature is not normally occupied.

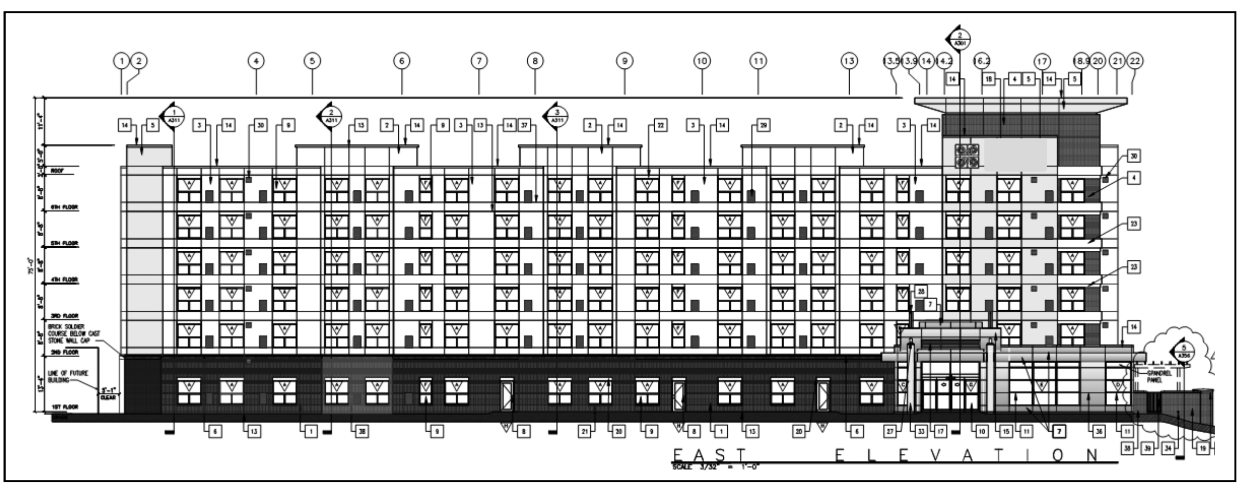


Figure-3: Elevation

Figure-4 is the floor plan of the main level. The floor plan presents with multiple uses. From left to right the floor plan consists of guest rooms, then meeting rooms and a fitness area, followed by an open floor plan consisting of the lobby, restaurant, and bar area. To conclude the floor plan layout are the service facilities including the kitchen, laundry, and equipment rooms located common to each other plan-north. All of the occupancy uses are without any required fire separations due to the "non-separated" mixed occupancy classification. Utilizing Type IB construction the Hotel is permitted to eliminate fire barriers between the different occupancies. One exception to the required fire barriers will be discussed during the performance based portion of this report.

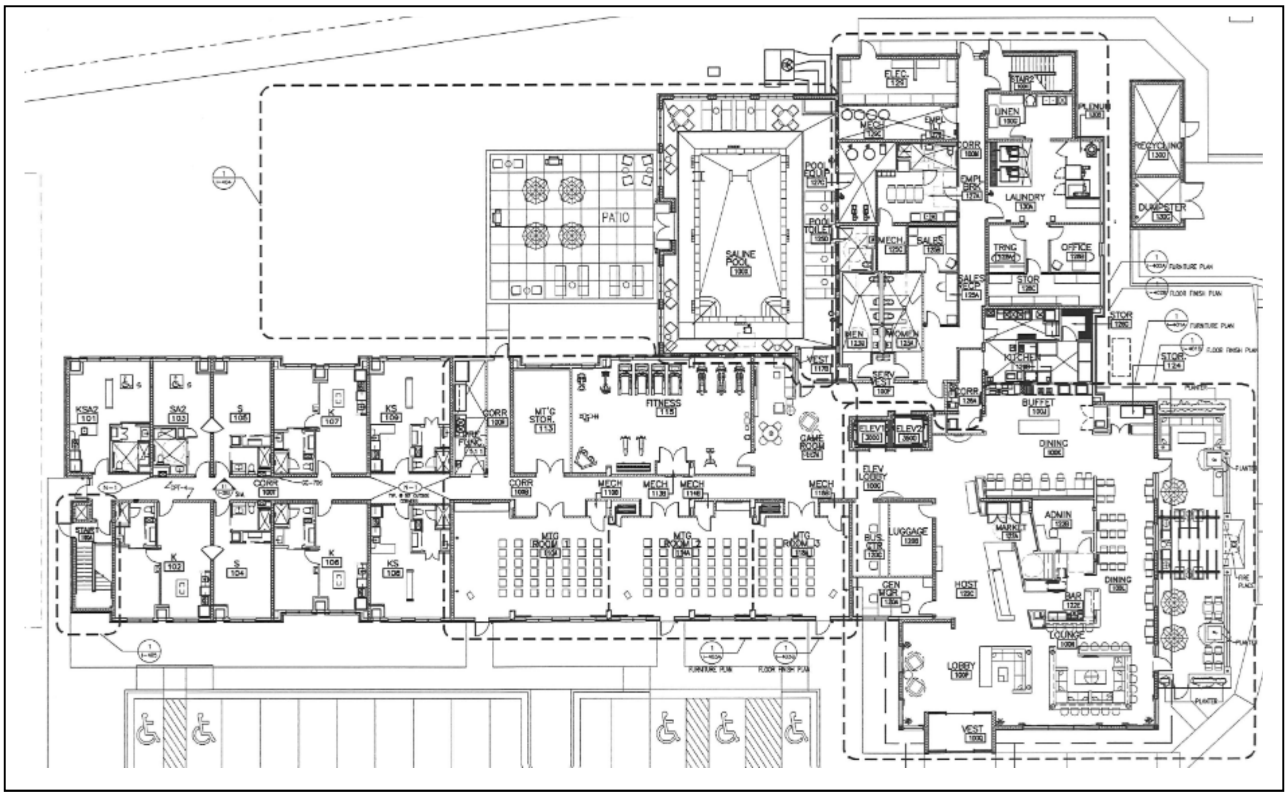


Figure-4: Floor Plan

FOUNDATION:

Figure-5 below is the proposed foundation plan. Several areas throughout the plan present with bulk footers to support columns (both masonry and steel), interior load bearing walls, exterior load bearing walls, stairways, and elevators. All reinforcement steel shall conform to ASTM A615 and have a minimum cover of 3 inches when cast against earth and 2 inches in all other areas throughout the foundation. All cast-in-place concrete shall have a 28-day compressive strength of at least 3000 psi with the columns and beams to have a minimum of 4000 psi compressive strength.

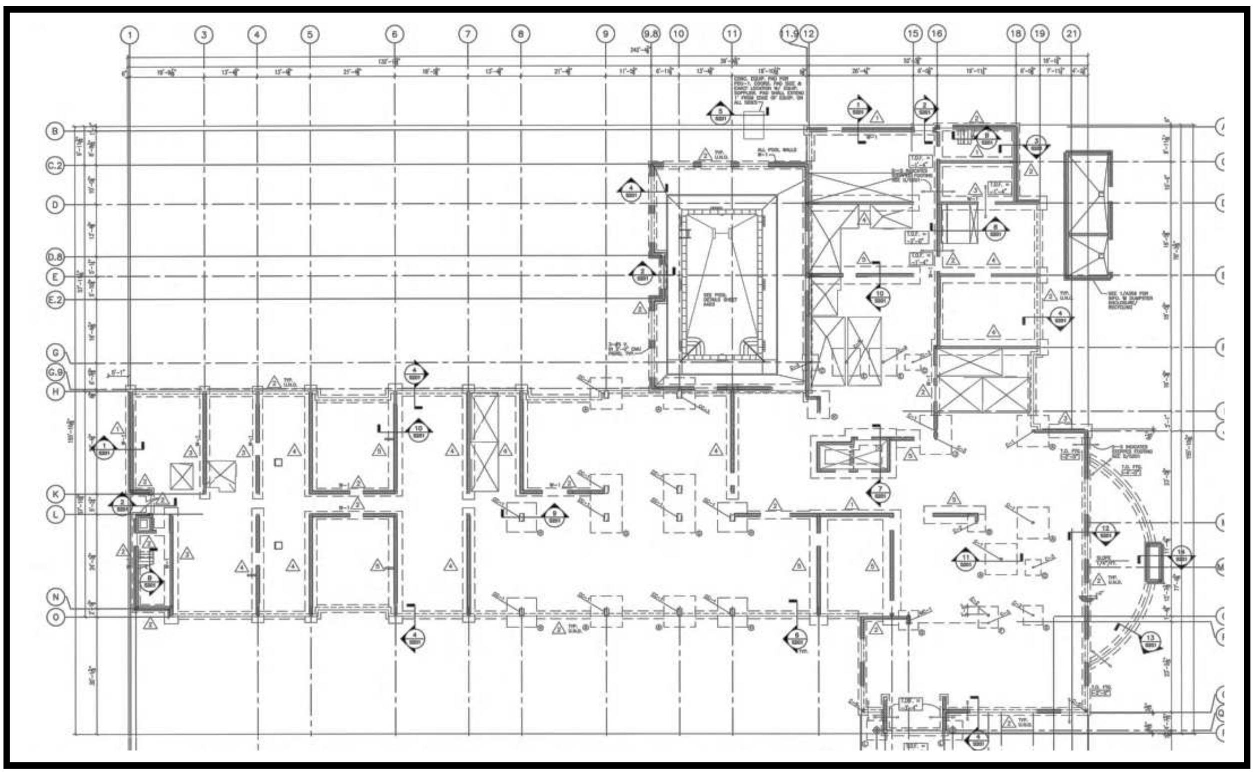


Figure-5: Foundation Plan

FLOOR SYSTEM:

The floor system is an assembly of pre-stressed pre-cast concrete planks with a topping of Gypcrete to establish a 2-hr fire resistance rating. An excerpt from Oldcastle's Pre-cast Building Systems technical specifications is included below to document an 8" plank with a 1/2" topping of Gypcrete obtains a 2-hour floor assembly, when considered restrained. Proposed is an 8" plank with ¾" Gypcrete topping, exceeding the Oldcastle system design by ¼". The fire resistance rating for the precast planks was established through fire test in accordance with PCI

MNC 124 a testing standard published by the Prestressed Concrete Institute. Expressed in the document is the test standard published by ASTM E119. Section 721.2.2.1.1 IBC also addresses hollow-core pre-stressed slabs through an equivalent thickness of concrete that is calculated using the net cross sectional area divided by the width. This equivalent thickness is compared to the minimum slab thickness published in Table 721.2.2.1 IBC for the applicable hourly fire resistance rating. Another publication for the fire resistant rating is below. An excerpt from the technical data sheet on the concrete planks list the hourly rating for multiple assemblies tested in accordance with UL design J994.

Underwriters Laboratories Fire Resistive Ratings

Prior to codes including prescriptive fire-endurance rating methods, fire tests provided the primary source of ratings classifications. While some plank sections were fire tested, others can be evaluated by UL to qualify for existing UL numbers.

The table below lists the UL ratings available with Elematic® plank. Note that these ratings are dependent upon whether or not the ends of the planks are restrained. Determination of the restraint must be made by the Architect or the Engineer of Record, as it is primarily a function of the support structure.

UL Number	Rating (Hour)		Plank Thickness (Inch)	Topping Thickness (Inch)
	Restrained	Unrestrained		
J994	1½	1½	8,10,12	0
J994	2	1½	8,10,12	½ Gypcrete
J994	3	1½	8,10,12	2 1/8 Topping
J994	4	1½	8,10,12	3 3/8 Topping

Figure-6: Oldcastle's Pre-cast Building Systems technical specifications

The following is documentation from ASTM E119-88 to justify that precast concrete can be evaluated as restrained when resistance to thermal thrust is accommodated.

Figure 6.4.2 Examples of typical restrained and unrestrained construction classifications (from Appendix X3 of ASTM E119-88)

I. Wall Bearing:

Single span and simply supported end spans of multiple bays[a]

(1)	Open-web steel joists or steel beams, supporting concrete slab, precast units or metal decking	unrestrained
(2)	Concrete slabs, precast units or metal decking	unrestrained

Interior spans of multiple bays:

(1)	Open-web steel joists, steel beams or metal decking, supporting continuous concrete slab	restrained
(2)	Open-web steel joists or steel beams, supporting precast units or metal decking	unrestrained
(3)	Cast-in-place concrete slab systems	restrained
(4)	Precast concrete where the potential thermal expansion is resisted by adjacent construction[b]	restrained

[a]Floor and roof systems can be considered restrained when they are tied into walls with or without tie beams, the walls being designed and detailed to resist thermal thrust from the floor or roof system.

[b]For example, resistance to potential thermal expansion is considered to be achieved when:

(1) Continuous structural concrete topping is used.

(2) The space between the ends of precast units or between the ends of units and the vertical face of supports is filled with concrete or mortar.

(3) The space between the ends of precast units and the vertical faces of supports, or between the ends of solid or hollow core slab units does not exceed 0.25 percent of the length for normal weight concrete members or 0.1 percent of the length for structural lightweight concrete members.

Figure-7: ASTM E119-88

Below, Figure-8 is a detail of how the design accounts for the thermal thrust by filling the voids at the ends of the pre-cast planks with grout. The detail is of an interior CMU wall with pre-cast 8" planks resting on the top of the wall. Another CMU wall begins on the top-side of the pre-cast plank then continues vertical. You can also observe the imbedded steel for the tensional support.

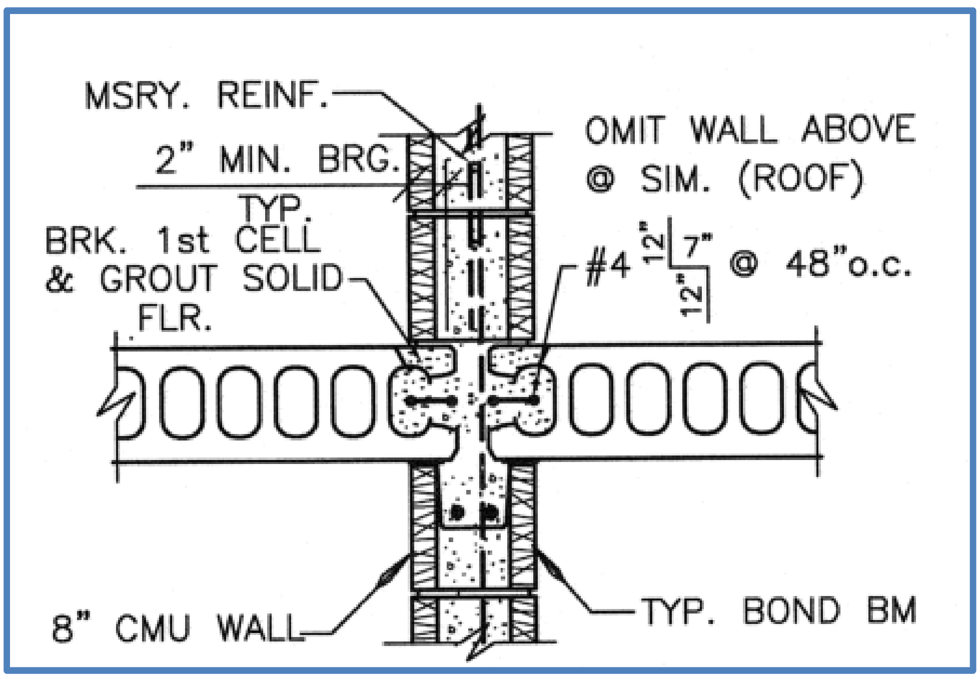


Figure-8: Section of precast concrete planks

FRAMING:

The following figure is the 2nd Floor framing plan. A combination of CMU (concrete masonry unit), steel beams, steel columns, and metal studs make up the framing plan to support the second floor. The floor system is comprised of 8" pre-cast pre-stressed concrete planks that are supported by the CMU and beams. A secondary concern in the Hotel design is acoustics; utilizing CMU between the rooms provides an advantageous sound barrier. Where clear spans or open floor plans are required in the meeting rooms, lobby, and restaurant areas, steel beams are used to support the concrete planks.

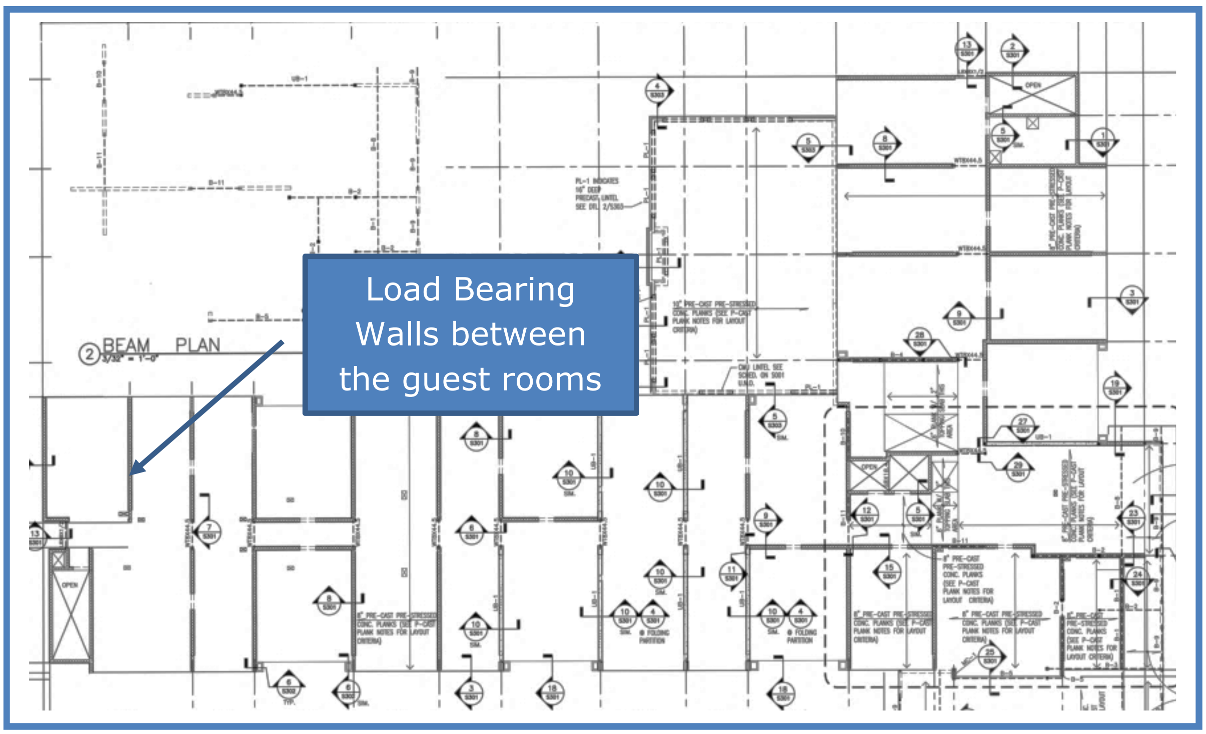


Figure-9: 2nd Foundation Plan

Figure-10 below is a detail of a structural shape landing on a CMU wall with anchor lugs and the 8” plank floor system supported by the structural shape. This system is utilized where large open spaces are desired.

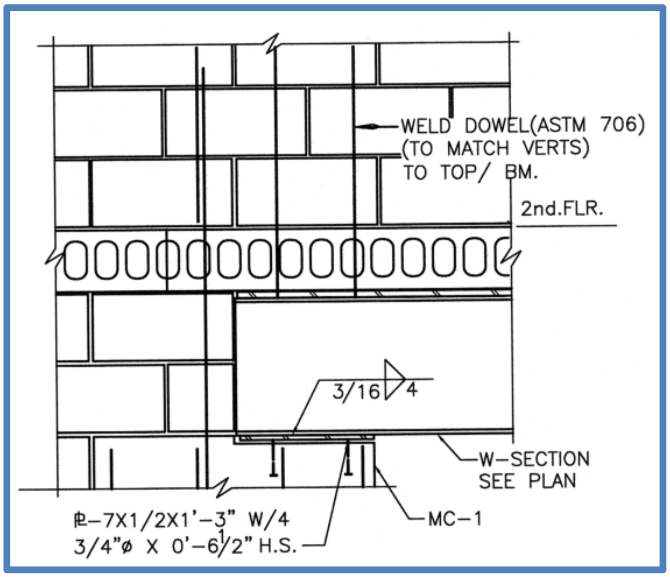


Figure-10: Section of Load Bearing Wall

The fire resistances rating of the CMU walls are to be calculated in accordance with IBC Section 721.3.2. Ratings are based on an equivalent thickness of masonry per ASTM C 140. An 8x8x16 unit block of sand and siliceous gravel aggregate has an equivalent thickness of 4.73 inches allowing for a 2.25-2.5 hour fire resistance rating.

All guest rooms are separated by adjacent guest rooms by fire partitions per Section 708 IBC. The required fire resistant rating of the partitions shall be at least 1-hour. The CMU wall between each guest room from floor to floor provides a 2-hour fire resistance rating, which exceeds the fire partition requirement of 1-hour.

The corridor shall have a 0.5-hour fire-resistance rating per Section 1017 IBC when the Residential occupancy is equipped with a fire sprinkler system. Proposed is a metal stud wall with Type-X 5/8” gypsum on either side from floor to floor providing a 1-hr fire resistance rating per Table 720.1(2) IBC.

All structural steel will be protected with spray applied fire proofing. The thickness of the spray applied fire resistant material may be calculated from the following formula published in Section 721.5.1.3 IBC for steel columns:

$$R = \left[C_1\left({}^{W}\!/_{D} + C_2\right)\right]h$$

R= Fire resistance (minutes)

H= Thickness of spray-applied fire-resistant material (inches)

D= Heated perimeter of the structural steel column (inches)

C_1 & C_2 = Material-dependent constants

W= Weight of structural steel columns (pounds per linear foot)

All structural beams shall be protected in accord with UL design D902. The equivalency shall be calculated using the following formulas from Section 721.5.2.2:

$$h_2 = h_1\,[W_1/D_1 + 0.60]/[W_2/D_2 + 0.60]$$

h= Thickness of spray-applied fire-resistant material in inches

W= Weight of the structural steel beam or girder in pounds per linear foot.

D= Heated perimeter of the structural steel beam in inches.

All concrete masonry units (CMU) are to be calcareous materials and based on an 8″ minimum face to face thickness. The IBC prescriptively rates a 8″ CMU wall un-filled as 4 hour fire-resistance in accord with Table 720.1(2).

HAZARD PROTECTION:

Per Section 28.3.2.2.1 LSC, Life Safety Code any hazardous area shall be protected in accordance with Section 8.7.

Table 28.3.2.2.2 Hazardous Area Protection

Hazardous Area Description	Separation/Protection[a]
Boiler and fuel-fired heater rooms serving more than a single guest room or guest suite	1 hour and sprinklers
Employee locker rooms	1 hour or sprinklers
Gift or retail shops	1 hour or sprinklers
Bulk laundries	1 hour and sprinklers
Guest laundries $\leq 100\ ft^2$ ($\leq 9.3\ m^2$) outside of guest rooms or guest suites	1 hour or sprinklers[b]
Guest laundries $>100\ ft^2$ ($>9.3\ m^2$) outside of guest rooms or guest suites	1 hour and sprinklers
Maintenance shops	1 hour and sprinklers
Storage rooms[c]	1 hour or sprinklers
Trash collection rooms	1 hour and sprinklers

[a]Minimum fire resistance rating.
[b]Where sprinklers are provided, the separation specified in 8.7.1.2 and 28.3.2.2.3 is not required.
[c]Where storage areas not exceeding 24 ft^2 (2.2 m^2) are directly accessible from the guest room or guest suite, no separation or protection is required.

Figure-11: Hazard Protection

The laundry facilities are constructed with 8" CMU walls with openings protected with fire resistance rating doors.

VERTICAL OPENINGS:

All vertical openings shall comply with either the LSC or NFPA 82, Standard on Incinerators and Waste and Linen Handling Systems and Equipment.

Section 8.6.5 LSC requires all floor opening enclosures connecting 4 or more stories to have a 2-hr fire resistance rating. Based on the hotel occupancy chapter, Section 28.3.1.1.3 allows the enclosure rating to be reduced to 1-hr because the building is not a high-rise and is equipped with a supervised automatic sprinkler system.

Section 7.1.3.2.1 specifically addresses exit enclosures but allows the occupancy chapter to reduce the rating to 1-hr. However, the designer has chosen to not decrease the rating.

NFPA 82 requires all linen chutes connecting more than 4 stories to have continuous walls with a fire resistance rating of 2-hr.

The following figure identifies the vertical opening locations:

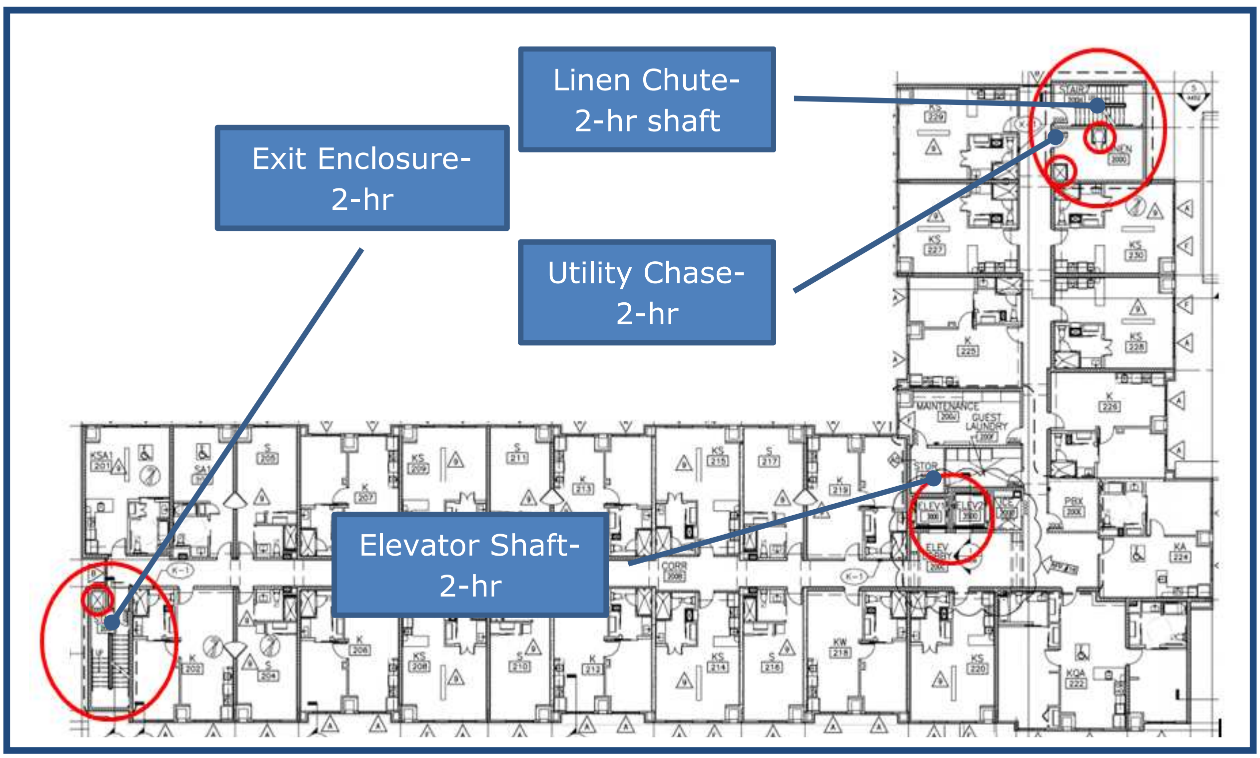


Figure-12: Vertical Opening Locations

Elevator Lobbies:

The Rules and Regulations modifies Section 9.4.2.1 LSC to require elevator lobbies on the primary and secondary recall floors of non-high rise buildings of more than 3 stories. The designer has implemented horizontal mechanical fire barriers across the corridors to create elevator lobbies operated by local smoke detectors. Egress is permissible through the elevator lobbies. To egress through the elevator lobbies once the mechanical barriers are activated the barriers are equipped with pressure sensors that retract the barriers for a set time. The application of pressure is the force of someone's hand against the barrier upon approaching the barrier.

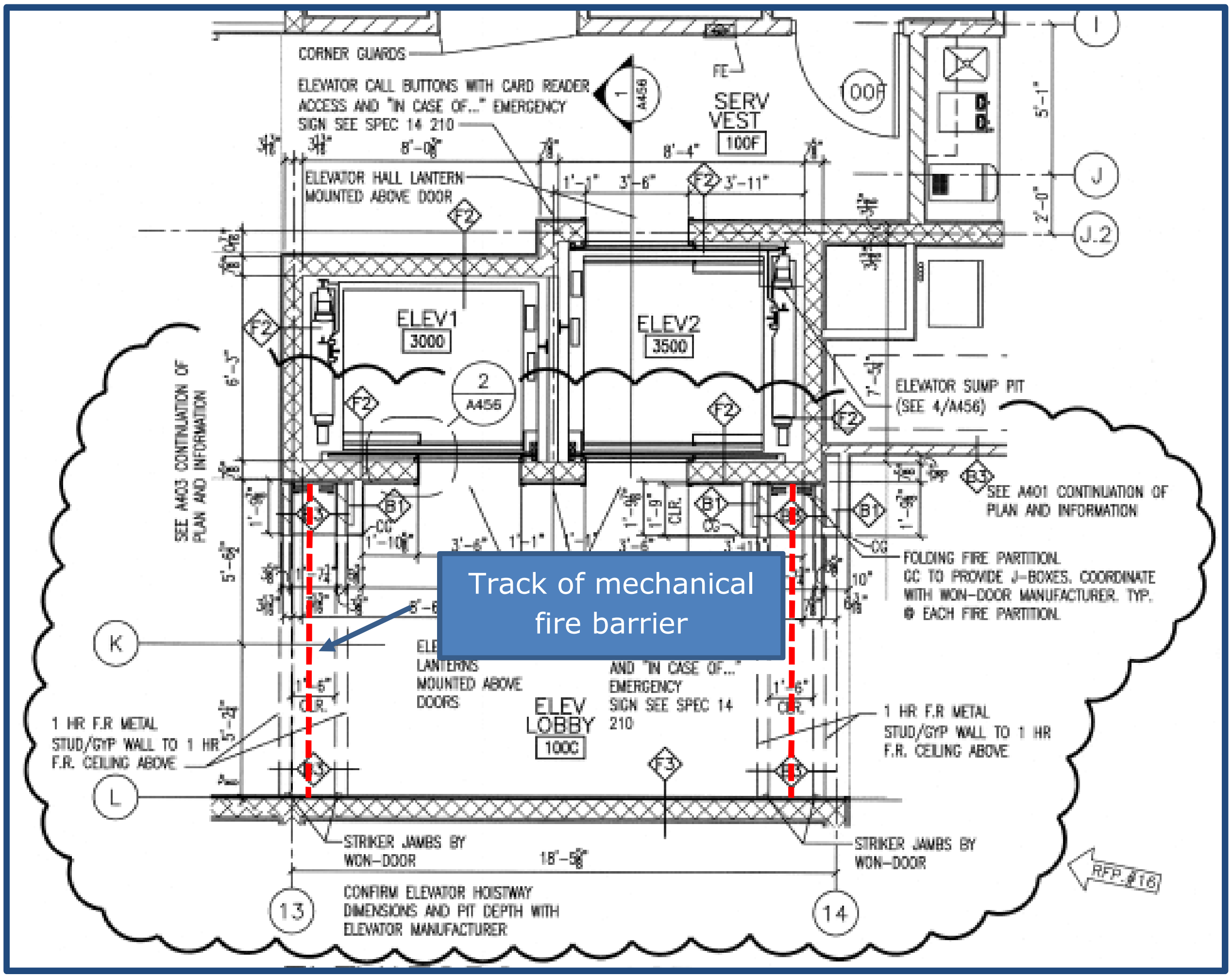


Figure-13: Elevation Lobby with Horizontal Mechanical Doors

WATER BASED FIRE SUPPRESSION

Fire Sprinkler System:

Levels 1-6 will be equipped with a NFPA 13 wet fire sprinkler system throughout. Each stairwell will be equipped with an NFPA 14 Class-1 manual-wet standpipe with hose valves on the intermediate landings and at the highest stairway landing that leads to the roof. The fire sprinkler system is supplied from the standpipe on each level and controlled by a floor control valve complete with a flow switch for fire alarm annunciation. Due to the water supply provided by the municipality this building does not require a fire pump for the fire sprinkler demands.

Throughout the building the overall hazard classification is light with areas of ordinary hazard classification scattered throughout. All fire sprinkler piping in the light hazard areas will be CPVC (Chlorinated Polyvinyl Chloride). Ordinary hazard (OH) areas over 400 sf will be supplied by steel pipe after transitioning from the CPVC main in the light hazard area. NFPA 13 allows for ordinary hazard rooms of less than 400 sf to be supplied by CPVC however, all the manufacturer's installation criteria must be followed. Because we have several OH rooms that are not intended to have ceilings requiring the CPVC to meet all the criteria for an exposed installation, the designers chose to transition to steel in all OH rooms.

Use and Hazard Classification:

The following is the breakout of the hazard classifications throughout the building. Each area was evaluated and compared to the hazard classification definition as defined in Table-3 below.

Table-3: Occupancy Description per Hazard Class

Classification:	Description
Light Hazard	the quantity and/or combustibility of contents is low and fires with relatively low rates of heat release are expected
Ordinary Hazard Group 1	where combustibility is low, quantity of combustibles is moderate, stockpiles of combustibles do not exceed 8 ft, and fires with moderate rates of heat release are expected.
Ordinary Hazard Group 2	where the quantity and combustibility of contents are moderate to high, stockpiles of contents with moderate rates of heat release do not exceed 12 ft , and stockpiles of contents with high rates of heat release do not exceed 8 ft.

Table-4 and 5 below list the different areas throughout the building according to the corresponding hazard classification and the design density for each area. All design densities are listed before any reduction was implemented for the use of quick response sprinklers.

Table-4: Occupancy Classification per area Level-1:

Room Label	Hazard Classification	Design Density
Restaurant Seating	Light	.1/1500
Conference Room		
Guest Room		
Workout Facility		
Kitchen	Ordinary	.15/1500
Laundry Room		

Table-5: Occupancy Classification per area Level 2-6:

Room Label	Hazard Classification	Design Density
Guest Room	Light	.1/1500
Corridor		
Storage	Ordinary Group 2	.2/1500
Linen	Ordinary Group 1	.15/1500

Figure-14 from NFPA 13, shown below, allows the sprinkler designer to pick any point along the associated line according to the hazard classification desired.

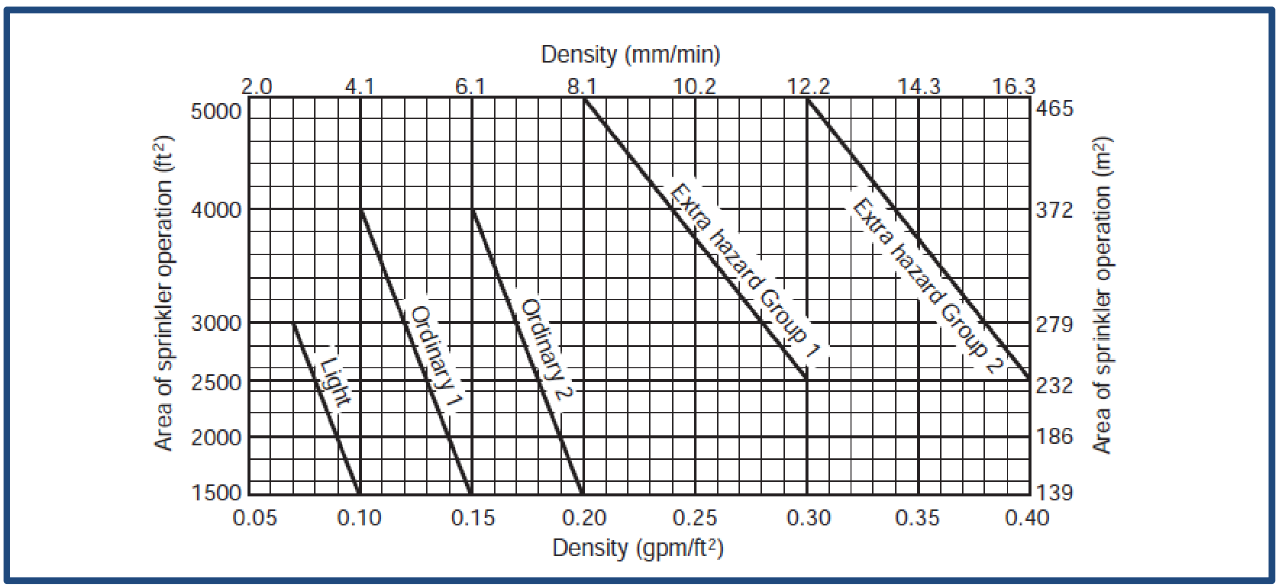


Figure-14: NFPA 13 Design Density Graph

The guest room sprinkler system design was based on the residential criteria established in NFPA 13 for residential occupancies. Above, the design density was specified as a 1500 square-feet remote area, however, NFPA 13 allows residential occupancy sprinkler systems to be designed based on the 4 most demanding sprinkers. The excerpt below is Section 11.3.1.3 from NFPA 13:

> **11.3.1.3** Unless the requirements of 11.3.1.4 are met, the minimum required discharge from each of the four hydraulically most demanding sprinklers shall be the greater of the following:
>
> (1) In accordance with minimum flow rates indicated in individual listings
>
> (2) Calculated based on delivering a minimum of 0.1 gpm/ft^2 (4.1 mm/min) over the design area in accordance with the provisions of 8.5.2.1 or 8.6.2.1.2

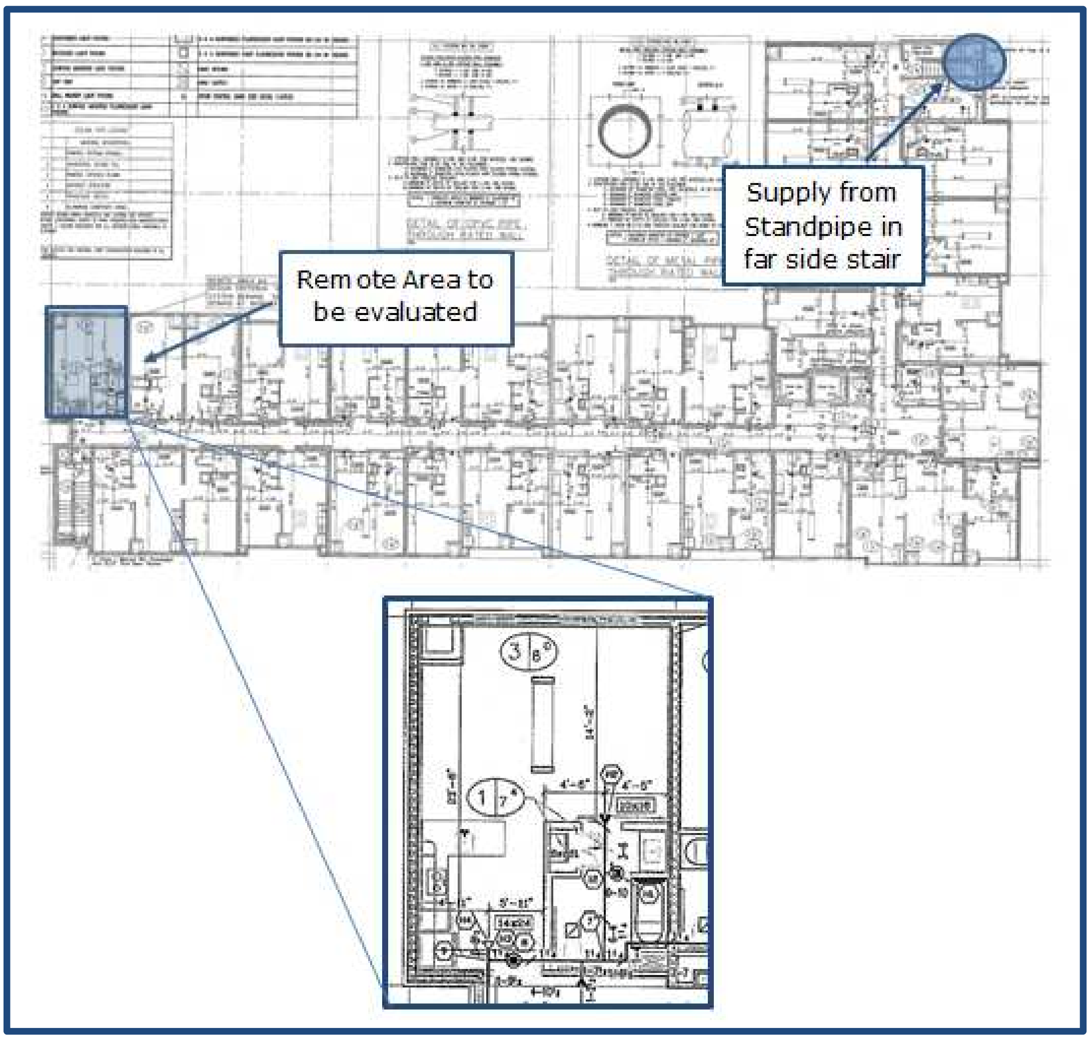


Figure-15: Sprinkler Remote Area 6th Floor

Water Supply:

Static	162 psi
Residual	154 psi
Flow	960 gpm
Flow @ 20 psi	4538 gpm

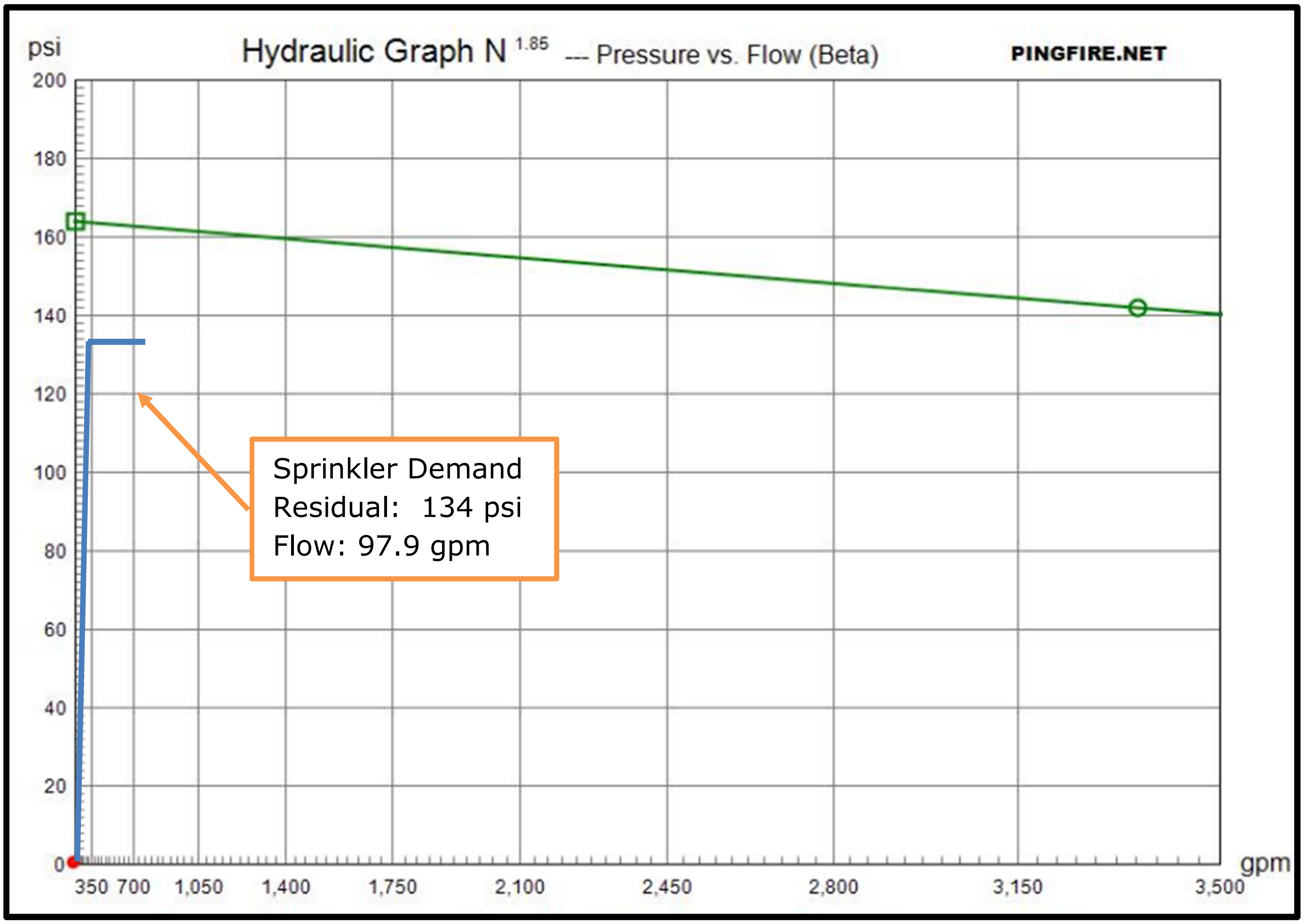


Figure-16: Hydraulic Graph

Hydraulic Calculations:

An analysis was performed to compare the hydraulic calculations presented by the sprinkler designer using the computer program "HASS" versus hand calculations both utilizing the Hazen Williams formula. One primary difference in the two calculations is the sprinkler designer is utilizing the hydraulic advantage of a looped system while the hand calculations will be based on a single main system design. As shown in Figure-3 the looped system requires a 1_1/4" main that runs along the wall between the guest rooms and the corridor.

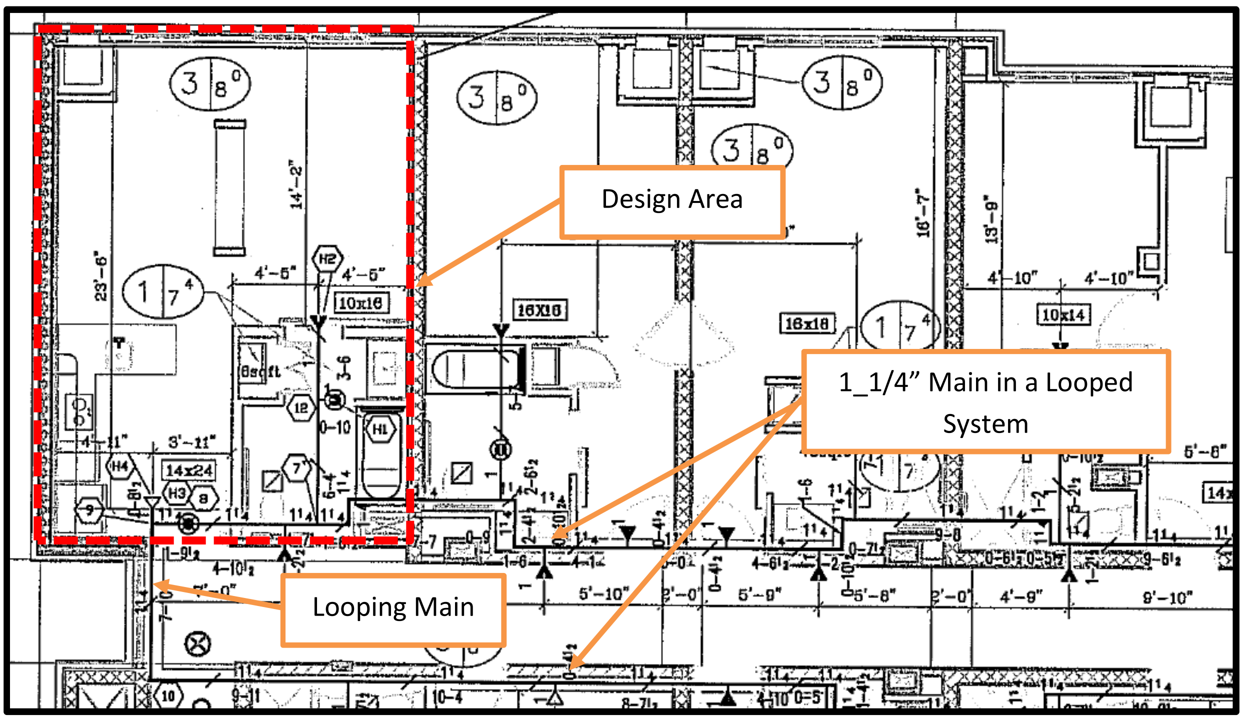


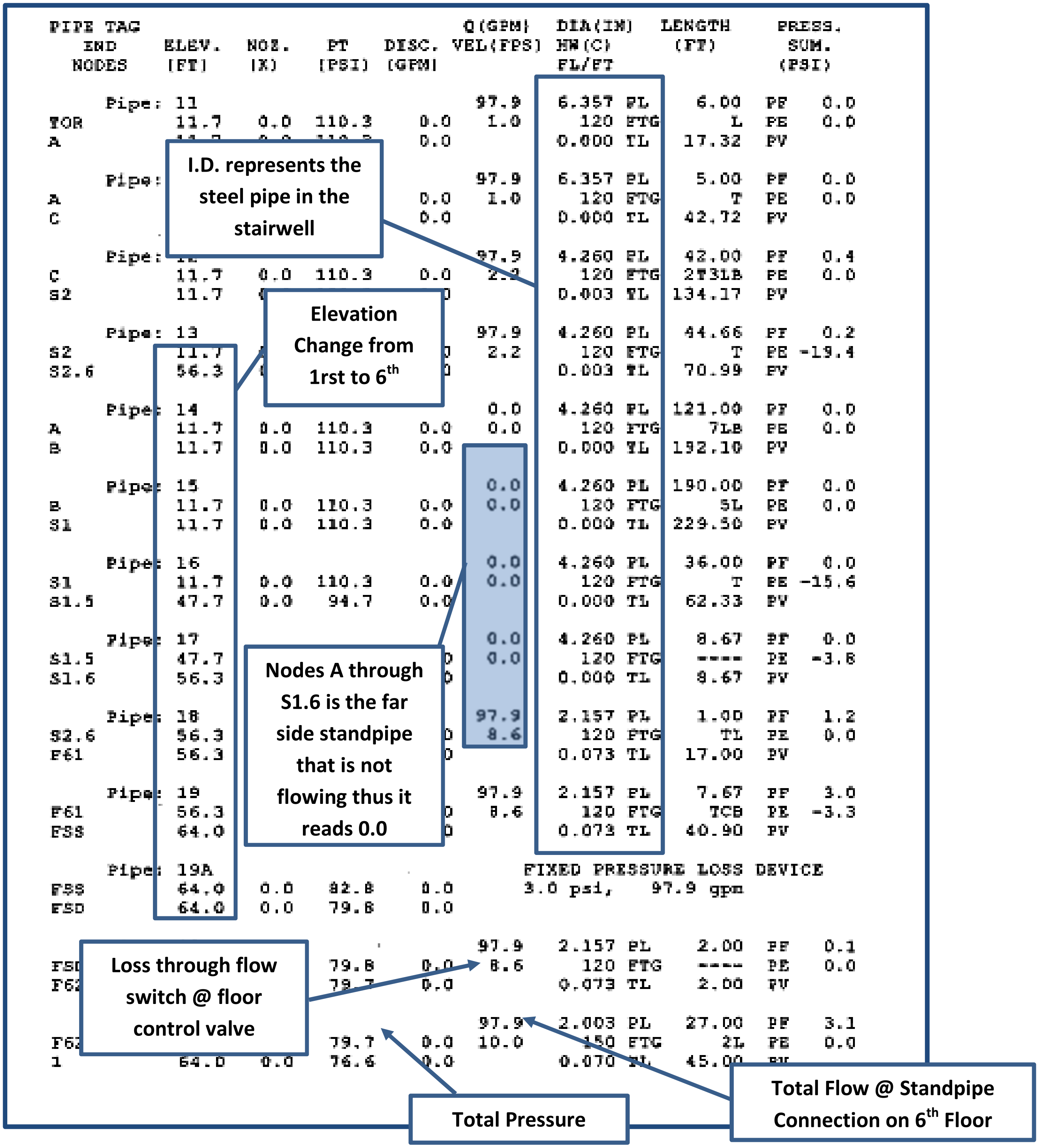
Figure-18: Sprinker Plan of remote area

Table-6 below identifies the Sprinkler Identification Number (SIN#) for each sprinkler shown in Figure-18.

Table-6: Fire Sprinkler Legend

SYMB.	SIN #	ORF.	K	TEMP.	DESCRIPTION
⊛	VK468	1/2"	4.9	155	VIKING RESIDENTIAL WHITE PENDENT
◁	VK178	1/2"	5.6	286	VIKING QR DRY SIDEWALL-WHITE
◀	VK305	1/2"	5.6	200	VIKING QR BRASS SIDEWALL

Figure-19 below is an excerpt of the calculation conducted using HASS, indicating the flow from the Top of Riser (TOR) to the connection floor control valve at the standpipe.



PIPE TAG END NODES	ELEV. (FT)	NOZ. (K)	PT (PSI)	DISC. (GPM)	Q(GPM) VEL(FPS)	DIA(IN) HW(C) FL/FT	LENGTH (FT)	PRESS. SUM. (PSI)
Pipe: 11					97.9	6.357 PL	6.00	PF 0.0
TOR	11.7	0.0	110.3	0.0	1.0	120 FTG	L	PE 0.0
A				0.0		0.000 TL	17.32	PV
Pipe:					97.9	6.357 PL	5.00	PF 0.0
A				0.0	1.0	120 FTG	T	PE 0.0
C				0.0		0.000 TL	42.72	PV
Pipe:					97.9	4.260 PL	42.00	PF 0.4
C	11.7	0.0	110.3	0.0	2.2	120 FTG	2T3LB	PE 0.0
S2	11.7					0.003 TL	134.17	PV
Pipe: 13					97.9	4.260 PL	44.66	PF 0.2
S2	11.7				2.2	120 FTG	T	PE -19.4
S2.6	56.3					0.003 TL	70.99	PV
Pipe: 14					0.0	4.260 PL	121.00	PF 0.0
A	11.7	0.0	110.3	0.0	0.0	120 FTG	7LB	PE 0.0
B	11.7	0.0	110.3	0.0		0.000 TL	132.10	PV
Pipe: 15					0.0	4.260 PL	190.00	PF 0.0
B	11.7	0.0	110.3	0.0	0.0	120 FTG	5L	PE 0.0
S1	11.7	0.0	110.3	0.0		0.000 TL	229.50	PV
Pipe: 16					0.0	4.260 PL	36.00	PF 0.0
S1	11.7	0.0	110.3	0.0	0.0	120 FTG	T	PE -15.6
S1.5	47.7	0.0	94.7	0.0		0.000 TL	62.33	PV
Pipe: 17					0.0	4.260 PL	8.67	PF 0.0
S1.5	47.7				0.0	120 FTG	----	PE -3.8
S1.6	56.3					0.000 TL	8.67	PV
Pipe: 18					97.9	2.157 PL	1.00	PF 1.2
S2.6	56.3				8.6	120 FTG	TL	PE 0.0
F61	56.3					0.073 TL	17.00	PV
Pipe: 19					97.9	2.157 PL	7.67	PF 3.0
F61	56.3				8.6	120 FTG	TCB	PE -3.3
FSS	64.0					0.073 TL	40.90	PV
Pipe: 19A					FIXED PRESSURE LOSS DEVICE			
FSS	64.0	0.0	82.8	0.0	3.0 psi, 97.9 gpm			
FSD	64.0	0.0	79.8	0.0				
					97.9	2.157 PL	2.00	PF 0.1
FSD			79.8	0.0	8.6	120 FTG	----	PE 0.0
F62			79.7	0.0		0.073 TL	2.00	PV
					97.9	2.003 PL	27.00	PF 3.1
F62			79.7	0.0	10.0	150 FTG	2L	PE 0.0
1	64.0	0.0	76.6	0.0		0.070 TL	45.00	PV

Figure-19: Computer Based Hydraulic Calculation Excerpt

Figure-20 below indicates hydraulic node points for the hand calculations.

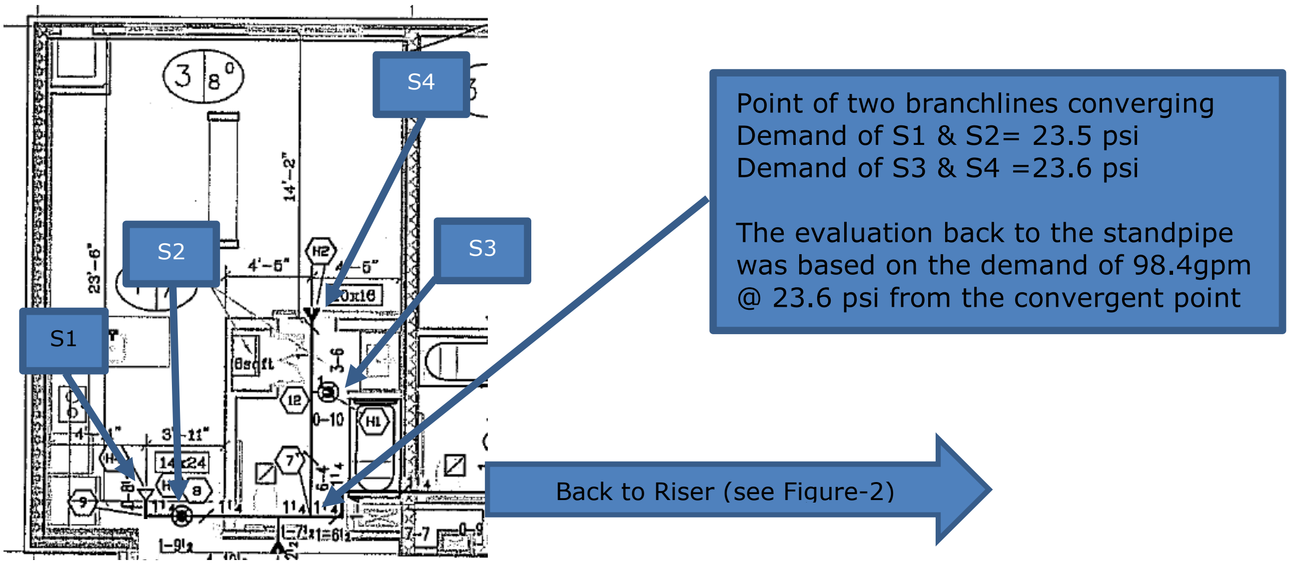


Figure-20: Node points for hand calculations

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Project name:			FPE 523											Date:
2	Step No.	Nozzle Ident and Location			Flow in gpm	Pipe size	Pipe Fittings and Devices		Equivalent Pipe Length		Friction loss (psi/ft)		Pressure Summary		Normal Pressure
3	1		S1	q	38.0	1.109	1E	L	1.5	C=	150	Pt	22.6	Pt	
4								F	2			Pe		Pv	
5				Q				T	3.5	pf	0.215	Pf	0.8	Pn	
6	2		S2	q	20.3	1.602	1T	L	1	C=	150	Pt	23.4	Pt	
7								F	8			Pe		Pv	
8				Q	58.3			T	9	pf	0.011	Pf	0.1	Pn	
9				q				L		C=		Pt	23.5	Pt	
10								F				Pe		Pv	
11				Q				T		pf		Pf		Pn	
12	3		S4	q	20.3	1.109		L	3.5	C=	150	Pt	21.8	Pt	
13								F				Pe		Pv	
14				Q				T		pf	0.068	Pf	0.2	Pn	
15	4		S3	q	19.7	1.109		L	6.5	C=	150	Pt	22.0	Pt	
16								F				Pe		Pv	
17				Q	40.1			T		pf	0.237	Pf	1.5	Pn	
18				q				L		C=		Pt	23.6	Pt	
19								F				Pe		Pv	
20				Q				T		pf		Pf		Pn	
21	5			q	98.4	1.602		L	324.75	C=	150	Pt	23.6	Pt	
22								F	138			Pe		Pv	
23				Q				T	462.75	pf	0.209	Pf	96.5	Pn	
24				q				L		C=		Pt	120.1	Pt	
25								F				Pe		Pv	
26				Q				T		pf		Pf		Pn	
27	5			q	98.4	2.003		L	324.75	C=	150	Pt	23.6	Pt	
28								F	138			Pe		Pv	
29				Q				T	462.75	pf	0.070	Pf	32.6	Pn	
30				q				L		C=		Pt	56.2	Pt	

Branchline 1 (rows 3–9)

Branchline 2 (rows 12–18)

1_1/2" main= 120.1 psi demand

2" main= 56.2 psi demand @ standpipe connection

Figure-21: Hand Calculations in an Excel Spreadsheet

Table-7 below provides a side by side comparison of the calculations. The reviewer must be sure to take into consideration that the computer based design is essentially two 1_1/4" mains and the hand calculation is a single 2" main. For reference the sectional area of the mains are also provided. The 2" main has a 5% larger area than two 1_1/4" but has a 29% reduction in the total pressure demand.

Table-7: Calculation Comparison

	Pressure (psi)	Flow (gpm)	Area of main(in^2)
Computer Based Calc	79.7	97.9	2 x 1.5 = 3.0
Hand Calc	56.2	98.4	3.15
Difference (%)	29	0.5	5.0

Figures-22 and 23 provide the equivalent pipe length for each fitting and the internal piping diameters used in the calculations.

Allowance for Friction Loss in Fittings (SDR 13.5 Equivalent Pipe)							
	3/4" (20 mm)	1" (25mm)	1-1/4" (32mm)	1-1/2" (40 mm)	2" (50 mm)	2-1/2" (65 mm)	3" (80 mm)
Tee Branch	3' (0.91 m)	5' (1.52 m)	6' (1.83 m)	8' (2.44 m)	10' (3.05 m)	12' (3.66 m)	15' (4.57 m)
Elbow 90	7' (2.13 m)	7' (2.13 m)	8' (2.44 m)	9' (2.74 m)	11' (3.35 m)	12' (3.66 m)	13' (3.96 m)
Elbow 45	1' (0.31 m)	1' (0.31 m)	2' (0.61 m)	2' (0.61 m)	2' (0.61 m)	3' (0.91 m)	4' (1.22 m)
Coupling	1' (0.31 m)	1' (0.31 m)	1' (0.31 m)	1' (0.31 m)	1' (0.31 m)	2' (0.61 m)	2' (0.61 m)
Tee Run	1' (0.31 m)	1' (0.31 m)	1' (0.31 m)	1' (0.31 m)	1' (0.31 m)	2' (0.61 m)	2' (0.61 m)

Figure-22: Equivalent Footage per Coupling

BlazeMaster® Pipe Dimensions & Weights SDR 13.5 (ASTM F-442)				
Nominal Size Inches/ (mm)	Average OD Inches/ (mm)	Average ID Inches/ (mm)	Empty lbs/ft (Kg/m)	H_20 Filled lbs/ft (Kg/m)
3/4" (20.0 mm)	1.050" (26.7 mm)	0.874" (22.2 mm)	0.168 lbs (0.250 kg)	0.428 lbs (0.637 kg)
1" (25.0 mm)	1.315" (33.4 mm)	1.101" (28.0 mm)	0.262 lbs (0.390 kg)	0.675 lbs (1.005 kg)
1-1/4" (32.0 mm)	1.660" (42.2 mm)	1.394" (35.4 mm)	0.418 lbs (0.622 kg)	1.079 lbs (1.606 kg)
1-1/2" (40.0 mm)	1.900" (48.3 mm)	1.598" (40.6 mm)	0.548 lbs (0.816 kg)	1.417 lbs (2.109 kg)
2" (50.0 mm)	2.375" (60.3 mm)	2.003" (50.9 mm)	0.859 lbs (1.278 kg)	2.224 lbs (3.310 kg)
2-1/2" (65.0 mm)	2.875" (73.0 mm)	2.423" (61.5 mm)	1.257 lbs (1.871 kg)	3.255 lbs (4.844 kg)
3" (80.0 mm)	3.500" (88.9 mm)	2.950" (75.0 mm)	1.867 lbs (2.778 kg)	4.829 lbs (7.186 kg)

Figure-23: Pipe Dimension per nomial sizes

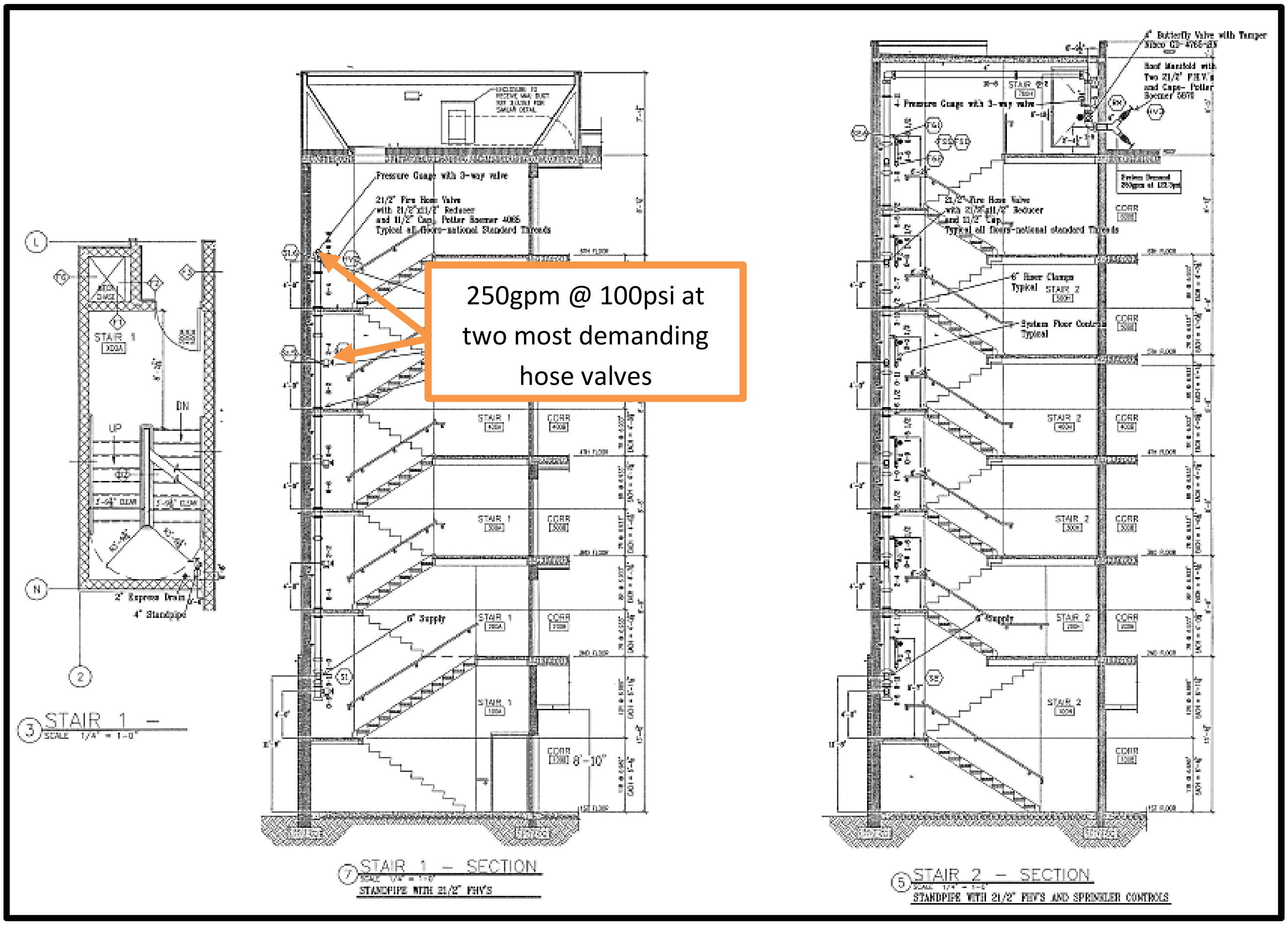


Figure-24: Wet-manual Standpipe

Standpipe System:

A Class-1 manual-wet standpipe was provided in both stairwells of which one provided access to the roof deck. Due to the available water supply, the designer provided hydraulic calculations to prove that the far side (most remote stair from the location where the supply enters the building) standpipe was capable of providing 500 gpm @ 100psi with only the city water supply. If an automatic standpipe was required the designer would be required to also flow an additional 250 gpm @ 100 psi from the near standpipe closest to the water supply connect at the most demanding hose valve. The standpipes are connected on the main level with a 4" line. All piping materials are sch-10 steel connected through grooved couplings.

Field Conditions:

The images below is a photograph of the CPVC piping inside the soffit area of a guest room. The photo was captured during the construction phase before the gypsum was installed.

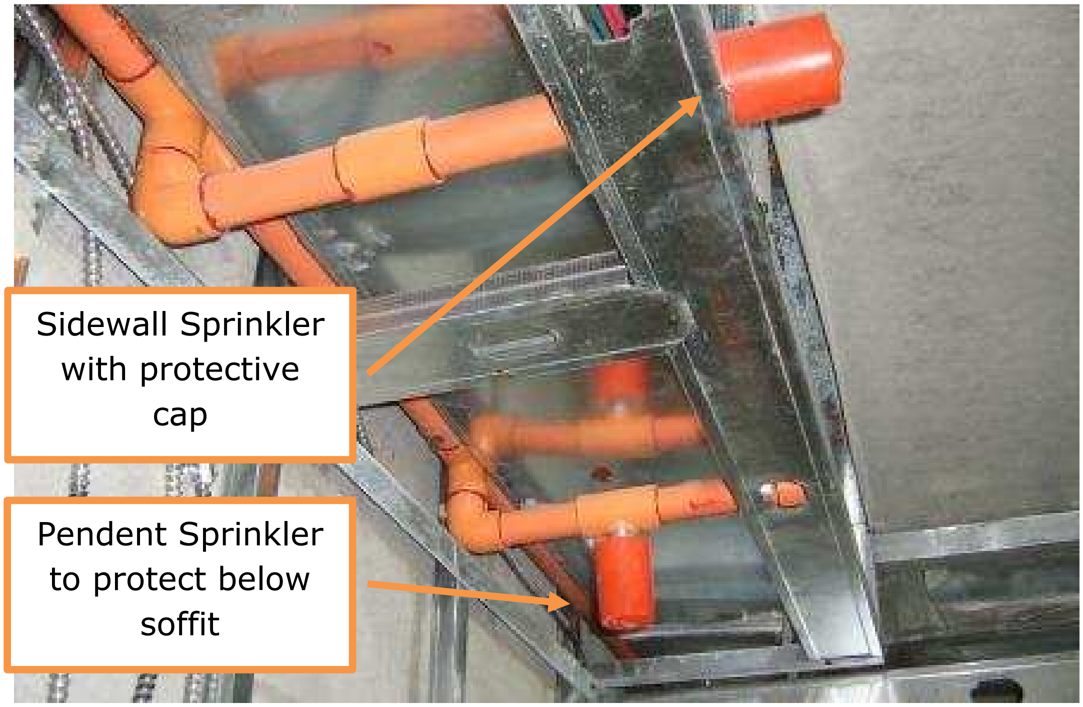


Figure-25: Sprinkler Pipe Photo

Figure-26: Sprinkler Pipe Photo II

Technical Data:

Below are excerpts from the manufacturers technical specifications for a sample of materials used in the fire sprinkler system. Complete specifications are available through each manufacturer's website.

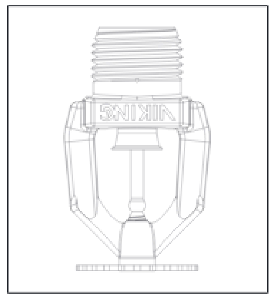
June 12, 2013 | Sprinkler 149m

VIKING® | **TECHNICAL DATA** | **FREEDOM® RESIDENTIAL PENDENT SPRINKLER VK468 (K4.9)**

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

1. DESCRIPTION

Viking Freedom® Residential Pendent Sprinkler VK468 is a small, thermosensitive, glass-bulb residential sprinkler available in several different finishes and temperature ratings to meet varying design requirements. The Electroless Nickel PTFE (ENT) coating has been investigated for installation in corrosive atmospheres and is cULus Listed as corrosion resistant as indicated in the Approval Chart. The orifice design, with a K-Factor of 4.9 (70.6 metric†), allows efficient use of available water supplies for the hydraulically designed fire-protection system. The glass bulb operating element and special deflector characteristics meet the challenges of residential sprinkler standards.



2. LISTINGS AND APPROVALS

cULus Listed: Category VKKW

NYC Approved: MEA 89-92-E, Volume 35

UL Classified to: NSF/ANSI Standard 61, Drinking Water System Components (MH48034). Refer to the Approval Chart on page 149o and Design Criteria on page 149q for cULus Listing requirements that must be followed.

Figure-27: Sprinkler Data Sheet

June 28, 2013 | Sprinkler 80a

VIKING® | **TECHNICAL DATA** | **QUICK RESPONSE EXTENDED COVERAGE HORIZONTAL SIDEWALL SPRINKLER VK630 (K8.0)**

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

1. DESCRIPTION

Viking Quick Response Extended Coverage Horizontal Sidewall Sprinkler VK630 is a thermosensitive spray sprinkler available in several different finishes and temperature ratings to meet varying design requirements. The glass bulb operating element and special deflector characteristics meet the challenges of quick response extended coverage standards.

The special Polyester, PTFE, and Electroless Nickel PTFE (ENT) coatings can be used in decorative applications where colors are desired. In addition, these coatings have been investigated for installation in corrosive atmospheres and are listed/approved as corrosion resistant as indicated in the Approval Charts. (Note: **FM Global approves the ENT coating as corrosion resistant.** FM Global has no approval classification for PTFE and Polyester coatings as corrosion resistant.)

For Light Hazard Occupancies Only

2. LISTINGS AND APPROVALS

cULus Listed: Category VNIV

FM Approved: Class 2022

NYC Approval: MEA 89-92-E, Volume 32

Refer to Approval Chart 1 and Design Criteria on pages 80c-d for cULus Listing requirements, and refer to Approval Chart 2 and Design Criteria on page 80e for FM Approval requirements that must be followed.

Figure-28: Sprinkler Data Sheet

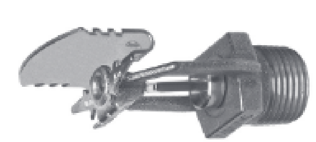
January 13, 2012 | Sprinkler 143m

VIKING | TECHNICAL DATA | FREEDOM® RESIDENTIAL HORIZONTAL SIDEWALL SPRINKLER VK450 (K4.2)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com

1. DESCRIPTION

Viking Freedom® Residential Horizontal Sidewall Sprinkler VK450 is a small, thermosensitive, glass-bulb residential sprinkler available in several different finishes and temperature ratings to meet varying design requirements. The sprinkler orifice design, with a K-Factor of 4.2, allows efficient use of available water supplies for the hydraulically designed fire-protection system. The glass bulb operating element and special deflector characteristics meet the challenges of residential sprinkler standards.



2. LISTINGS AND APPROVALS

c UL us **cULus Listed:** Category VKKW

Refer to the Approval Charts on pages 143o-p and Design Criteria on page 143q for cULus Listing requirements that must be followed.

Figure-29: Sprinkler Data Sheet

Viking Plastics | BlazeMaster® CPVC Pipe

Features

- **Sizes Available (Nominal):** 3/4" (DN20) through 3" (DN80) pipe diameters, with a Standard Dimension Ratio (SDR) of 13.5 as specified in ASTM F442.
- **Environmental Specifications:** Indoor use only. Maximum Ambient Temperature: 150°F (65°C)
- **Hazen-Williams C Value:** 150
- **Pressure Data: Working Pressure:** 175 PSI (12.1 bar) at 150°F (65°C)
- **Specifications:**
  - Meets NFPA 13R and 13D standards for residential occupancies as well as NFPA 13 standards for light hazard occupancies.
  - Pipe meets or exceeds ASTM F442.
  - Certified by NSF International for potable water services.
  - CPVC pipe from Viking Plastics use compound cell class 23547 (demonstrated highest structural properties).
  - cULus Listed, FM Approved, New York City (MEA) Approved, LPCB Approved.

c UL us LISTED

FM APPROVED

NSF

LPCB

Figure-30: Sprinkler Pipe Data Sheet

Inspection, Testing and Maintenance:

Below is an excerpt from NFPA 101, Life Safety Code that requires all automatic sprinkler and standpipe systems to be inspected, tested, and maintained in accordance with NFPA 25.

> **9.7.5 Maintenance and Testing.** All automatic sprinkler and standpipe systems required by this *Code* shall be inspected, tested, and maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

Figure-31: IT&M Requirements

Table-8: IT&M of the Major Components

Component:	Inspection	Testing	Maintenance
Control Valve	Valves shall be visually inspected as to ensure the correct position, no physical damage, no external leaking, accessible, locked or supervised, and identified	Valves shall be operated through its full range then returned to its normal position. A main drain test shall be conducted after each valve closure. During valve closure the supervisory signals can also be tested.	OS&Y stems are to be lubricated. Alarm Valves must be inspected internally and cleaned at least every 5 years.
Gauges	Visually inspected to ensure they are in good condition and that normal water supply pressure is maintained	Every 5 years the gauges shall be tested by comparison to a calibrated gauge	Replace if needed
Piping	The piping is inspected from the floor level for damage, leaks, corrosion, and that no other load is hanging or resting on the pipe	An internal pipe investigation is required at least every 5 years to check for the presents of organic or inorganic materials	If MIC is discovered a full flushing programs must be administered
Sprinklers	A visual inspection from the floor level is conducted to check for damage, leaks, loading, paint, fluid in the fusible link, orientation, escutcheon ring, and corrosion	Any deficient sprinkler shall be replaced and a sampling of the sprinklers must be tested on a recurring basis	Replacement sprinklers shall have the same characteristics for the application

The following excerpt from NFPA 25 list the frequency for Inpection, Testing, and Maintenance of each component of the Fire Protection System.

Table 5.1.1.2 Summary of Sprinkler System Inspection, Testing, and Maintenance

Item	Frequency	Reference
Inspection		
Gauges (dry, preaction, and deluge systems)	Weekly/quarterly	5.2.4.2, 5.2.4.3, 5.2.4.4
Control valves		Table 13.1.1.2
Waterflow alarm devices	Quarterly	5.2.5
Valve supervisory signal devices	Quarterly	5.2.5
Supervisory signal devices (except valve supervisory switches)	Quarterly	5.2.5
Gauges (wet pipe systems)	Quarterly	5.2.4.1
Hydraulic nameplate	Quarterly	5.2.6
Buildings	Annually (prior to freezing weather)	4.1.1.1
Hanger/seismic bracing	Annually	5.2.3
Pipe and fittings	Annually	5.2.2
Sprinklers	Annually	5.2.1
Spare sprinklers	Annually	5.2.1.4
Information sign	Annually	5.2.8
Fire department connections		Table 13.1.1.2
Valves (all types)		Table 13.1.1.2
Obstruction, internal inspection of piping	5 years	14.2
Heat trace	Per manufacturer's requirements	5.2.7
Test		
Waterflow alarm devices		
Mechanical devices	Quarterly	5.3.3.1
Vane and pressure switch–type devices	Semiannually	5.3.3.2
Valve supervisory signal devices		Table 13.1.1.2
Supervisory signal devices (except valve supervisory switches)		Table 13.1.1.2
Main drain		Table 13.1.1.2
Antifreeze solution	Annually	5.3.4
Gauges	5 years	5.3.2
Sprinklers (extra-high or greater temperature solder type)	5 years	5.3.1.1.1.4
Sprinklers (fast-response)	At 20 years and every 10 years thereafter	5.3.1.1.1.3
Sprinklers	At 50 years and every 10 years thereafter	5.3.1.1.1
Sprinklers	At 75 years and every 5 years thereafter	5.3.1.1.1.5
Sprinklers (dry)	At 10 years and every 10 years thereafter	5.3.1.1.1.6
Sprinklers (in harsh environments)	5 years	5.3.1.1.2
Valves (all types)		Table 13.1.1.2
Valve status test		13.3.1.2.1
Maintenance		
Valves (all types)		Table 13.1.1.2
Low-point drains (dry pipe system)		13.4.4.3.2
Sprinklers and automatic spray nozzles protecting commercial cooking equipment and ventilation systems	Annually	5.4.1.9
Investigation		
Obstruction		14.3

Figure-32: IT&M Schedule

Sprinkler Summary:

From the information presented, the proposed sprinkler and standpipe design complies with the applicable NFPA standards. The utilization of the wet standpipes in the stairwells to supply the sprinkler system on each level is a common industry practice. It is recognized that the floor control valves are not required but are notably implemented to allow the hotel operators to isolate each floor individually. The sprinkler system design employing a looped system is hydraulically more efficient than the tree type system that was compared. An automatic wet standpipe in a 6 story building without the need for a fire pump is an excellent use of the utility infrastructure. With a 4" standpipe the "manual" wet standpipe is capable of flowing 500 gpm at 100 psi in the far side stairwell allowing the responding fire crews to begin operations before a positive water supply is established to the FDC. Implementation of NFPA 25 through ongoing Inspections, Testing, and Maintenance will ensure that the building contains a superior fire protection system.

FIRE ALARM

All hotel occupancies are required to be equipped with a fire alarm system. Proposed is an addressable fire alarm system with visual and audible notification in all occupiable areas except the guest rooms and suites. The guest rooms and suites are only provided with audible notification unless the rooms are designed for occupancy by hearing-impaired individuals. Initiation of a general alarm is by one of the following: manual pull station, sprinkler system, or by one of the smoke detectors located throughout. All guest rooms are equipped with a smoke detector that only initiates the guest room and does not initiate the entire building. A guest room detector will also provide a supervisory signal at the fire alarm control panel (FACP) for hotel staff response. The system will be equipped with emergency forces notification by an offsite monitoring service and no alarm verification will be implemented.

Below is a section of the Sequence of Operations to validate what initiation activates a full alarm while substantiating that the guest room detectors do not.

		CONTROL UNIT ANNUNCIATION							NOTIFICATION							FIRE SAFETY CONTROL																			
	SYSTEM OUTPUTS	ACTUATE COMMON ALARM SIGNAL INDICATOR	ACTUATE AUDIBLE ALARM SIGNAL	ACTUATE COMMON SUPERVISORY SIGNAL INDICATOR	ACTUATE AUDIBLE SUPERVISORY SIGNAL	ACTUATE COMMON TROUBLE SIGNAL INDICATOR	ACTUATE AUDIBLE TROUBLE SIGNAL	ACTUATE APPROPRIATE LOCATION INDICATOR	ACTUATE ALL AUDIBLE EVACUATION SIGNALS	ACTUATE ALL VISIBLE EVACUATION SIGNALS		DISPLAY / PRINT CHANGE OF STATUS	TRANSMIT ALARM SIGNAL TO SUPERVISING STATION	TRANSMIT SUPV. SIGNAL TO SUPERVISING STATION	TRANSMIT TROUBLE SIGNAL TO SUPERVISING STATION	RELEASE MAGNETICALLY HELD SMOKE DOORS	UNLOCK SECURITY DOORS	RELEASE ELEVATOR FIRE DOORS	ELEVATOR SHUNT TRIP	MAIN FLOOR ELEVATOR RECALL	ALTERNATE FLOOR ELEVATOR RECALL	ELEVATOR HAT FLASH	ACTIVATE SOUNDER IN ASSOCIATED UNIT	ACTIVATE SOUNDER & STROBES ACCESSIBLE ROOMS								REMOTELY DISPLAY ACTIVE STATUS	FAN SHUT DOWN	DAMPER SHUT DOWN	PRESSURIZE STAIRWELLS	
	SYSTEM INPUTS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	
1	SMOKE SENSOR/DETECTOR	•	•					•	•	•		•	•			•	•						•	•								•	•	•	•	1
2	MANUAL PULL STATION	•	•					•	•	•		•	•			•	•						•	•								•				2
3	HEAT SENSOR/DETECTOR	•	•					•	•	•		•	•			•	•						•	•								•				3
4	DUCT SENSOR/DETECTOR			•	•			•				•		•		•	•															•				4•
5	MAIN FLR. ELEV. LOBBY SMOKE DETECTOR	•	•					•	•	•		•	•					•			•		•	•								•	•	•	•	5
6	ELEVATOR LOBBY SMOKE DETECTORS (EXC. MAIN FLR.)	•	•					•	•	•		•	•			•	•	•		•			•	•								•	•	•	•	6
7	ELEVATOR MECH. ROOM HEAT DETECTOR	•	•					•	•	•		•	•			•	•		•				•	•								•	•	•	•	7
8	ELEVATOR MECH. ROOM SMOKE DETECTOR	•	•					•	•	•		•	•			•	•			•		•	•	•								•	•	•	•	8
9	ELEVATOR SHAFT HEAT DETECTOR	•	•					•	•	•		•	•			•	•		•				•	•								•	•	•	•	9
10	ELEVATOR SHAFT SMOKE DETECTOR	•	•					•	•	•		•	•							•		•	•	•								•	•	•	•	10
11	ELEVATOR POWER MONITOR			•	•			•				•		•		•	•															•				11
12	WATERFLOW SWITCH	•	•					•	•	•		•	•			•	•						•	•								•	•	•	•	12
13	TAMPER SWITCH			•	•			•				•		•		•	•															•				13
14	POST INDICATOR VALVE SWITCH			•	•			•				•		•		•	•															•				14
15	FIRE ALARM AC POWER FAILURE					•	•					•			•																	•				15
16	FIRE ALARM SYSTEM LOW BATTERY					•	•					•			•																	•				16
17	OPEN CIRCUIT OR GROUND FAULT					•	•					•			•																	•				17
18	CLASS B NOTIFICATION APPLIANCE CIRCUIT SHORT					•	•					•			•																	•				18
19	S SENSOR IN ACCESSIBLE AND HEARING IMPAIRED UNIT			•	•							•		•										•								•				19
20	SMOKE SENSOR IN GUEST UNITS			•	•							•		•									•									•				20
21	SMOKE SENSOR AT THE TOP OF STAIRWELL	•	•					•	•	•		•	•			•	•						•	•								•	•	•	•	21
22	KITCHEN SUPPRESSION SYSTEM	•	•					•	•	•		•	•			•	•						•	•								•	•	•	•	22
23																																				23

Figure-33: Sequence of Operations

Figure-34 is another section of the fire alarm drawings, the riser diagram. The section is intended to provide the reviewer with a brief summary of how many initiating and notification addresses are in the system. The diagram also provides the reviewer with information as to where the FACP will be located and that there are both power supplies and terminal cabinets on subsequent floors above the ground level.

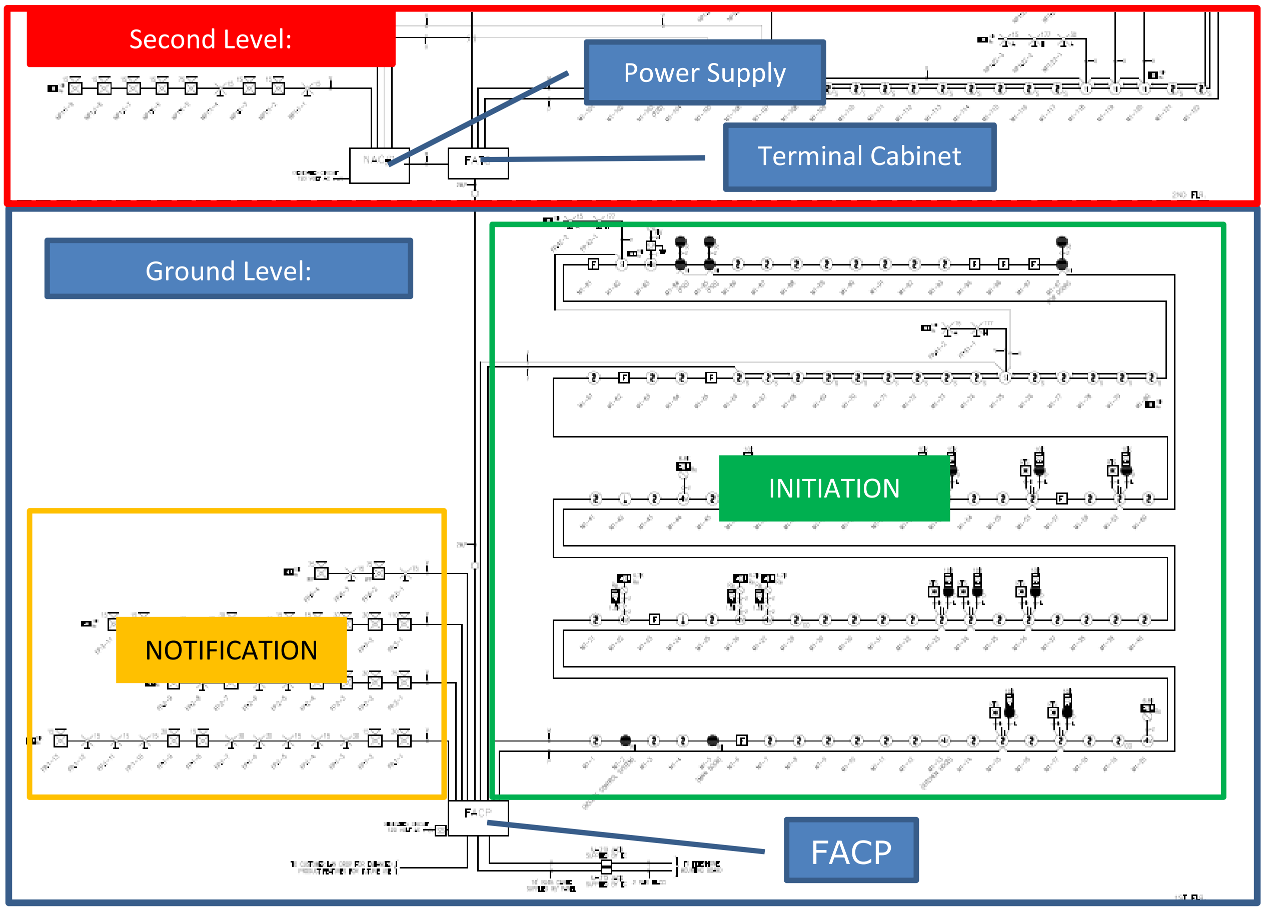


Figure-34: Alarm Riser Diagram

Figure-35 is a section of the fire alarm shop drawings indicating several key aspects. One of the first items to note is that two of the guest rooms are labeled as accessible. Accessible is an Americans with Disability Act term in this case but it identifies –as far as the fire alarm is concerned- that the rooms are equipped with visual notification in addition to the audible notification that is in all rooms. It is also worthy of noting that the corridor is equipped with a smoke detection system. The LSC allows the corridor smoke detection system to be eliminated in a fully sprinkled building ,however, the designer has implemented detectors throughout the corridor. Later in the report –during the performance based analysis- it will be discovered that the designer may have used the corridor smoke system as an equivalency to another prescriptive requirement.

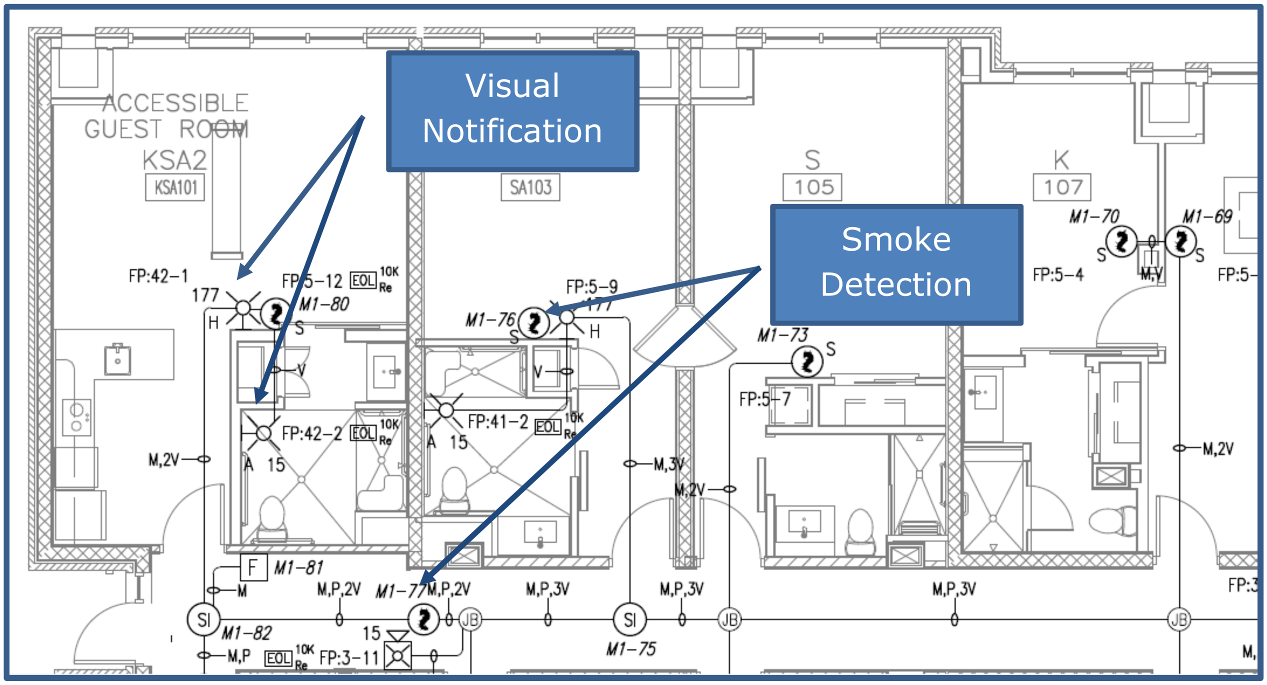


Figure-35: Sample Fire Alarm in Guest Rooms

Fire Alarm Summary:

The proposed alarm system meets or exceeds the prescriptive based requirements of the Life Safety Code and the National Fire Alarm Code. Through audible and visual notification appliances located throughout the common use areas and guest rooms all occupants of the building are prescriptively notified in the event of an emergency. The non-required corridor smoke detection system aids to notify building occupants while the fire is still in the incipient phase. With any implemented initiation equipment that is not prescriptively required, there is a concern that unwanted alarm frequency will increase. Implementation of a solid inspection, testing, and maintenance program will ensure years of adequate performance of the fire alarm system.

EGRESS

EGRESS ANALYSIS

The following egress analysis is divided into two parts, prescriptive and performance based:

Prescriptive Code Requirements
- Capacity of Means of Egress
- Means of Egress
- Fire Barriers
- Interior Finish

Performance Based Design
- Occupant Characteristics
- Tenability
- Fire Model
- Egress Time Analysis- Hand Calculation Method
- Egress Time Analysis- Computer Based Method

The prescriptive code will come from the Life Safety Code and the performance based criteria will be established using the Life Safety Code and SFPE Handbook.

The proposed structure is a Mixed Occupancy since the main level is comprised of multiple occupancies that are intermingled. Section 6.1.14.3 LSC requires that each area of a Mixed Occupancy be classified according to its use and shall meet the most restrictive fire and life safety requirements of the occupancies involved. Each of the occupancies on the main level will be evaluated separately during the egress analysis; all other levels will be evaluated based on the requirements of a hotel occupancy.

PRESCRIPTIVE CODE ANALYSIS

This report addresses the following items as part of a complete prescriptive based egress code analysis. Items not listed are deemed to be outside of the scope of the report and are not considered relevant to the egress analysis. The primary objective of this analysis is to identify the minimum requirements outlined in the Life Safety Code to allow prompt evacuation from the building.

The proposed six-story hotel does not meet the definition of a high-rise structure in accordance with Section 3.3.32.7 LSC therefore specific requirements for high-rise structures are not applicable. However, there are specific occupancy requirements that are identified below that the egress analysis is dependent upon:

Hotel Occupancy Requirements- Chapter 28 LSC

- Supervised automatic sprinkler system
- Fire alarm system
- Smoke alarms in every guest room
- All hazardous areas protected in accordance with Table 28.3.2.2.2

Construction Type: I-B, Section 503 IBC

Building height limitations shown in feet above grade plane. Story limitations shown as stories above grade plane.
Building area limitations shown in square feet, as determined by the definition of "Area, building," per story

GROUP		TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
	HEIGHT(feet)	UL	160	65	55	65	55	65	50	40
	STORIES(S) AREA (A)									
M	S A	UL UL	11 UL	4 21,500	2 12,500	4 18,500	2 12,500	4 20,500	3 14,000	1 9,000
R-1	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 12,000	2 7,000

Figure-36: *International Building Code:* Table 503

Occupant Load:

- The use of each area will determine how many occupants are anticipated to occupy the space. Based on the use of each space determines the appropriate occupant load factor divisor to calculate the occupant load. An accurate occupant load is essential to determine the required exiting capacity and predict the maximum number of occupants present at one time.

  Below Figure-36 & Figure-37 identifies each area of the building according to the use of the space. The service areas, restrooms, elevator lobbies, and exit access corridors are also identified.

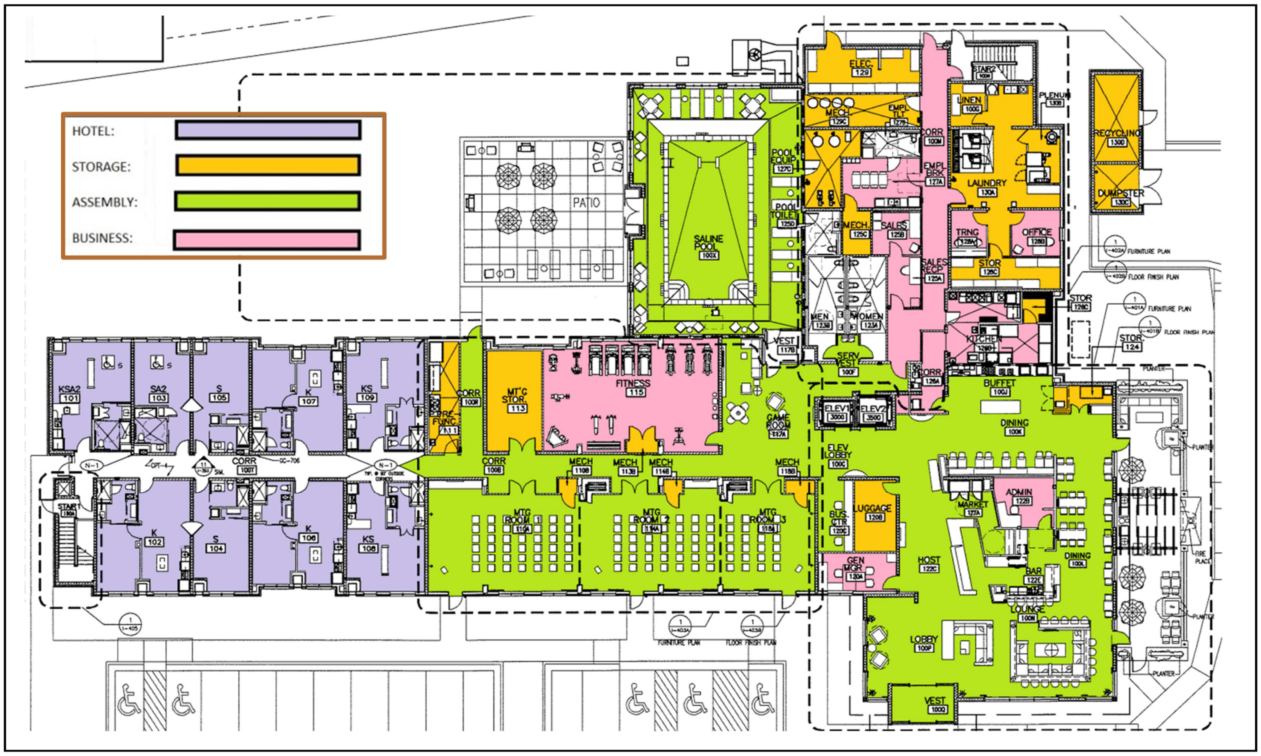


Figure-36: Main Level Usage

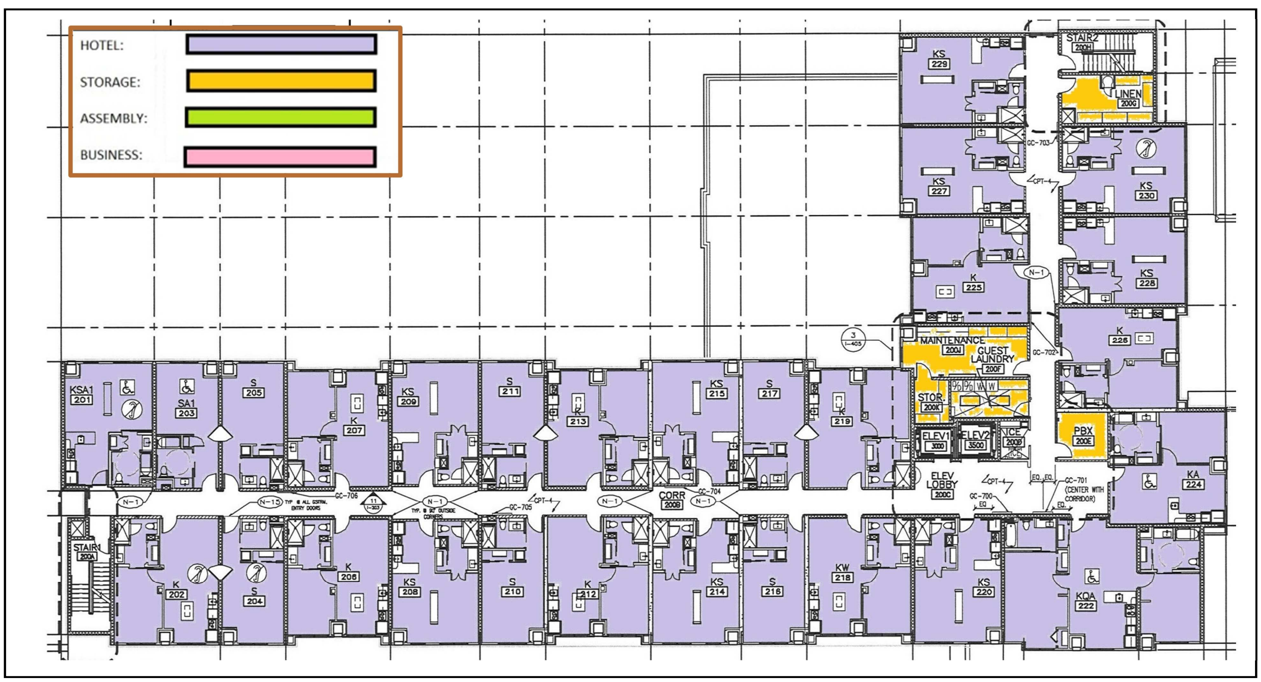


Figure-37: Levels 2-6 Usage

- Table 9 presents the occupant load calculations established for each area of the building. Included in the chart is the required egress capacity for each area, based on the limiting exit feature in accordance with Section 7.3.3 LSC. All floors above the level of exit discharge were determined to be limited based on the width of the stair when compared to the capacity of the entrance and exit doorways. The provided capacity of the stair is calculated to be approximately 300 occupants per floor exceeding the occupant load of 85 occupants.

  The main level egress capacity is based on level exiting through doorways. The calculation determines that at least five nominal 3'-0" doors are required for adequate egress capacity. In accordance with Section 7.4.1.2 LSC if the occupant load exceeds 1000 not less than four means of egress shall be provided. The main level is provided with eight 3'-0" doors located at the end of each corridor the rest distributed around the exterior of the assembly areas, a 5'-0" listed break-away sliding door in the lobby, and a set of 3'-0" doors from the pool area.
- The occupant load factors were extrapolated from Table 7.3.1.2 LSC. These occupant load factors also match Section 1004 IBC.

Table-9: Occupant Load Calculation

OCCUPANCY CALCULATIONS							
LEVEL	USE	OCCUPANT LOAD FACTOR	FLOOR AREA	OCCUPANT LOAD	NUMBER OF EXITS	STAIR EXIT CAPACITY REQUIRED	STAIR EXIT CAPACITY PROVIDED
6TH	HOTEL	1/200 GROSS	17000	85	2	85 X 0.3=25.5 IN	45.5625IN (X2)/0.3=303 OCC
5TH	HOTEL	1/200 GROSS	17000	85	2	86 X 0.3=25.5 IN	45.5625IN (X2)/0.3=303 OCC
4TH	HOTEL	1/200 GROSS	17000	85	2	87 X 0.3=25.5 IN	45.5625IN (X2)/0.3=303 OCC
3RD	HOTEL	1/200 GROSS	17000	85	2	88 X 0.3=25.5 IN	45.5625IN (X2)/0.3=303 OCC
2ND	HOTEL	1/200 GROSS	17000	85	2	89 X 0.3=25.5 IN	45.5625IN (X2)/0.3=303 OCC
						DOOR EXIT CAPACITY REQUIRED	DOOR EXIT CAPACITY PROVIDED
1ST	HOTEL	1/200 GROSS	5000	25	1	25 X 0.2=5 IN	(1) 3'-0" DOOR= 34 IN
	LOBBY (ASSEMBLY)	1/7 NET	500	71	2	71 X 0.2=14.2 IN	(2) 3'-0" DOOR= 34 IN
	OFFICE (BUSINESS)	1/100 GROSS	2800	28	1	28 X 0.2=5.6 IN	(3) 3'-0" DOOR= 34 IN
	MEETING (ASSEMBLY)	1/7 NET	2000	285	2	285 X 0.2=57 IN	(4) 3'-0" DOOR= 34 IN
	LAUNDRY (STORAGE)	1/100 GROSS	1500	15	1	15 X 0.2=3 IN	(5) 3'-0" DOOR= 34 IN
	DINING (ASSEMBLY)	1/15 NET	3000	200	2	200 X 0.2=40 IN	(6) 5'-0" DOOR= 60 IN
	KITCHEN	1/100 GROSS	600	6	1	6 X 0.2=1.2 IN	(7) 3'-0" DOOR= 34 IN
	FITNESS	1/50 NET	1000	20	1	20 X 0.2=4 IN	(8) 3'-0" DOOR= 34 IN
	MECHANICAL	1/300 GROSS	2500	8	1	8 X 0.2=1.6 IN	(9) 3'-0" DOOR= 34 IN
	POOL	1/50 GROSS	1500	30	2	30 X 0.2=6 IN	(10) 3'-0" DOOR= 34 IN
	POOL DECK	1/30 GROSS	1000	33	2	6.6 IN	(11) 3'-0" DOOR= 34 IN
TOTAL			106400	1146		144.2 IN	400 IN

Egress Arrangement:

- Section 7.5.1.1 LSC requires exits to be accessible at all times.
- In accordance with Section 7.5.1.3.2 LSC, Figure-39 indicates the configuration of the exits are remote from each other by a distance greater than 1/3 of the overall diagonal distance. The red line is the overall diagonal distance; the blue line is the distance between the doors indicating the exits are remote.
- Assembly use areas with an occupant load exceeding 50 or more are required to have two remote exits from the space. The meeting rooms are equipped with moveable partitions, when collapsed create one large open space or when expanded create three individual rooms. The green line measures the overall diagonal distance and the purple line confirms the exits are remote.

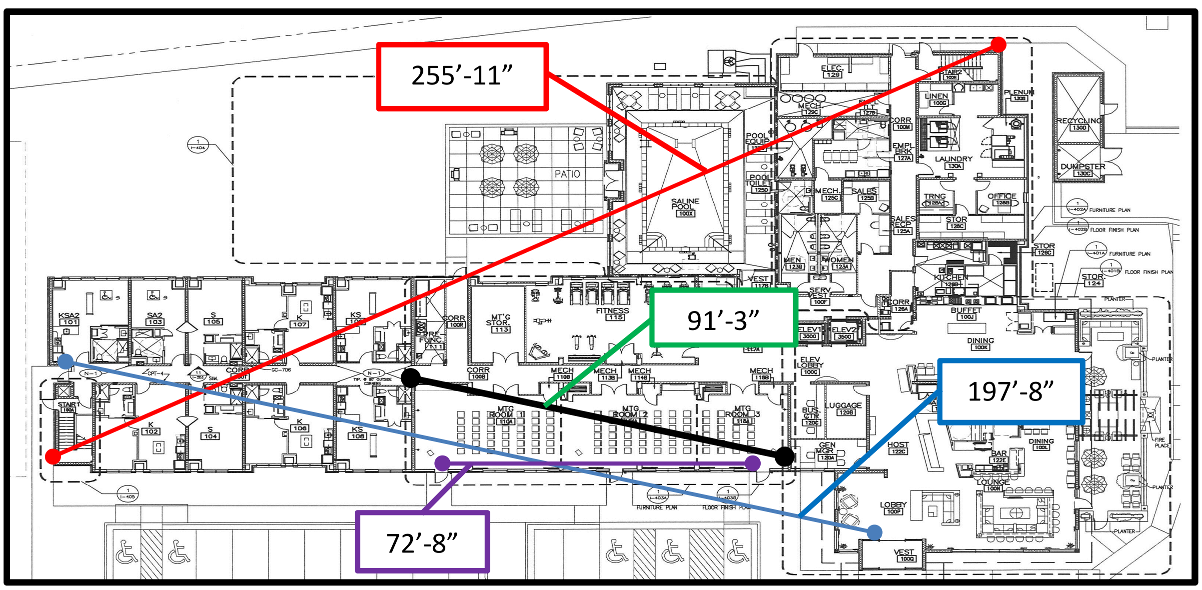


Figure-39: Remote Exits on the Main

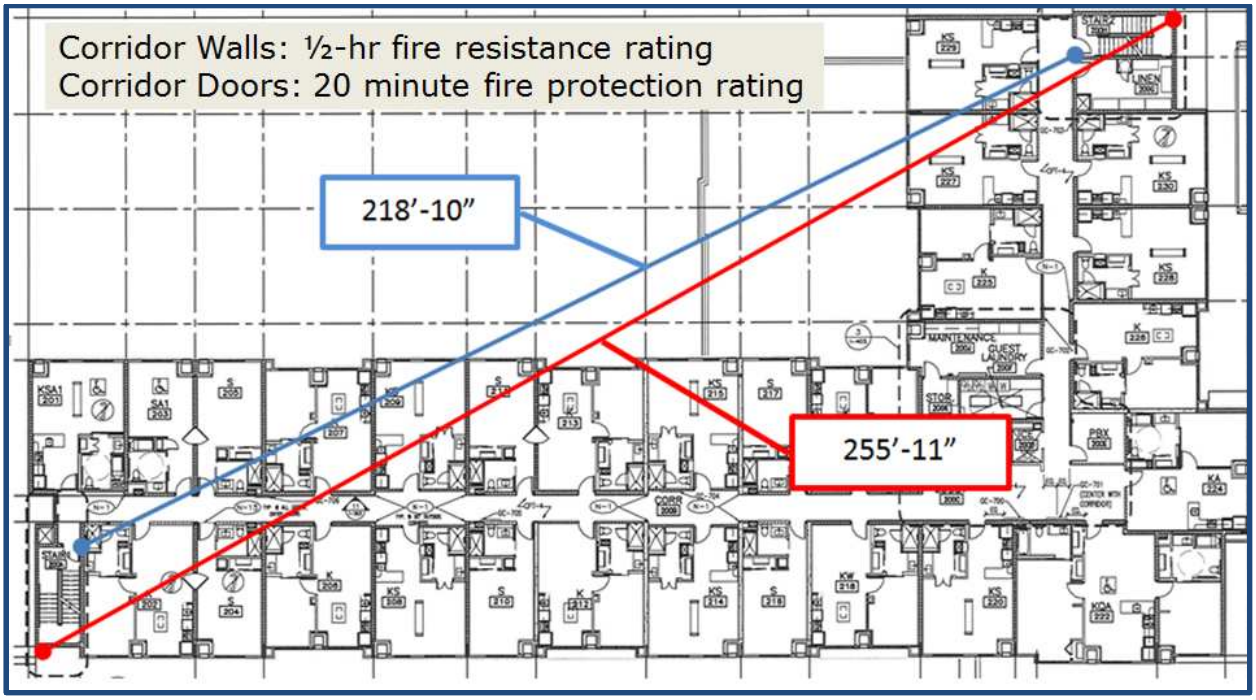


Figure-40: Remote Exits on Levels 2-6

- Table-10 below identifies the maximum values for travel distance, common path of travel, and dead-end corridors in accordance with the applicable occupancy classification.

Table-10: Egress Distances

	Hotel	Business	Assembly
Travel Distance	125 ft. within the guest room/ 200 ft. from guest room to nearest exit	300 ft.	250 ft.
Common Path of Travel	50 ft. within guest room (Each room exceeding 2000 sf shall have two remote exit access doors)	100 ft.	75 ft. if O/L<50, 20 ft. for any number of occupants
Dead-end Corridors	50 ft.	50 ft.	20 ft.

Fire Resistance:

Egress features, hazardous areas, and vertical openings are required to be protected through passive fire protection. Below are the required fire barriers according to their location and Figure-41 list the proposed fire barrier ratings of each:

Corridors

The fire resistance rating of the corridor is proposed as 1-hr meeting the requirements outlined in the LSC presented below:

- LSC Section 7.1.3.1: *Corridors used as exit access and serving an area having an occupant load exceeding 30 shall be separated from other parts of the building by walls having not less than a 1-hour fire resistance rating*

Stairways

The two proposed stairways are required to be of a 1-hr fire barrier, the 2-hr barrier proposed exceeds the minimum outlined:

- LSC Section 28.2.2.1.2: *In buildings, other than high-rise buildings, that are protected throughout by an approved, supervised automatic sprinkler system, exit enclosures shall have a minimum 1-hour fire resistance rating, and doors shall have a minimum 1-hour fire protection rating.*
    - LSC Section 7.2.2.5.1.1: *All inside stairs serving as an exit or exit component shall be enclosed in accordance with 7.1.3.2*
    - LSC Section 7.1.3.2(2): *The separation shall have a minimum 2-hour fire resistance rating where the exit connects four or more stories, unless one of the following conditions exists:*
        - *The minimum 1-hour enclosures in accordance with 28.2.2.1.2 shall be permitted as an alternative to 7.1.3.2.1 (2).*

Vertical Openings

There are at least two vertical openings or shafts proposed. One of the shafts will house the elevators and the other will be for the laundry chute. All vertical openings are required to have a 2-hr fire resistance ratings in accordance with the following:

- Section 8.6.5: *The minimum fire resistance rating for the enclosure of floor openings shall be as follows:*
  1. *Enclosures connecting four or more stories in new construction- 2-hour fire barriers*

CONSTRUCTION TYPE IB – SPRINKLERED FIRE RESISTANCE RATINGS (TABLE 601) *

COMPONENT		REQUIRED FIRE RATING
STRUCTURAL FRAME		2 HOURS
EXTERIOR BEARING PARTITIONS		2 HOURS
INTERIOR BEARING PARTITIONS		2 HOURS
EXTERIOR NON-BEARING PARTITIONS (IN ACCORDANCE WITH THE REQUIREMENTS OF TABLE 602)	(LESS THAN 5' FIRE SEPARATION DISTANCE – R1 / A2)	1 HOUR
	(LESS THAN 5' FIRE SEPARATION DISTANCE – S2)	1 HOUR
	(30'+ FIRE SEPARATION DISTANCE)	0 HOUR
FLOOR CONSTRUCTION INCLUDING SUPPORTING BEAMS AND JOISTS		2 HOURS
ROOF CONSTRUCTION INCLUDING SUPPORTING BEAMS AND JOISTS		1 HOUR
FIRE WALLS		NOT APPLICABLE
VERTICAL SHAFT AND STAIR ENCLOSURES		2 HOURS
TENANT SEPARATION		1 HOUR
EXIT PASSAGEWAY ENCLOSURES		1 HOUR
MAXIMUM AREA OF UNPROTECTED EXTERIOR WALL OPENINGS AT PROPERTY LINES WITH 0'-3-0" SEPARATION) IN ACCORDANCE WITH TABLE 704.8		NOT PERMITTED

* IN ACCORDANCE WITH THE CRITERIA DEFINED IN SECTION 403.3 OF THE 2006 INTERNATIONAL BUILDING CODE, CONSTRUCTION TYPE IS REDUCED FROM 1A TO 1B. WITH THE EXCEPTION OF STRUCTURAL COLUMNS SUPPORTING FLOORS, STRUCTURAL

Figure-41: Proposed Fire Resistance

Interior Finish:

Table-11 list the required minimum interior finish classifications according to there location.

Table-11: Interior Finish

	Exit enclosure	**Lobbies and corridors**	**Other spaces**
Hotel	Class A	Class A or B	Class A, B, or C
Assembly	Class A	Class A or B	Class A or B (if O/L >300), Class C is permitted if not
Business	Class A or B	Class A, B, or C	Class A, B, or C

Means of Egress Marking

- Below is a guideline for the placement of exit signs in accordance with Section 7.10 LSC.
- Additional criteria to consider when locating exit signage:
  - i. Any point where the exit or way to the exit is not readily apparent
  - ii. No point in the exit access corridor is in excess of 100 ft. from a sign
  - iii. Directional indicators shall be placed in every location where the direction of travel to the nearest exit is not apparent
  - iv. Shall be suitably illuminated by a reliable light source

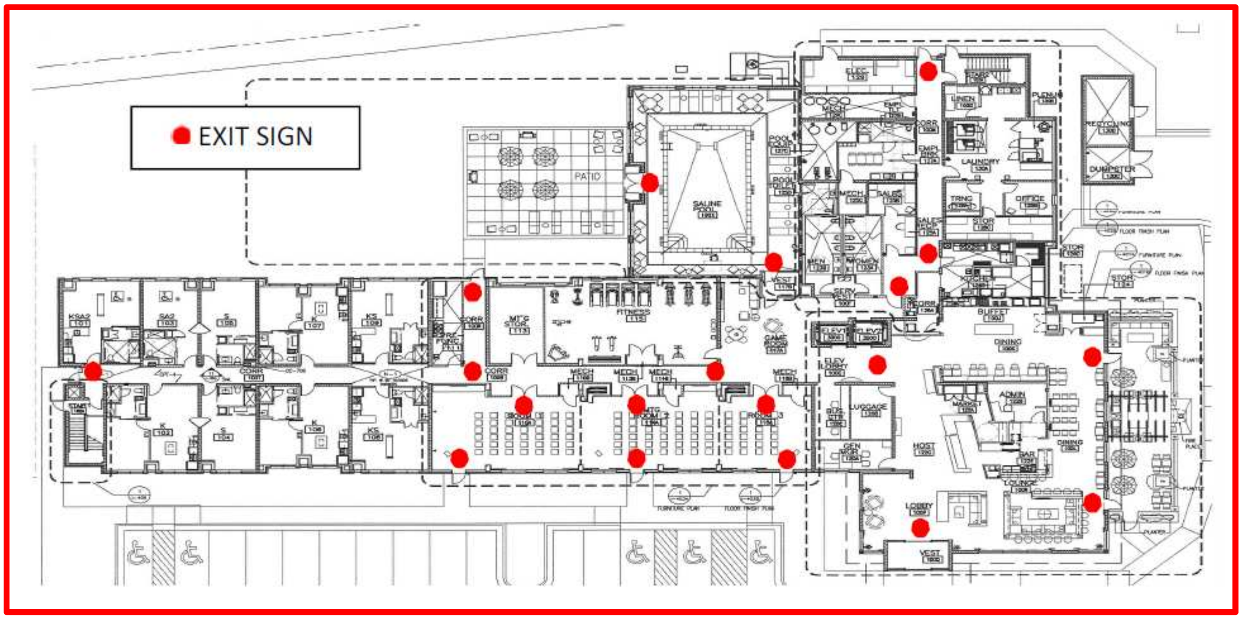


Figure-42: Exit Signage on the Main Level

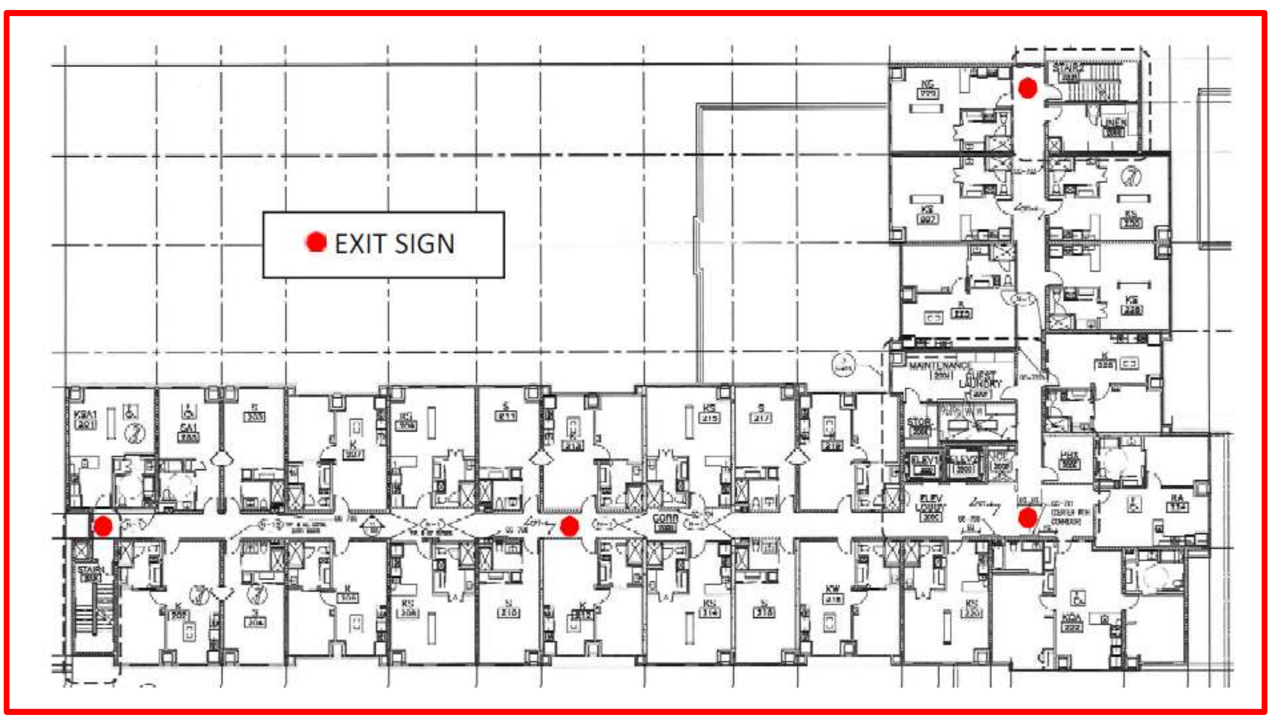


Figure-43: Exit Signage on Levels 2-6

Performance Based Approach

When the construction of a building does not meet the prescriptive design parameters engineers are able to use an alternate approach identified as performance based design. One area of the six-story hotel building does not meet the prescriptive based analysis therefore a performance based approach was selected to evaluate the level of fire protection provided. This analysis will start by identifying how the design does not meet the prescriptive design parameters followed by calculations on the total building evacuation time. The total building evacuation calculations are necessary to enable the analysis to concentrate on the one area versus the entire structure. Due to the fire resistance ratings of the stairwells and floor ceiling separations the evacuation calculations can substantiate the exclusion of floors 2-6 from the performance based analysis.

Below is an excerpt from the Georgia State Amendments to the International Building Code. As shown in the boxed region in figure 44, all Group-R occupancies shall be separated from all other occupancies if all non-separated occupancy requirements are met.

MIXED USE AND OCCUPANCY

*Revise Section 508.3.1.3 'Separation' to add exceptions as follows:

Exceptions:

1. Group H-2, H-3, H-4 or H-5 occupancies shall be separated from all other occupancies in accordance with Section 508.3.3.
2. All Group R occupancies shall be separated from other accessory occupancies in accordance with Section 508.3.3.4.

(Effective January 1, 2007)

*Revise Exception to Section 508.3.2.3 'Separation' as follows:

Exceptions:

1. Group H-2, H-3, H-4 or H-5 occupancies shall be separated from all other occupancies in accordance with Section 508.3.3.
2. All Group R occupancies shall be separated from other occupancies in accordance with Section 508.3.3.4.

(Effective January 1, 2007)

Figure-44: State Modifications to the IBC

Section 508.3.3.4 states that individual occupancies shall be separated from adjacent occupancies in accordance with Table 508.3.3

Table 508.3.3 requires Group-R Occupancies to be separated from Group-A Occupancies in a sprinkled building by a minimum of 1-hr fire barriers in accordance with Section 706

Figure-45: IBC References

This analysis will focus on the required fire barrier between the Residential-R occupancy and the Assembly-A occupancy. Below is the floor plan of the main level indicating the area evaluated inside the circle. As the report continues the area is enlarged to provide the reviewer a clear view of where the occupancies meet. The remainder of this report will focus on the fire barrier. Is the barrier continuation corridor imperative or is there a single alternative of a compilation of possible equivalencies?

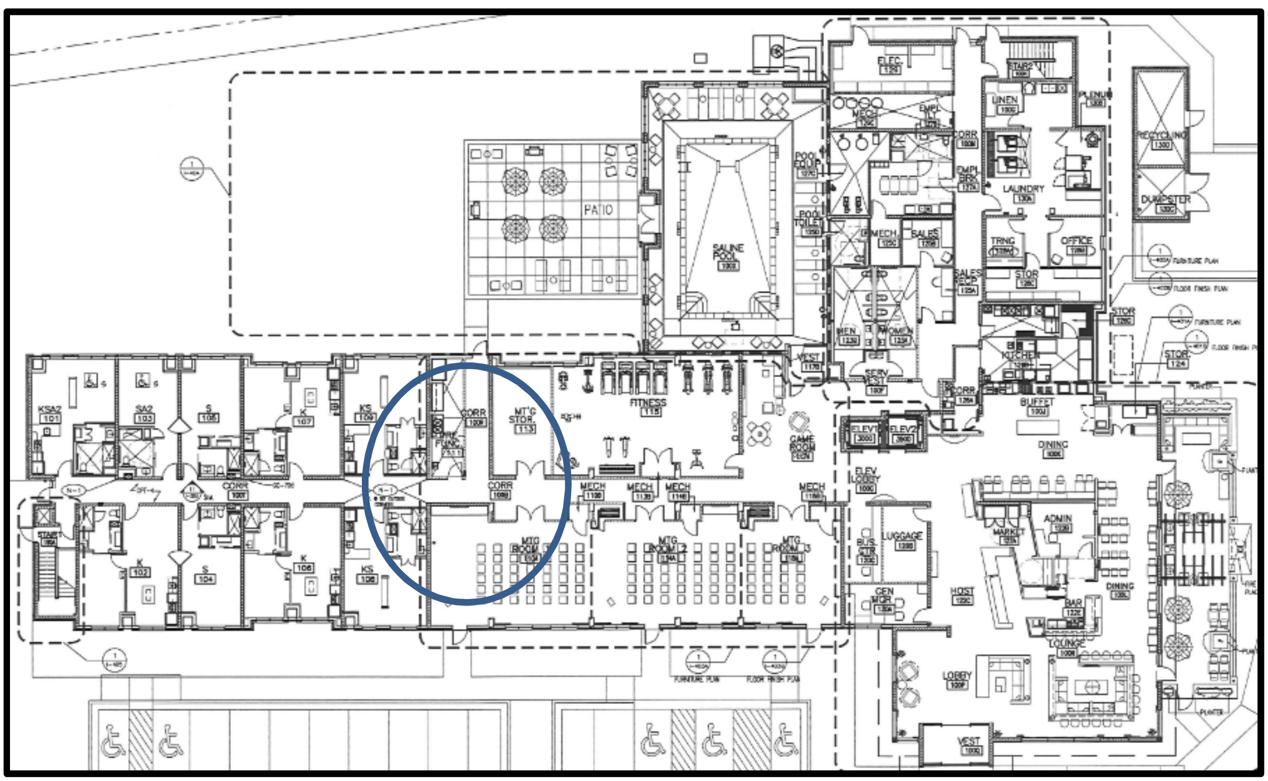


Figure-46: Area to be analyzed

The area of concentration is at the intersection of two exit access corridors, the meeting rooms, the meeting room storage, an area for the preparations of accommodations for the meeting room, and a selection of guest rooms. Inside the circle you can witness the corridors are configured in a “T” shape with each leg providing remote access to three separate means of egress. This analysis will evaluate a fire inside the meeting storage room and the subsequent elimination of the two exit access corridors which share a wall with the meeting storage room. All occupants of the guest rooms on the main level will be presumably forced to exit out the exit access corridor away from the meeting storage room in the plan east direction.

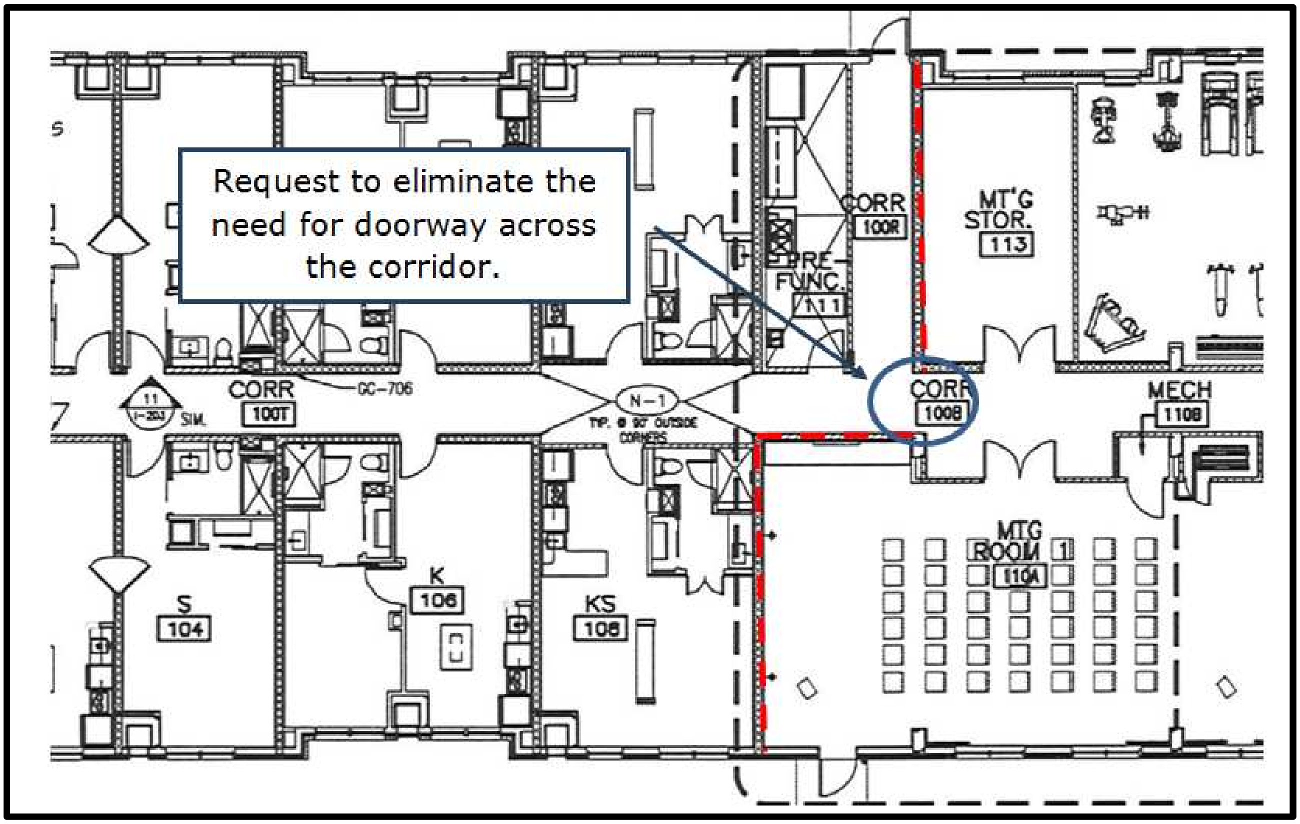


Figure-47: Location of fire barrier analyzed

Required Safe Egress Time

To start we will analyze the required safe egress time (RSET) through both hand calculations and through the use of a computer egress model. First, we will attempt to determine a reasonable estimate of the pre-movement time, the time from alarm to the time occupants make purposeful movements toward egress. Next the egress movement time will be calculated through calculations and using the aid of a computer egress model.

Figure-48 below is a graphic to identify the steps of a fire evacuation. As indicated the available escape time –also identified as the available safe egress time ASET-is comprised of several phases from ignition to tenability limit. The premovement time is made up of three phases, perception, interpretation, and action. This time increment is the time between when the occupants receive the alarm notification to the time they make purposeful movements toward evacuation.

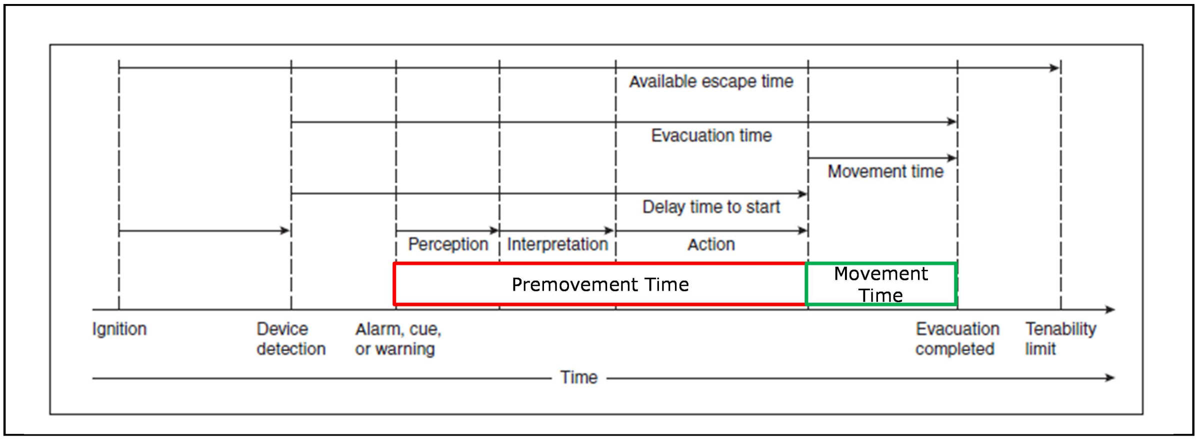


Figure-48: Steps to Evacuation

PRE-MOVEMENT

Occupants of a hotel can be anyone requiring shelter on a temporary basis when traveling for business or pleasure. Without evidence of why particular selections of people do not travel -unless under the supervision of the penal system or medical direction- it will be determined that anyone could occupy the hotel. The age group of the occupants may fluctuate from day to day depending on the need or events planned around the area. Needless to say, hotels are occupied by all ages of people from all around the globe with varying degrees of mobility. Of the many logistical barriers that are required to be overcome in the evacuation of a building there may also be language and cultural barriers to overcome. For this analysis it will be presumed that all occupants above the first level will be capable of transcending the stairways without assistance.

When appraising the pre-movement time the following assumptions are made:

- the occupants of the hotel rooms will be sleeping
- the occupants will not physically see smoke or flame
- the occupants have not been formally trained in evacuating the structure
- the only notification of an emergency is through the fire alarm system
- the fire alarm system is designed to wake occupants
- the occupants have not experienced false alarms in this building
- the occupants are unfamiliar with the layout of the building

Research is published by Guylene Proulx in the fourth edition of the SFPE handbook from actual fire drills of mid and high-rise residential buildings. The data presents pre-evacuation times averages from 2.5 minutes up to 9.7 minutes for both mid and high-rise apartment buildings. Numerous similarities can be made between the pre-evacuation activities of occupants of an apartment and a hotel simply, either house occupants at rest or sleeping. Contrary an argument can be made that occupants of a hotel are more transient and less familiar with the building therefore they are more responsive than occupants of an apartment building.

Here is a list of tasks occupants of a hotel may conduct before starting to evacuate (concurrent with NFPA publications):

- Dress or change attire depending on climate, additional time is needed if the occupant was bathing at the time of alarm activation
- Aid children, pets, or other less able occupants in attire donning
- Gather or secure belongings
- Phone the front desk and/or the emergency dispatch center
- Look out the window and/or into the exit corridor
- Turn on the TV or computer for weather predictions
- Travel to adjacent room if other occupants in same party of travel

It is estimated that the task involved in the pre-evacuation movement phase for hotel occupants will take between 5-6 minutes on a median basis.

MOVEMENT TIME

The following will estimate the time required for occupants to evacuate the building. First, hand calculations using the first-order hydraulic approximation method and then through the utilization of the computer software PATHFINDER.

Using the first-order hydraulic approximation method from the SFPE Handbook:

1.) Flow capability of stairway

Egress Component	Effective Width (Table 3-13.1)	Specific flow assumed to equal maximum specific flow (Table 3-13.5)
Stair: 44 in	44in. – (6in. boundary x2) = 32in	$18.5 \, {}^{persons}/_{min}/_{ft} \; x \left(32in.* \frac{ft}{12\ in.}\right) = 49.2 \, {}^{persons}/_{min}$

2.) Flow capability the stairway entrance/exit door

Egress Component	Effective Width (Table 3-13.1)	Calculated flow= Specific Flow x Effective Width
Door: 34 in.	34in.- (6in. boundary x2)= 22in.	$22in. x \left({ft}/_{12in} \right) x \left(24 \, {}^{persons}/_{min}/_{ft} \right)$ $= 44 \, {}^{persons}/_{min}$

3.) Time to descend stairway:
S=Speed along the line of travel
k= constant (Table 3-13.2)
a= 2.86 $^{ft}/_{min}$

D= Density set to 0.175 $^{persons}/_{ft^2}$ (assumed for maximum specific flow)

$$S = k - akD$$

$$S = 212 - \left(2.86 \, x \, 212 \, x \, 0.175 \, {}^{persons}/_{ft^2}\right) = 105 \, {}^{ft}/_{min}$$

Travel distance between floors:
Floor to floor =10 ft.
Using Table 3-13.3, SFPE Handbook, conversion factor to calculate the distance along the line of movement:

$$10ft. x(1.85\,) = 18.5\, ft.$$

Adding the travel distance on the landings = $18.5\, ft + (8ft\, x\, 2) = 34.5\, ft$

Traveling $105 \, {}^{ft}/_{min} \; for \; 34.5 \, ft = \; 0.33 \, {}^{min}/_{floor}$

4.) Estimated building evacuation time based on the limiting factor of the discharge door :

Egress capacity with two 44in. stairs:
$t_{trav} + t_{flow} = \dfrac{[85 \, people \, x \, (5floors)]}{[2 \, x \, (48 \, {}^{persons}/_{min})]} = 4.4 \, min.$

5.) Estimate of the evacuation time starting at the point of purposeful movement: (The hydraulic models exclude a calculation for t_{n-e} but to include a total evacuation time it was included)

$$t_e = (t_{trav} + t_{flow}) + (t_{n-e}) = (4.4\, min) + (6min) = 10.4\, min$$

Figure-49: Time Egress Analysis Hand-Calculations

The egress time is limited by the stairwell discharge doors. Accounting for 6” of boundary space on either side of doorway for occupants egressing through a 36 inch door the balance of effective width through the door is 24 inches. Utilizing Table 3-13.5 of the SFPE HB it is estimated that 24 persons can transcend through a doorway, corridor, aisle, or ramp every minute per 1 foot of effective width. For a 24 inch doorway (2 feet) it is estimated that 48 persons can egress every minute. Based on 5 levels above the level of exit discharge, 17191 foot per level, gross 200 square feet per person, 85 persons per floor, 425 persons total it will take 4.4 minutes for all occupants to discharge the stair. Accounting 6 minutes of pre-evacuation and 4.4 minutes of movement the total evacuation time is 10.4 minutes.

Computer Based Egress Analysis

The following computer based egress analysis was conducted using software provided by Thunderhead Engineering identified as PATHFINDER. PATHFINDER was utilized by importing the first level plan through a DWG file and extracting the rooms to give the program knowledge of the barriers. The second level was similarly imported and each additional level was copied from the second until all six levels were present at their perspective elevations. A stairwell was created with intermediate landings while maintaining dimensional accuracy (to the best of the operator's ability). The doorways were inserted in their model correct locations with dimensional accuracy maintained. Each floor was loaded with occupants using the area-density tool according to the occupant load factors of the LSC that are pre-loaded into the software. The model was executed without a built-in pre-movement delay to simulate the time when the occupants are attempting to make purposeful movements toward an exit. Once the occupants enter the stairwell they would be considered in the exit but the model was continued for a total evacuation timeframe and to enable a comparison to the hand-calculations. Pathfinder was processed using the SFPE framework.

Figure-50 below is an isometric image of the model identifying the load densities based on the occupant load factors.

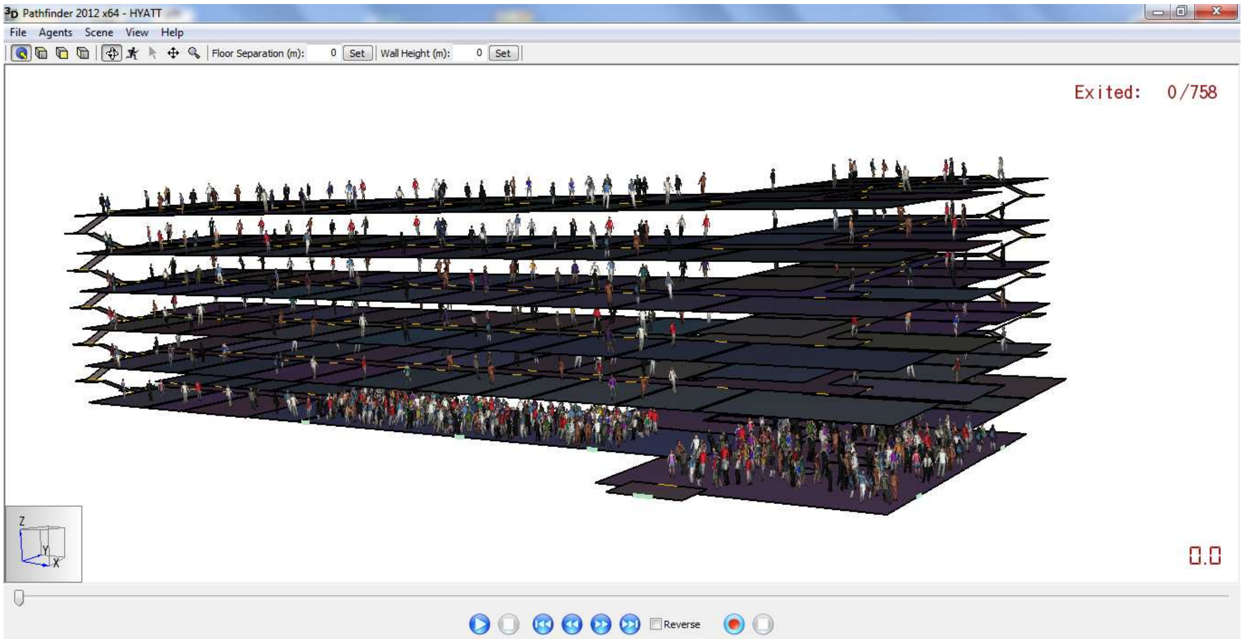


Figure-50: SMOKEVIEW Rendering

Figure-51 below is the final image of the evacuated building at the time increment of 264 seconds.

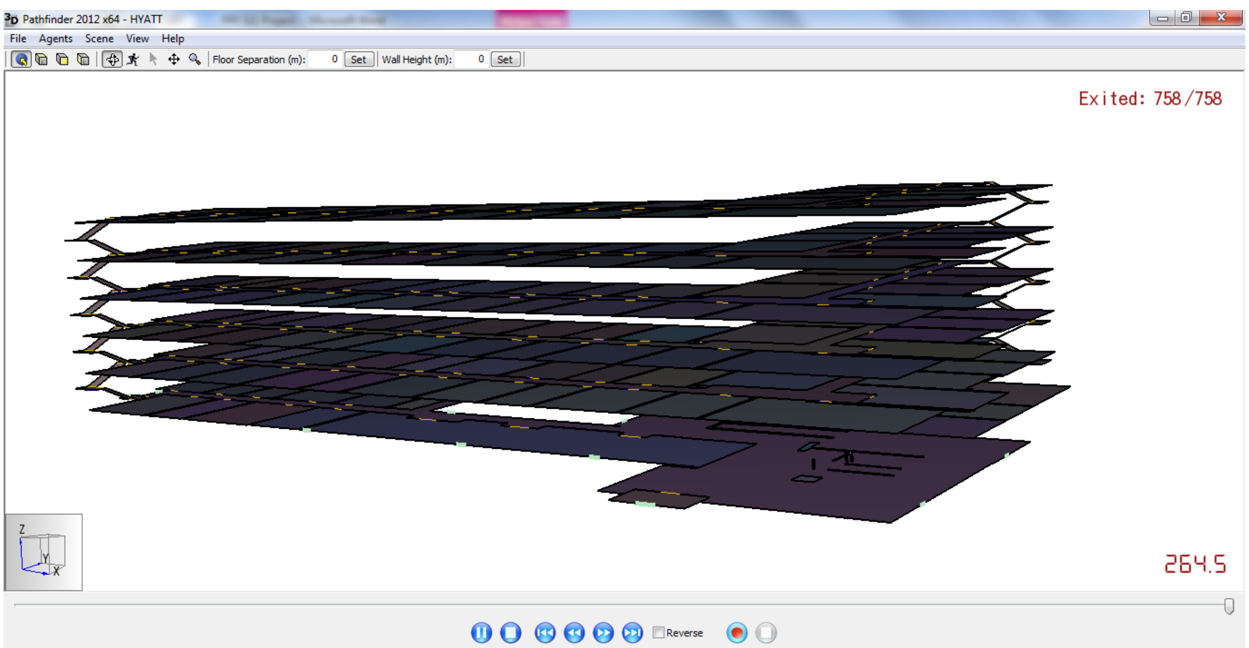


Figure-51: Rendering of the building once evacuation is complete

The computer model estimation of egress time of 4.4 minutes is equivalent to the hand-calculation method. Similar results using both the hand calculations and the computer based model is an indicator that the egress time is appropriately evaluated with both egress analysis tools.

Available Safe Egress Time

Tenability

Utilizing a performance-based design approach from the Life Safety Code requires that Chapters 1 through 5 be adhered to. Part of Chapter 5 is the performance criteria. The performance criterion is defined as: *any occupant who is not intimate with ignition shall not be exposed to instantaneous or cumulative untenable conditions.* Untenable conditions are expanded to be defined in the annex of the Life Safety Code as:

1. *Method 1: The design team can set detailed performance criteria that ensure that occupants are not incapacitated by fire effects.*
2. *Method 2: For each design fire scenario and the design specifications, conditions, and assumptions, the design team can demonstrate that each room or area will be fully evacuated before the smoke and toxic gas layer in that room descends to a level lower than 6 ft. above the floor.*
3. *Method 3: For each design fire scenario and the design specifications and assumptions, the design team can demonstrate that the smoke and toxic gas layer will not descend to a level lower than 6 ft. above the floor in any occupied room.*
4. *Method 4: For each design fire scenario and the design specifications and assumptions, the design team can demonstrate that no fire effects will reach any occupied room.*

Fire Scenario

As a means to substantiate removal of the fire barrier from across the corridor a fire model using software provided by NIST, Fire Dynamic Simulator (FDS) will be used. The performance criteria is established in the LSC, per Section 5.5.5 which states: *Any occupant who is not intimate with ignition shall not be exposed to instantaneous or cumulative untenable conditions*. Furthermore, the LSC provides a list of design fire scenarios to be considered. This report will evaluate the scenario of an ultra-fast developing fire in the primary means of egress with interior doors open at the start of the fire. Open doors are conducive of wedges or other alternative means to prop open fire doors designed to remain closed unless entering or exiting through the doors. In this scenario, open doors allow the fire room to be open to the exit access corridor.

Below is a graphic that sets up the scenario. The solid red circle represents the location of the fire in the meeting storage room. The model will be evaluated with the doors to the storage/fire room open as if they were propped open during either loading or unloading. This fire scenario was selected based on the fuel package, the proximity to the guest rooms, and the likelihood that the rated doors will be propped open. As previously mentioned it is presumed that a fire in the storage room will deem the section of the corridors immediately adjacent and sharing a wall with the storage room impassable. It must be mentioned that each section of the meeting room(s) has an exterior exit on the level of exit discharge allowing all occupants a secondary egress path separate from the corridor adjacent to the storage room. Each opening between the corridor and the meeting room(s) is equipped with magnetic door holders that release upon activation of local smoke detectors located on either side of the doorway. The door holders aid to protect occupants of the meeting room as well as the guest room occupants as a means to compartmentalize the area.

Shown below in Figure-52 is a summary of the modeled fire scenario. The solid red dot represents the fire location. The open blue circle represents the lack of separation between the environment adjacent to the storage room and the exit access corridor serving the guest room occupants. The precise location of the fire barrier is irrelevant to the analysis as it could shift to aid in egress but the objective is to indicate the common environment. Also noted below by way of a dashed green line is the egress path for guestroom occupants from the guestroom into the corridor continuing out toward the plan-east exit discharge.

As stated during the structural portion of this report the corridor walls are 1-hr fire resistant rated with 20-min doors equipped with self-closers. A second option for occupants of the guest rooms will be to remain inside the guest rooms until emergency response personnel are able to aid in their rescue. Protecting in place is not a popular option as the fight or flight intuition takes precedence but it must be noted that if conditions in the corridor are tenable then conditions in the guest rooms adjacent to the corridor are also tenable.

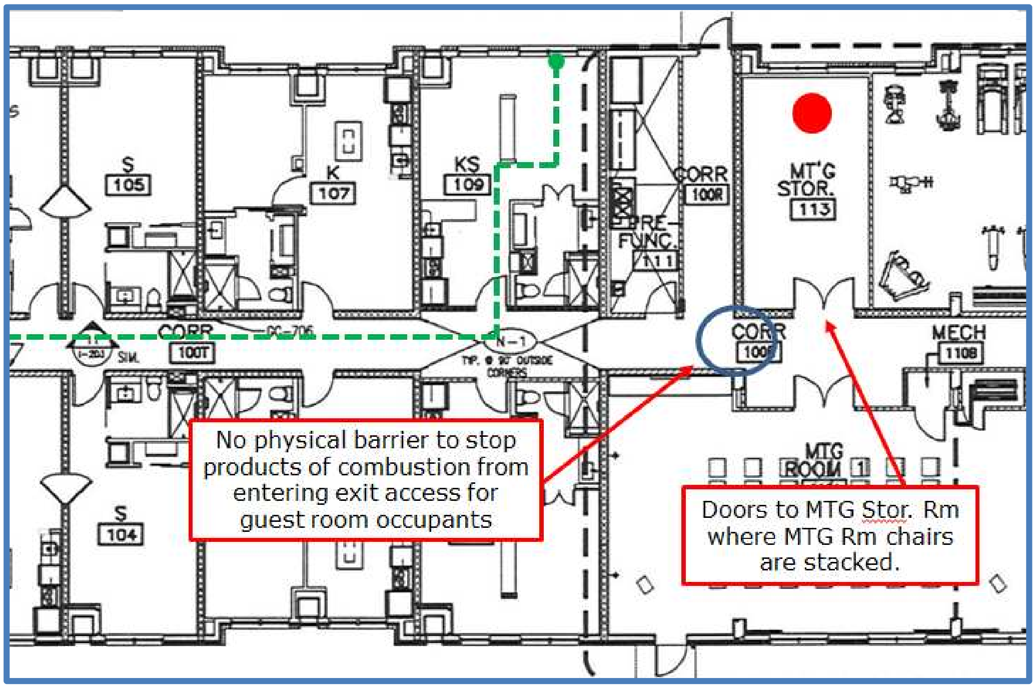


Figure-52: Modeled Fire

FUEL PACKAGE

The meeting storage room houses furniture and fixtures that are not currently in use in the meeting rooms. Below is a photograph of a meeting storage room:

Figure-53: Fuel load in meeting storage room

As shown in Figure-53 in the photograph the primary fuel source in the meeting storage room is the cushioned chairs. The chairs shown are structurally metal with upholstery covering foam with a rigid backer board providing a solid bottom and backrest. The largest stack of chairs was observed to be 8 chairs high. Based on the observations of the storage room it appears that an 8 chair stack allows the chair dollies to be utilized without the need to stack the chairs more than once when transporting from the meeting room. The SFPE Handbook was referenced to obtain a reliable source of fire test data for stackable cushioned chairs. Below is a graphic of the heat release rate (HRR) of a fire test conducted of stackable polyurethane cushioned chairs. As shown there are multiple scenarios outlined, 8-chairs in one stack, 8-chairs in one stack in the corner, 4 chairs in one stack, and a single chair. The HRR for 8 chairs stacked in the corner was the most conservative and selected HRR for the model. Figure-54 below is a portion of the FDS logic and the published fire test data presenting the model code was written to resemble the published data. Since the building is fully sprinkled the HRR curve was peaked at the point of sprinkler activation then maintained at the same value even with the graphs indicate a decrease after about 100 seconds. To account for a drop in HRR would not be accurate due to the amount of fuel available. During the fire test is it likely that only one stack of chairs was burned therefore the decrease happened once the foam and upholstery was burned off but before the backer-board ignited. Then once the backer-board ignited another spike in the HRR occurred. The ramp function was plateaued at 600kW due to the sprinklers activating in the room of origin at time equals 27 seconds.

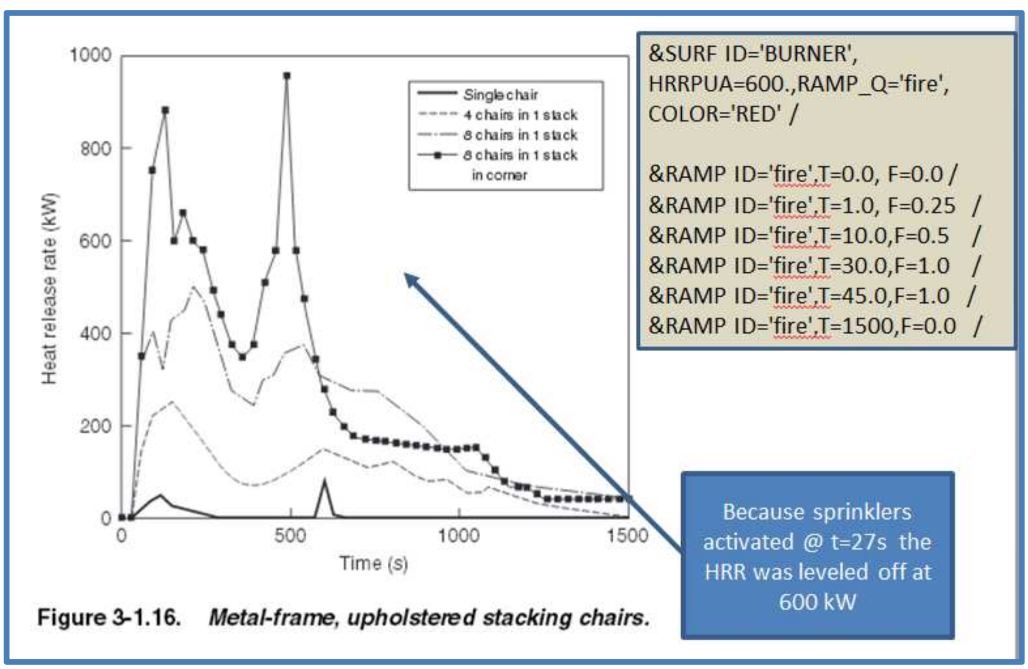


Figure-54: Fire Test versus FDS code

Based on the following figure the fire model would be considered an Ultra-fast growth rate fire.

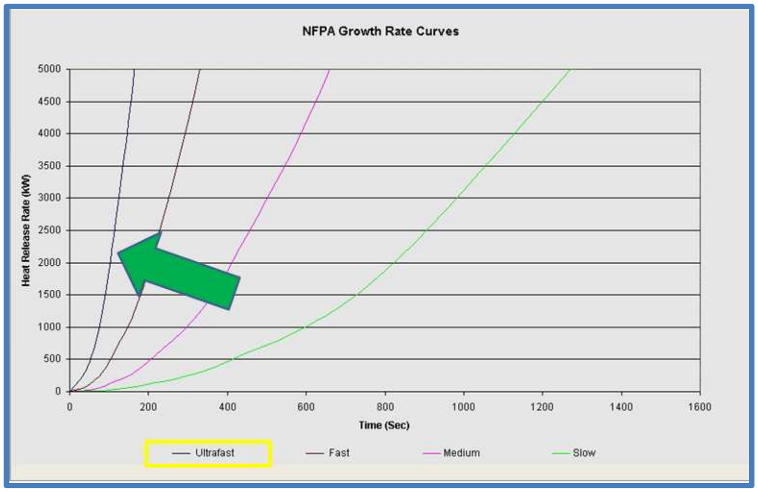


Figure-55: NFPA Growth Rate Curves

The following is the soot and CO yield values used in the FDS model based on GM27 Flexible Polyurethane Foam values published in the SFPE Handbook.

Table 3-4.14 *Yields of Fire Products and Chemical, Convective, and Radiative Heats of Combustion for Well-Ventilated Fires[a] (Continued)*

Material	ΔH_T (kJ/g)	y_{CO_2} (g/g)	y_{CO} (g/g)	y_{ch} (g/g)	y_s (g/g)	ΔH_{ch} (kJ/g)	ΔH_{con} (kJ/g)	ΔH_{rad} (kJ/g)
Polyurethane (flexible) foams								
GM21	26.2	1.55	0.010	0.002	0.131	17.8	8.6	9.2
GM23	27.2	1.51	0.031	0.005	0.227	19.0	10.3	8.7
GM25	24.6	1.50	0.028	0.005	0.194	17.0	7.2	9.8
GM27	23.2	1.57	0.042	0.004	0.198	16.4	7.6	8.8

Flexible polyurethane foams	
GM21	$CH_{1.8}O_{0.30}N_{0.05}$
GM23	$CH_{1.8}O_{0.35}N_{0.06}$
GM25	$CH_{1.7}O_{0.32}N_{0.07}$
GM27	$CH_{1.7}O_{0.30}N_{0.08}$

```
&REAC ID='POLYURETHANE_REAC',
    FYI='SFPE Handbook 3-143 and 3-155, GM27',
    FUEL='REAC_FUEL',
    C=1.0,
    H=1.7,
    O=0.3,
    N=0.08,
    CO_YIELD=0.042,
    SOOT_YIELD=0.198/
```

Figure-56: Soot and Co yields of Polyurethane

FIRE MODEL

The full FDS logic used to run the model is presented in the Appendix portion of this report. The following is a summary of the model results to aid the analysis in predicting the conditions of the corridor if a fire in the storage room occurs while the doors are propped open and the sprinkler system does not fully extinguish the fuel package. Creation of the model obstructions, the sprinkler head location, and detector locations utilized the computer software PYROSIM. Kristopher Overholt's website www.Koverholt.com was referenced for the mesh sizing aspect of the model, a medium scale cell size selected. The following results are considered conservative as the fire sprinkler system is only modeled as holding the heat release rate at a constant rate whereas it is anticipated that the sprinkler system would lower the heat release rate at a minimum. However, the opposing argument can be made that the 8 chair stack could grow when the storage room is required for other storage purposes mandating the 8 chair stack to grow to a 12 chair stack.

Below is an isometric SMOKEVIEW rendering of the FDS model created using the software PYROSIM.

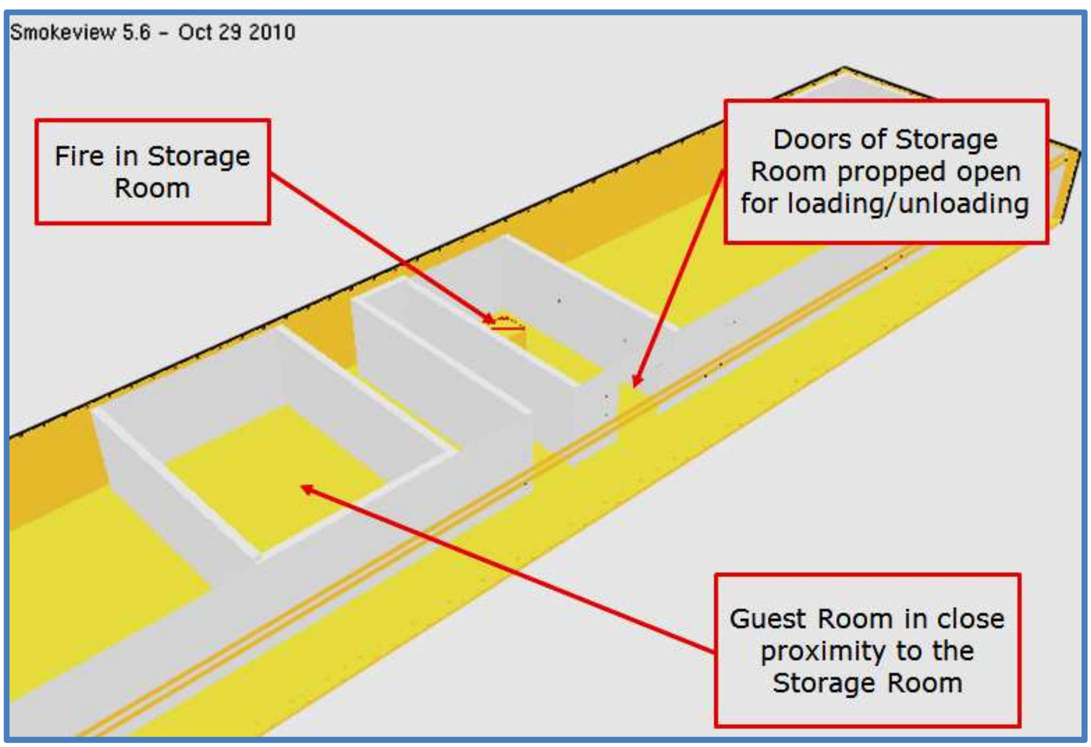


Figure-57: SMOKEVIEW Rendering

One benefit of having a fast growing high soot-yield fuel load is the fast initiation of local smoke detectors and subsequent sprinkler activation. Below are the results of the first detector activation outside the storage room and the first sprinkler activation in the storage room.

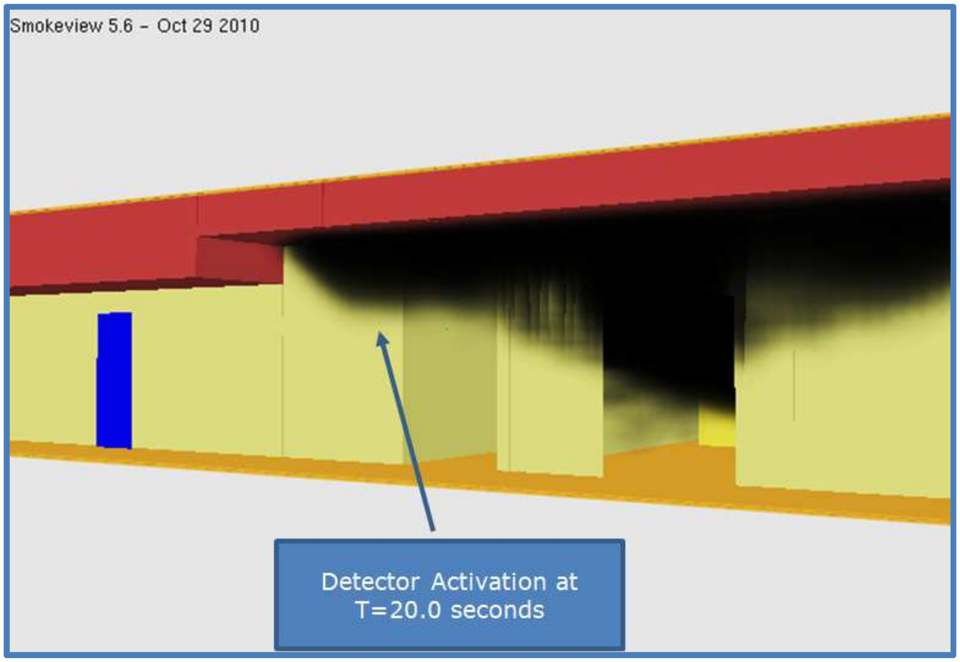


Figure-58: Detector Activation

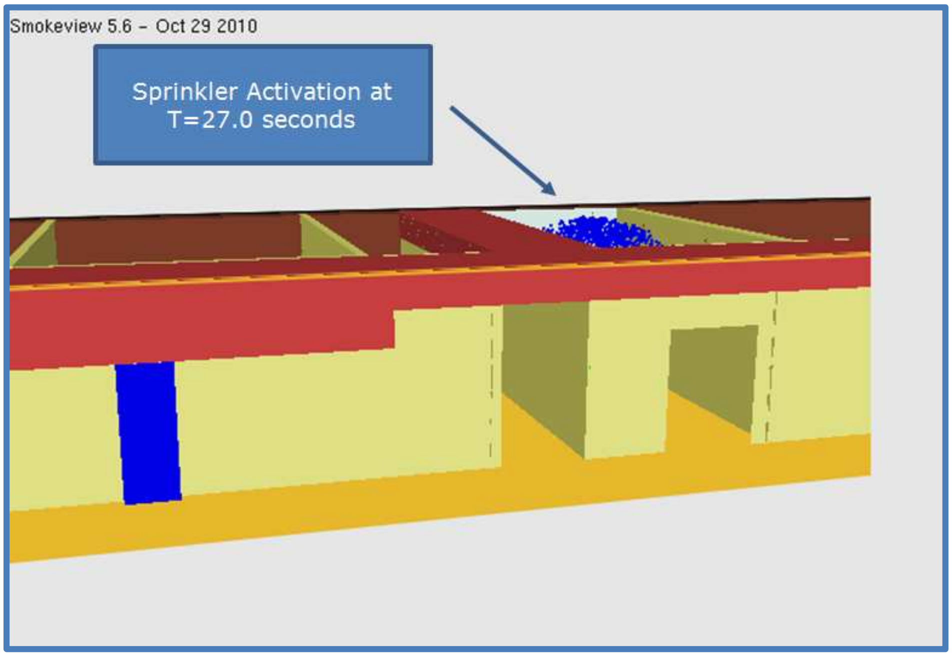


Figure-59: Sprinkler Activation

Early detection equates to early notification, notification of could be sleeping occupants in the guest rooms. When occupants of the guest room are notified of an alarm condition they will likely conduct multiple tasks before attempting to exit.

A questionnaire was sent out to the occupants of the MGM Grand Hotel during the tragic fire of 1980. The following is a compilation of the results arranged according to the percentage of occupants whom conducted each task and in which sequence the task was conducted. Review of the results provides an indication as to the first actions of occupants in a hotel once notified of an alarm condition. In the egress chapter of this report we made a correlation between apartment occupants and hotel occupants in order to estimate how much of a pre-movement time was necessary. For the remainder of this report we will focus on determining how much time is available for egress before conditions are untenable in the exit access corridor. Conditions in the exit access corridor will only be encountered if the occupants of the guest rooms choose to exit as opposed to remaining in the guest room. The analysis will be limited to the exit access corridor however, one can equate conditions within the guest rooms will be favorable to the corridor primarily due to passive fire protection. Conditions in the guest rooms will be separated from the corridor with 1-hr fire resistance rated construction with 20-min fire resistance rated doors.

Table 3-12.7 ***Compilation of the Initial Five Actions of Guests in the MGM Grand Hotel Fire Incident***[35]

	Percent of Population				
Actions	First	Second	Third	Fourth	Fifth
Dressed	16.8	11.6	6.5	—	—
Opened door	15.9	11.7	6.7	3.4	—
Notified roommates	11.6	3.0	—	—	—
Dressed partially	10.1	7.5	4.5	—	—
Looked out window	9.7	5.7	—	—	—
Got out of bed	4.5	—	—	—	—
Left room	4.3	5.4	8.1	2.4	2.0
Attempted to phone	3.4	3.6	—	2.8	—
Went to exit	2.5	10.3	9.5	16.1	6.7
Put towels around door	1.6	2.5	3.0	6.8	7.7
Felt door for heat	1.3	2.3	—	—	—
Wet towels for face	1.3	3.7	6.3	4.6	7.9
Got out of bath	1.1	—	—	—	—
Attempted to exit	1.1	3.0	5.8	4.3	—
Secured valuables	—	6.8	4.3	—	—
Notified other room	—	3.4	2.2	—	—
Returned to room	—	—	3.9	8.4	4.1
Went down stairs	—	—	3.9	5.4	21.3
Left hotel	—	—	3.4	2.6	2.0
Notified occupants	—	—	3.0	—	—
Went to another exit	—	—	—	3.6	4.8
Went to other room	—	—	—	3.6	3.6
Went to other room/others	—	—	—	3.4	8.7
Looked for exit	—	—	—	2.4	—
Broke window	—	—	—	—	4.3
Offered refuge in					

Figure-60: MGM Grand Hotel Survey

TENABILITY CRITERIA

Conditions in the corridor will be evaluated as to how long a tenable environment exist. The following analysis will evaluate tenable conditions based on visibility, temperature, and carbon monoxide levels. Below is a summary of the limitations set for each of the tenable criteria.

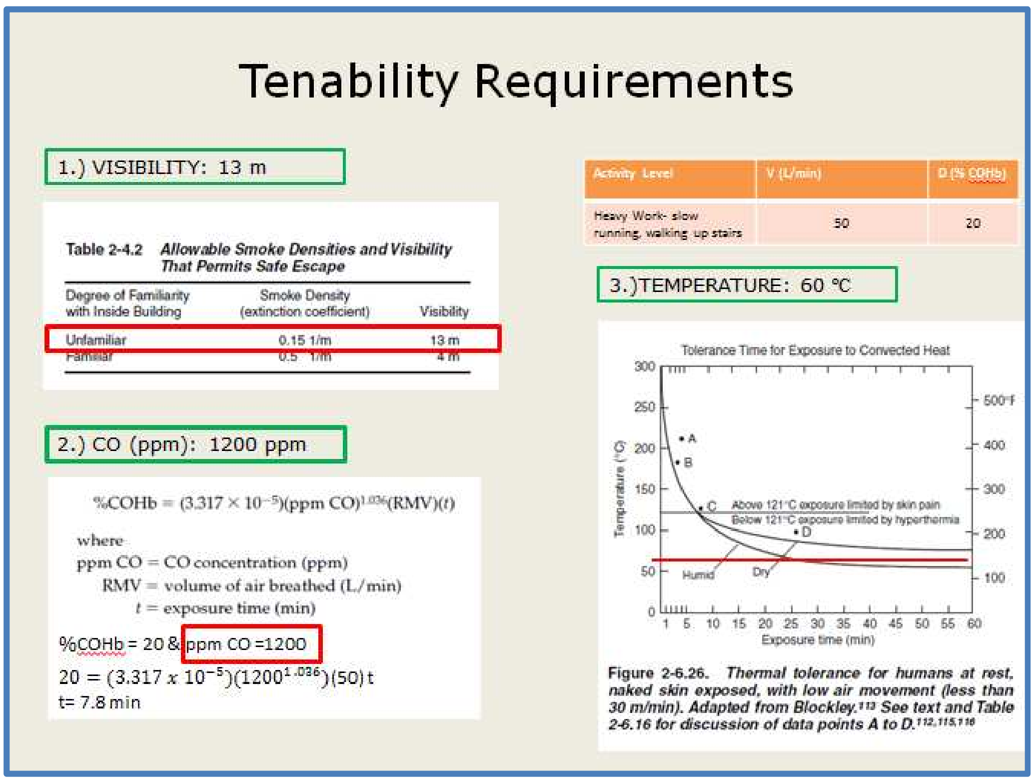


Figure-61: Tenability Requirements

The following image is a SMOKEVIEW rendering of a slice file along the corridor presenting the visibility levels. SMOKEVIEW is a separate visual aid program for Fire Dynamic Simulator (FDS). As shown at around 65 seconds the smoke plume has banked down to the top of the guest room door. Considering alarm initiation by detection occurs around 20 seconds occupants would have a pre-movement time of 45 seconds available before finding these conditions. A pre-movement of 45 seconds is limited for occupants whom may be sleeping or taking a bath. As shown in the results of the MGM questionnaire occupants are anticipated to conduct multiple tasks before attempting to egress. As shown previously in the egress time line the pre-movement time is comprised of three phases: perception, interpretation, and action.

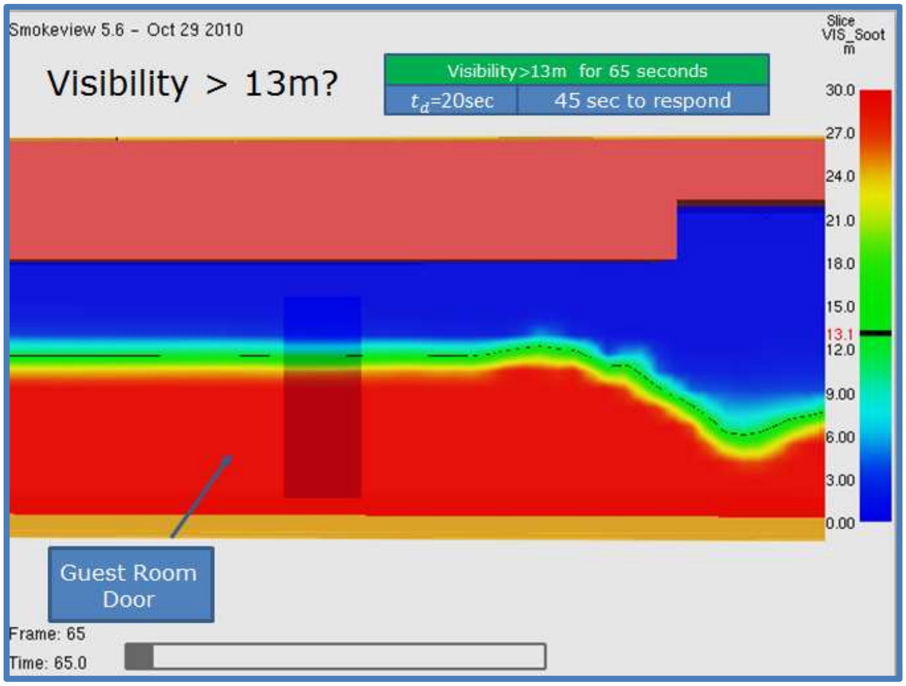


Figure-62: Corridor Visibilty at the Guest Room

The next rendering provided in Figure-63 below is the same slice file location as before but at the time increment of 120 seconds. As shown the smoke plume has banked down at the doorway to where the visilibilty criteria is met just a few inches off the floor. Next, we will look at what happens between 60-120 seconds.

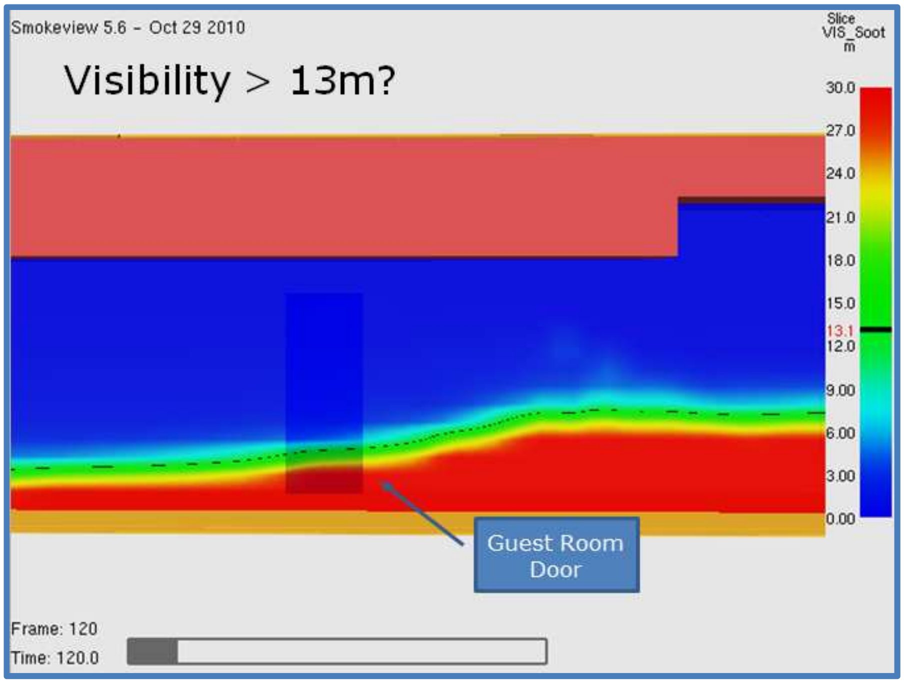


Figure-63: Visibilty at t=120s

Below is a rendition of what the visibility conditions may present the occupants with at the two time increments from a view point in the corridor at the guest room door. On the left at t=65 seconds the smoke layer is above the exit door but it is obstructing the view of the EXIT sign, mounted in the pendent position from the ceiling. On the right at t=120 seconds the smoke layer is almost to the floor reducing the visibility of the exit door.

Figure-64: Rendering of possible conditions

Shown below in Figure-65 is the same visibility slice file as before but panned out so more of the corridor is depicted. This is how the conditions present at t=75 seconds into the model. The smoke plume begins to bank down at the end of the exit corridor creating less visibility at the exit discharge than at the guest room doorway. In this scenario is it likely that occupants of the guest room may choose to enter the corridor and egress based on the visibility presented at the guest room doorway. Next, we will look at how long egress will take if conditions deteriorate to a visibility below 13 m. This will be an evaluation of occupants whom selected to egress through smoke.

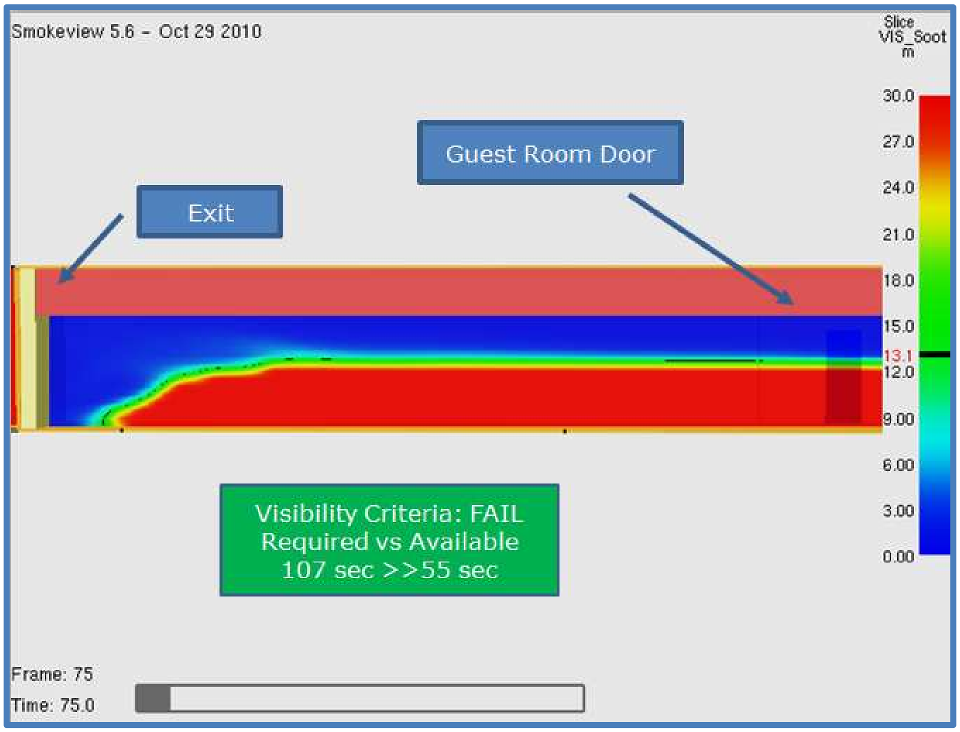


Figure-65: Visibility at t=75

Testing conducted by Jensen determind that occupants whom encountered smoke would continue through smoke when conditions present with optical densities between 1.09-1.58 L/m but at a much slower velocity, between .2-.4 m/s. Based on these velocities and the travel distance from the guest room doorway to the exit the total time required to travel the corridor is about 106 seconds. Below in Figure-66 the same slice file we were using for visibility above however the scale is for the optical density. As shown the upper limits of Jensen's parameters are met at around the 90 second time increment, which adds 30 seconds or so to our premovement time available, comparing to the 13m criteria. Based on this information and detection occuring around 20 seconds the occupants would have approximately 70 seconds to complete the premovement tasks then travel the corridor. Using the 106 seconds calculated above for occupants to travel through smoke the occupants would not have the time required with the visilibilty needed. Now we must determine if the other 2 tenability criteria are met while the occupants attempt to egress. The conclusion of the visibilty test is less than the criteria set, but the analysis will continue to evaluate the other two criteria.

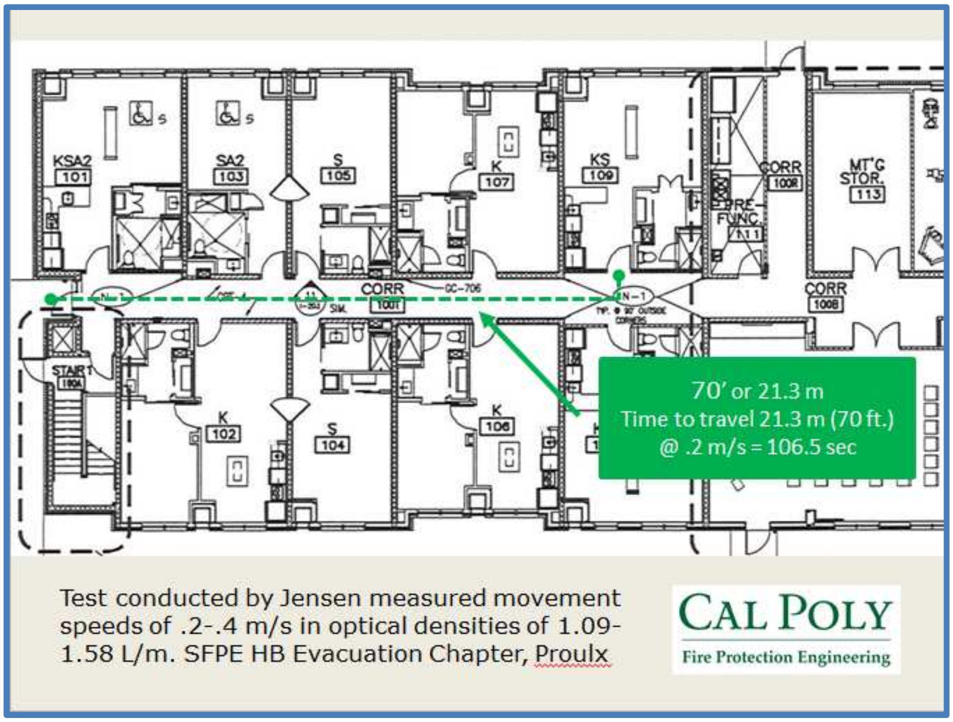


Figure-66: Exit travel time through smoke

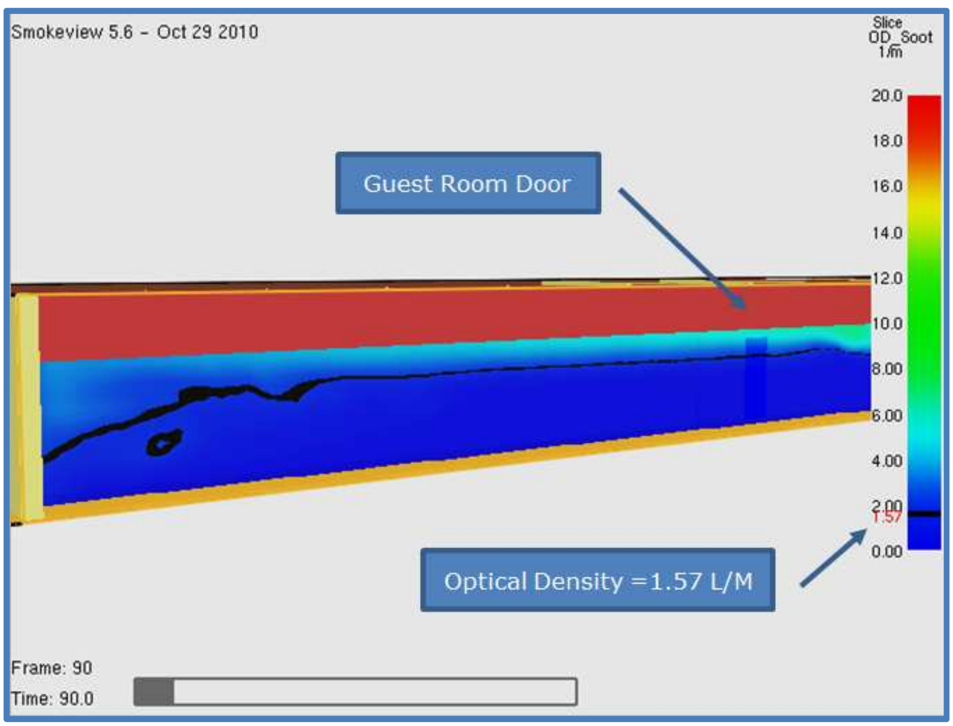


Figure-67: Vibility using Jensen's Approach

Below in Figure-68 is the slice file indicating the temperature of the corridor at the time increment of 735 seconds. As witnessed there is a section between the guest room door and the storage room door where the temperatures exceed the tenable criteria. As the model precedes the temperatures shown above 60 degrees subsides to levels below but for this portion of the analysis we will conclude that 735 seconds is available for safe egress.

As shown below 735 seconds or 12.25 minutes into the fire model the temperature in the corridor is just peaking at 60℃ above the guest room door. The area of higher temperature shown was an anomaly during this time segment and descended shortly thereafter as would be expected with the sprinkler system functioning.

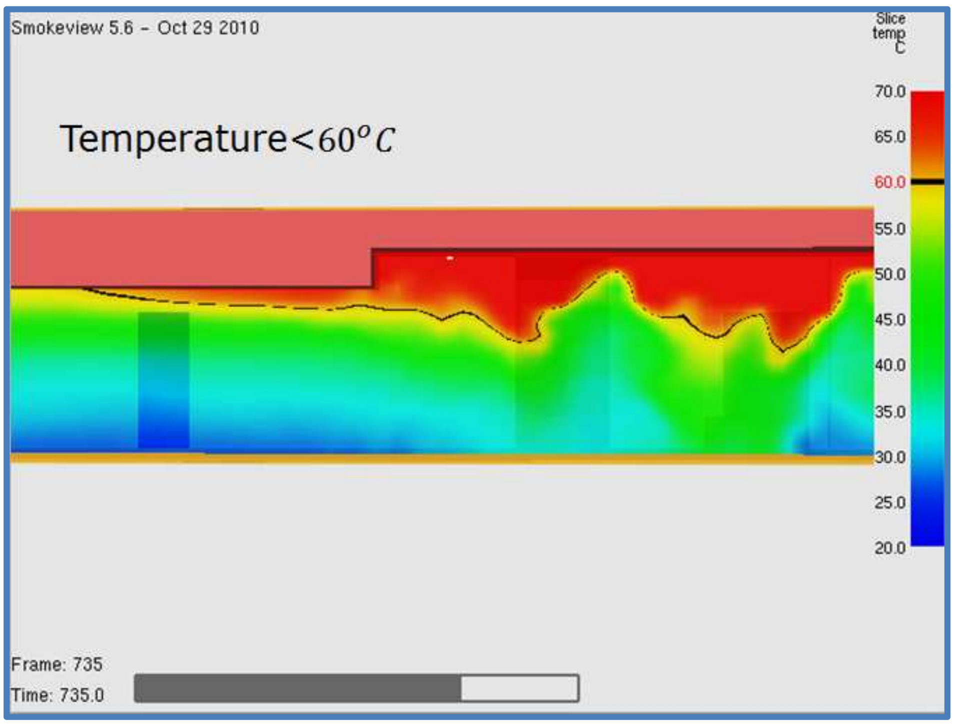


Figure-68: Corridor Temperatures

The next portion of the report will evaluate the CO levels in the corridor. Again, the time increment was selected to match the temperature portion at 735 seconds. As shown in Figure-59 you can see that the upper limits only approach 900 ppm well below the 1200 ppm criteria set.

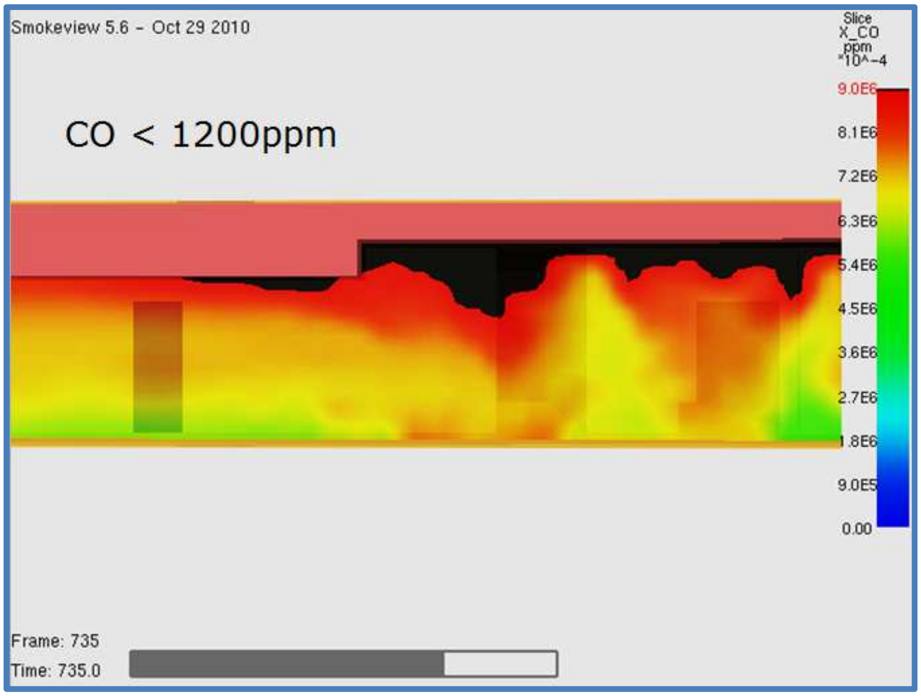


Figure-69: CO Levels in the corridor

To recap detection occurs at t=20 seconds, notification occurs at t=21 seconds, pre-movement time available is at the maximum t=90 seconds, and the time required to complete egress is t=197 seconds with reduced levels of visibility.

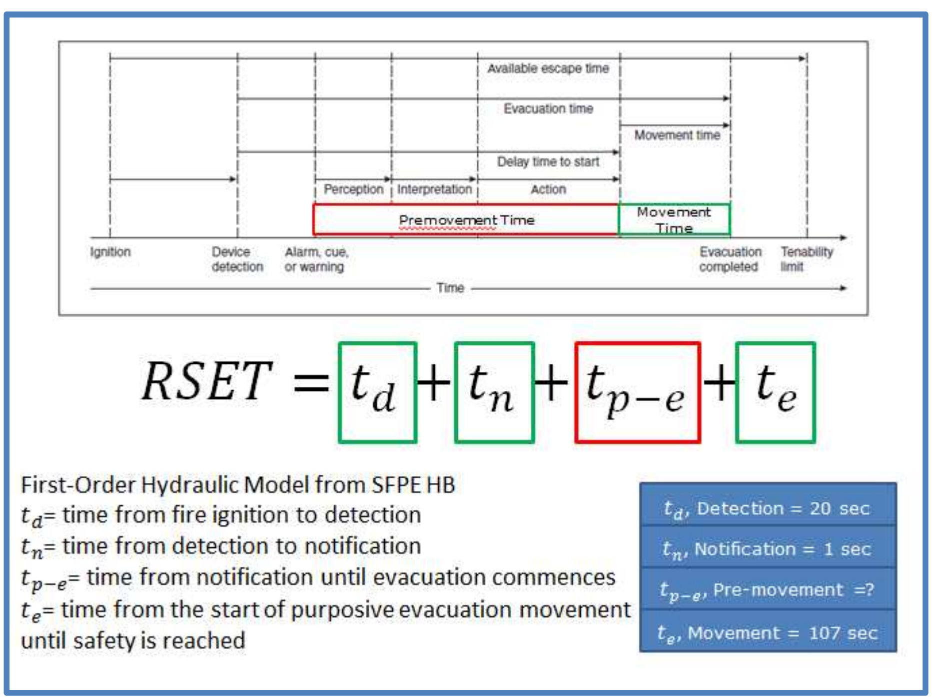


Figure-70: Egress Phases

OTHER FIRE SCENARIOS CONSIDERED

Shown below are other fire scenarios that were considered but deemed to be less threatening to the most vulnerable occupants of the hotel. Of those scenerios considered are the maids cart in the corridor, the meeting room, front main entrance, the kitchen, and the laundry facilities. The potential for fire scenarios complying with the criteria established in Section 5.5 of the *Life Safety Code* was abundant, however the scenario modeled was superior among the list of scenarios considered.

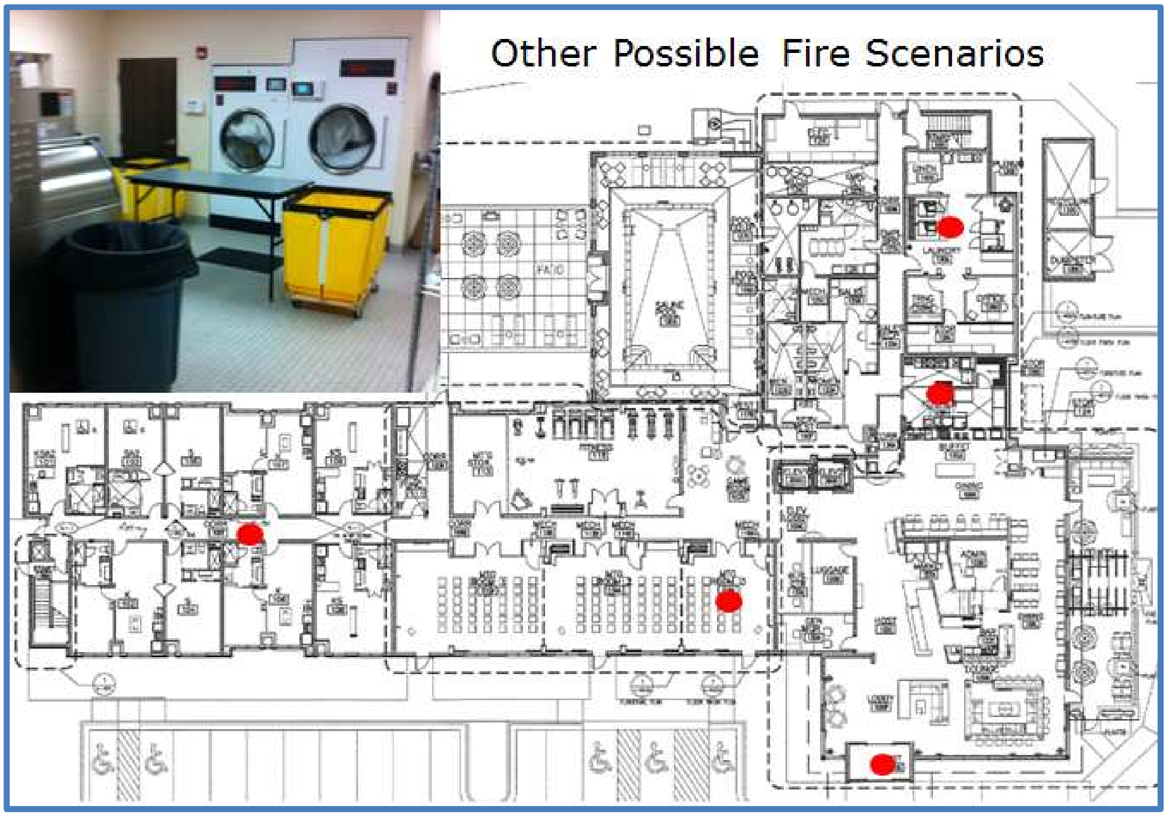


Figure-71: Fire Scenarios

POTENTIAL EQUIVALENCIES

- Continue the fire barrier across the corridor through the implementation of a rated door
- Corridor Smoke Detection System for early notification
- Install door holders for the storage room that release upon local detection to prevent the need for other door holder devices that do not release upon detection
- Change the access of the storage room to the exterior
- Replace the cushioned chairs with an equivalent non-combustible fixture
- Create a check and balance system by educating the workforce on the need for the doors to remain closed
- Implement directional sounders and/or photoluminescent markings as a continuous wayguidance system
- Pre-recorded message stating: “If you encounter smoke while opening the door remain in your room until further instruction is given. Conditions in your room are favorable”

ANNUAL COMPLIANCE CHECK

If any of the equivalencies/performance appraisals are accepted, the owner is required to submit a warrant of fitness on an annual bases to ensure that the criteria set forth continues to be valide.

> **4.6.9.2** Where compliance with this *Code* is effected by means of a performance-based design, the owner shall annually certify compliance with the conditions and limitations of the design by submitting a warrant of fitness acceptable to the authority having jurisdiction. The warrant of fitness shall attest that the building features, systems, and use have been inspected and confirmed to remain consistent with design specifications outlined in the documentation required by Section 5.8 and that such features, systems, and use continue to satisfy the goals and objectives specified in Sections 4.1 and 4.2. *(See Chapter 5.)*

Figure-72: Warrant of Fitness

Summary

The analyzed 6-story mixed-use non-separated hotel constructed of concrete and steel would be said to be “Fire-Proof” similar to the Winecoff a century ago. However, through this analysis we have learned that separation and compartmentalization is critical to proper smoke control. Code has developed throughout history and it appears that the State of Georgia is still implementing additional features to help prevent another hotel tragedy. To the extent possible the presented hotel is code compliant negating the fire resistance separation across the corridor adjacent to the residential occupancy.

Prescriptively this analysis has evaluated the active and passive fire protection systems implemented into the design of a mixed-use hotel. Based on the information available all systems are deemed compliant with the referenced standards. With any multi-story building there is a logistical hurdle to overcome with the egress system. As evaluated, the fire protection systems both active and passive provide the occupants with the time required to gain access to the exit system and through the exit system. The unknown pre-movement time in a residential occupancy can be improved upon through drills and education but it cannot be engineered out; to say that a defined timeline is needed for compliance is negligent.

The performance based evaluation determined that the occupants of the guest rooms have approximately one minute from receiving the alarm to reaching the exit discharge. However, the model was evaluated with an active fire protection system disabled, the doors to the storage room were propped open in accordance with the design fire scenario selected. Without further studies to prove that the timeline presented has a margin of safety incorporated the presented conditions are not considered acceptable.

Based on the fire test data available on the fuel source found in the meeting storage room the ultrafast growth rate fire overcomes the exit access corridor in just over one minute. The polyurethane cushioned chairs produce a dense black smoke causing the visibility to fall well below the tenable conditions established before the occupants of the guest room can be considered to have evacuated. This report concludes that a tenable environment is present for approximately one minute in the exit access corridor serving the guest rooms on the main level from the time of alarm initiation by the corridor smoke detection system.

Annex

Hotel.fds

Generated by PyroSim - Version 2014.1.0110

Feb 2, 2014 1:50:20 PM

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&TIME T_END=1000.0/

&DUMP RENDER_FILE='Hotel.ge1', DT_RESTART=300.0/


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      N=0.08,
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&PROP ID='K-5.6', QUANTITY='SPRINKLER LINK TEMPERATURE', RTI=50.,
C_FACTOR=0.0,
ACTIVATION_TEMPERATURE=68., OFFSET=0.10,PART_ID='water drops',
FLOW_RATE=189.3,
```

DROPLET_VELOCITY=10., SPRAY_ANGLE=30.,80. /

&PART ID='water drops', WATER=.TRUE., QUANTITIES(1:3)='DROPLET_DIAMETER','DROPLET_TEMPERATURE','DROPLET_AGE', DIAMETER=1750., SAMPLING_FACTOR=1 /

&DEVC ID='Device', PROP_ID='K-5.6', XYZ=33.9906,15.3577,3.95/

&DEVC ID='Device01', PROP_ID='K-5.6', XYZ=33.9906,12.6077,3.95/

&DEVC ID='Device02', PROP_ID='K-5.6', XYZ=33.9906,9.85772,3.95/

&DEVC ID='Device03', PROP_ID='K-5.6', XYZ=31.0,8.35772,3.35/

&DEVC ID='Device04', PROP_ID='K-5.6', XYZ=35.5,8.35772,3.35/

&SLCF QUANTITY='VOLUME FRACTION', SPEC_ID='carbon monoxide', PBZ=2.0/

&SLCF QUANTITY='VOLUME FRACTION', SPEC_ID='carbon monoxide', PBZ=1.0/

&SLCF QUANTITY='VOLUME FRACTION', SPEC_ID='carbon monoxide', PBY=8.0/

&DEVC ID='SD_29', PROP_ID='Smoke Detector', XYZ=28.5,8.35772,3.3 /

&PROP ID='Smoke Detector', QUANTITY='CHAMBER OBSCURATION', LENGTH=1.8,

ACTIVATION_OBSCURATION=3.28 /

&DEVC ID='SD_29', PROP_ID='Smoke Detector', XYZ=37.5,8.35772,3.3 /

&PROP ID='Smoke Detector', QUANTITY='CHAMBER OBSCURATION', LENGTH=1.8,

ACTIVATION_OBSCURATION=3.28 /

&SLCF QUANTITY='VOLUME FRACTION', SPEC_ID='oxygen', PBY=8.0 /

&SLCF QUANTITY='VISIBILITY', PBY=8.0/

&DEVC XYZ=31.0,8.35772,2.0, QUANTITY='oxygen', ID='EO2_FDS' /

&SURF ID='Masonry.Unit Masonry.CMU.Stretcher.Running',

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    RGB=105,106,95,
    ADIABATIC=.TRUE./
&SURF ID='Finishes.Metal Framing Systems.Stud',
    RGB=162,162,162,
    ADIABATIC=.TRUE./
&SURF ID='Finishes.Gypsum Board.Painted.White',
     RGB=200,200,140,
    ADIABATIC=.TRUE./
&SURF ID='Metals.Structural Metal Framing.Steel',
    RGB=179,100,100,
    ADIABATIC=.TRUE./
&SURF ID='Thermal & Moisture.Roofing & Siding Panels.Composite Panels.Grey',
    COLOR='GRAY 70',
    ADIABATIC=.TRUE./
&SURF ID='Thermal & Moisture.Insulation.Rigid Insulation',
    RGB=200,200,140,
    ADIABATIC=.TRUE./
&SURF ID='Masonry.Unit Masonry.Brick.Modular.Running',
    RGB=134,98,78,
    ADIABATIC=.TRUE./
&SURF ID='Finishes.Metal Framing Systems.Furring',
    RGB=162,162,162,
    ADIABATIC=.TRUE./
&SURF ID='Concrete.Cast-In-Place.Flat.Grey.1',
    RGB=0,0,255,
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    ADIABATIC=.TRUE./

&SURF ID='Storage Room',

    RGB=189,252,201,

    ADIABATIC=.TRUE./

&SURF ID='Exit',

    RGB=135,206,235,

    ADIABATIC=.TRUE./

&SURF ID='BURNER', HRRPUA=600.,RAMP_Q='fire', COLOR='RED' /

&RAMP ID='fire',T=0.0, F=0.0 /

&RAMP ID='fire',T=1.0, F=0.25   /

&RAMP ID='fire',T=10.0,F=0.5    /

&RAMP ID='fire',T=30.0,F=1.0    /

&RAMP ID='fire',T=45.0,F=1.0   /

&RAMP ID='fire',T=1500,F=0.0   /

&VENT XB= 32.0, 33.0, 15.0, 16.0, 1.2192, 1.2192, SURF_ID='BURNER' /

&OBST XB=32.0,33.0,15.0,16.0,0.0,1.2192, SURF_ID='INERT'/ FIRE

&OBST XB=2.7406,2.9906,7.35773,9.10773,0.0,4.0, SURF_ID='Finishes.Gypsum
Board.Painted.White'/ Obstruction

&OBST XB=2.9906,3.1,7.8,8.7,0.0,2.3, SURF_ID='Exit'/ Exit Door

&OBST XB=2.7406,27.2407,7.35773,9.10773,2.75,4.0,
SURF_ID='Metals.Structural Metal Framing.Steel'/ lower ceiling corridor 9'

&OBST XB=27.2407,53.9907,7.35773,9.10773,3.3528,4.0,
SURF_ID='Metals.Structural Metal Framing.Steel'/ lower ceiling corridor 11'

&OBST
XB=2.7406,53.9907,7.10773,7.35773,0.0,4.0,TRANSPARENCY=0,OUTLINE=.TRUE
, SURF_ID='INERT'/ Obstruction
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&OBST XB=21.2406,21.4906,9.35773,17.1077,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=21.2406,27.2407,9.10773,9.35773,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Guest Room

&OBST XB=26.9907,27.2407,9.35773,17.1077,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=29.4907,31.4907,9.10773,17.1077,3.3528,4.0, SURF_ID='Metals.Structural Metal Framing.Steel'/ corridor left of storage

&OBST XB=29.4907,29.7407,9.10773,16.6077,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=31.2407,31.4907,9.10773,16.6077,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Storage Room

&OBST XB=35.2407,35.4907,9.10773,16.6077,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Storage Room

&OBST XB=47.4907,47.7407,9.10773,16.8577,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=53.7407,53.9907,9.10773,16.8577,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=2.9906,21.2406,9.10773,9.10773,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=27.2407,29.4907,9.10773,9.10773,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=29.7407,31.2407,9.10773,9.10773,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=31.4907,35.2407,9.10773,9.10773,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=31.4907,35.2407,16.6077,16.6077,0.0,4.0, SURF_ID='Storage Room'/ Storage Room

&OBST XB=2.7,54.0,16.6077,17.3,0.0,4.0, SURF_ID='Masonry.Unit Masonry.Brick.Modular.Running'/ Back Wall

&OBST XB=35.4907,47.4907,9.10773,9.10773,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=47.7407,53.7407,9.10773,9.10773,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=53.9907,53.9907,7.35773,9.10773,0.0,4.0, SURF_ID='Finishes.Gypsum Board.Painted.White'/ Obstruction

&OBST XB=22.9101,23.8256,9.00,9.1,0.0,2.31648, SURF_ID='Concrete.Cast-In-Place.Flat.Grey.1'/ Guest Room Door

&HOLE XB=29.5973,31.2563,8.95668,9.15668,0.0,4.0/ Hole

&HOLE XB=52.1582,53.7883,8.8392,9.8392,0.0,4.0/ Hole

/&HOLE XB=22.9101,23.8256,9.1,9.15,0.0,2.31648, color='green'/ Guest Room Door

&HOLE XB=32.9907,34.7407,8.60773,9.60773,0.0,2.31648/ Storage Room Door

&SLCF QUANTITY='TEMPERATURE', PBX=33.5705/

&SLCF QUANTITY='TEMPERATURE', PBY=8.22437/

&SLCF QUANTITY='TEMPERATURE', PBX=23.1426/

&SLCF QUANTITY='OPTICAL DENSITY', PBY=8.22437/

&TAIL /

References:

- -International Code Council: 2006 *International Building Code* (IBC)
- -National Fire Protection Association: NFPA 101*, Life Safety Code* 2000 Edition (LSC)
- -National Fire Protection Association: NFPA 13*, Fire Sprinkler Standard* 2002 Edition
- -National Fire Protection Association: NFPA 14*, Standpipe* 2003 Edition
- -National Fire Protection Association: NFPA 24*, Standard on Fire Line* 2003 Edition (LSC)
- -National Fire Protection Association: NFPA 72*, Fire Alarm Code* 2002 Edition

- -Society of Fire Protection Engineers: *Handbook of Fire Protection Engineering*, 4th Edition
- -National Fire Protection Association: *Fire Protection Handbook*, 20th Edition
- -Thunderhead Engineer's Computer Based Egress Software: PATHFINDER
- Fire Dynamic Simulator (FDS) and Smokeview (SMV): National Institute for Standards and Training