

# GRANGE INSURANCE AUDUBON CENTER

Culminating Project Presentations  
by Gabriel Levy

June 09, 2022



# Gabriel Levy, EIT

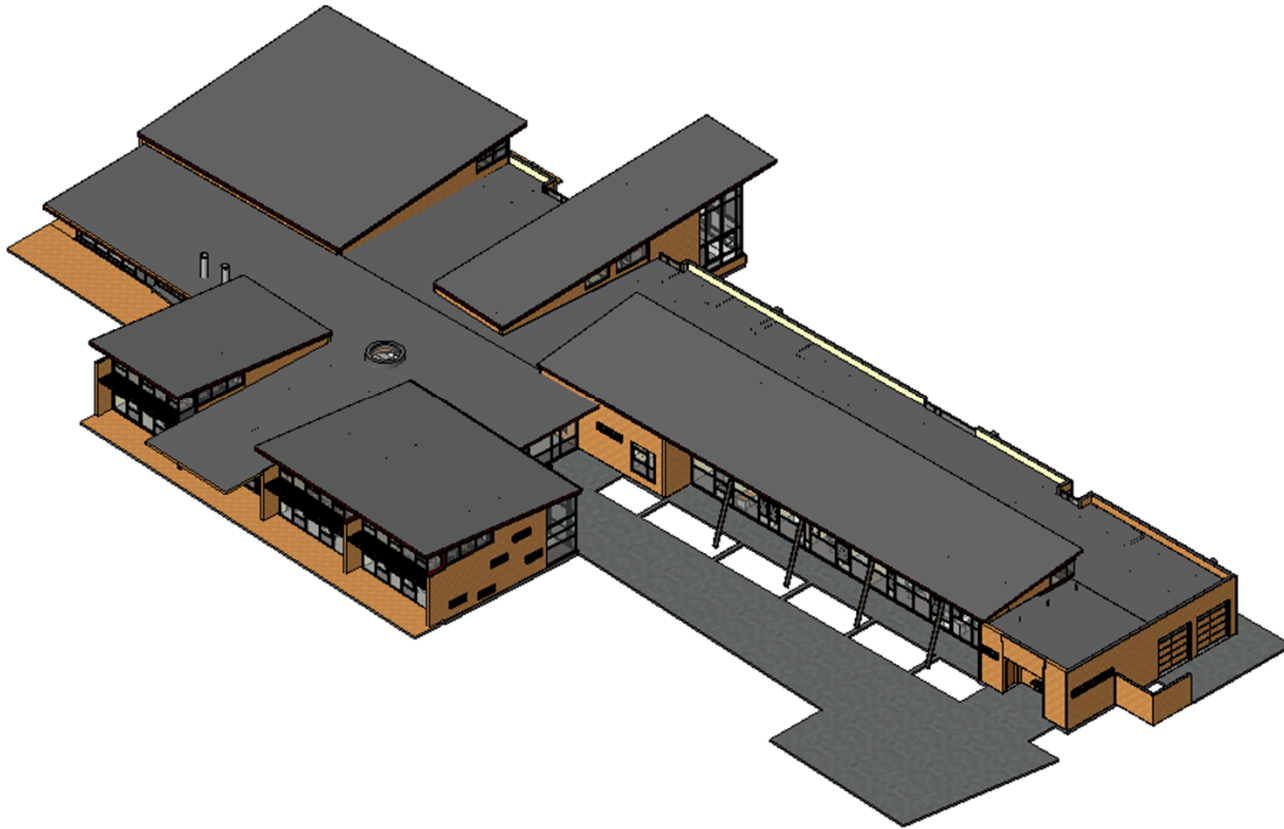
- ▶ Mechanical Engineering BSME
  - Cal Poly SLO, 2019
- ▶ FPE M.S.
  - Cal Poly SLO, 2022
- ▶ incandescence life safety, inc
  - Denver, CO
  - [glevy@incandescencels.com](mailto:glevy@incandescencels.com)
  - <http://www.incandescencelifesafety.com/gabriel-levy.html>







# Project Background



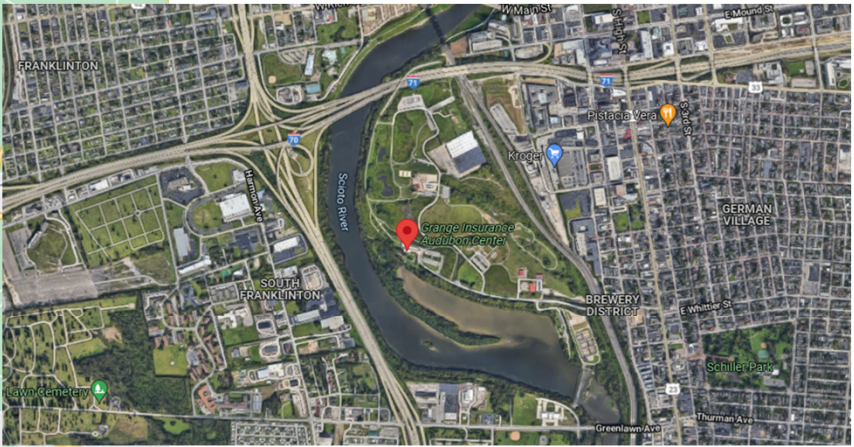
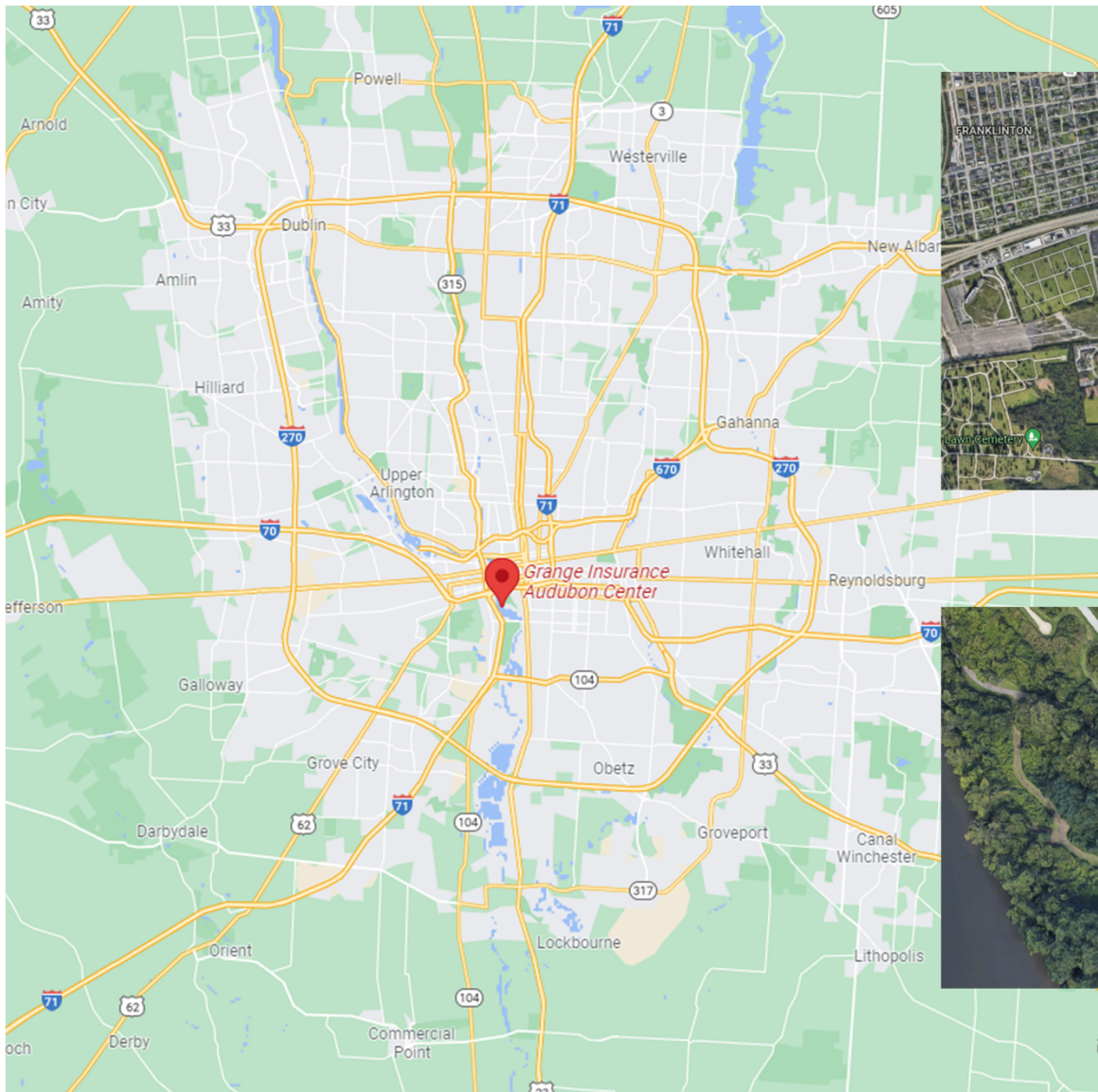
# Summary

## Prescriptive

- Occupancy Classifications
- Building Construction
- Egress Systems
- Fire Alarm Systems
- Fire Suppression Systems
- Smoke Control Systems

## Performance Based

- Design Fires
- Fire Modeling
- Egress Modeling
- RSET vs ASET





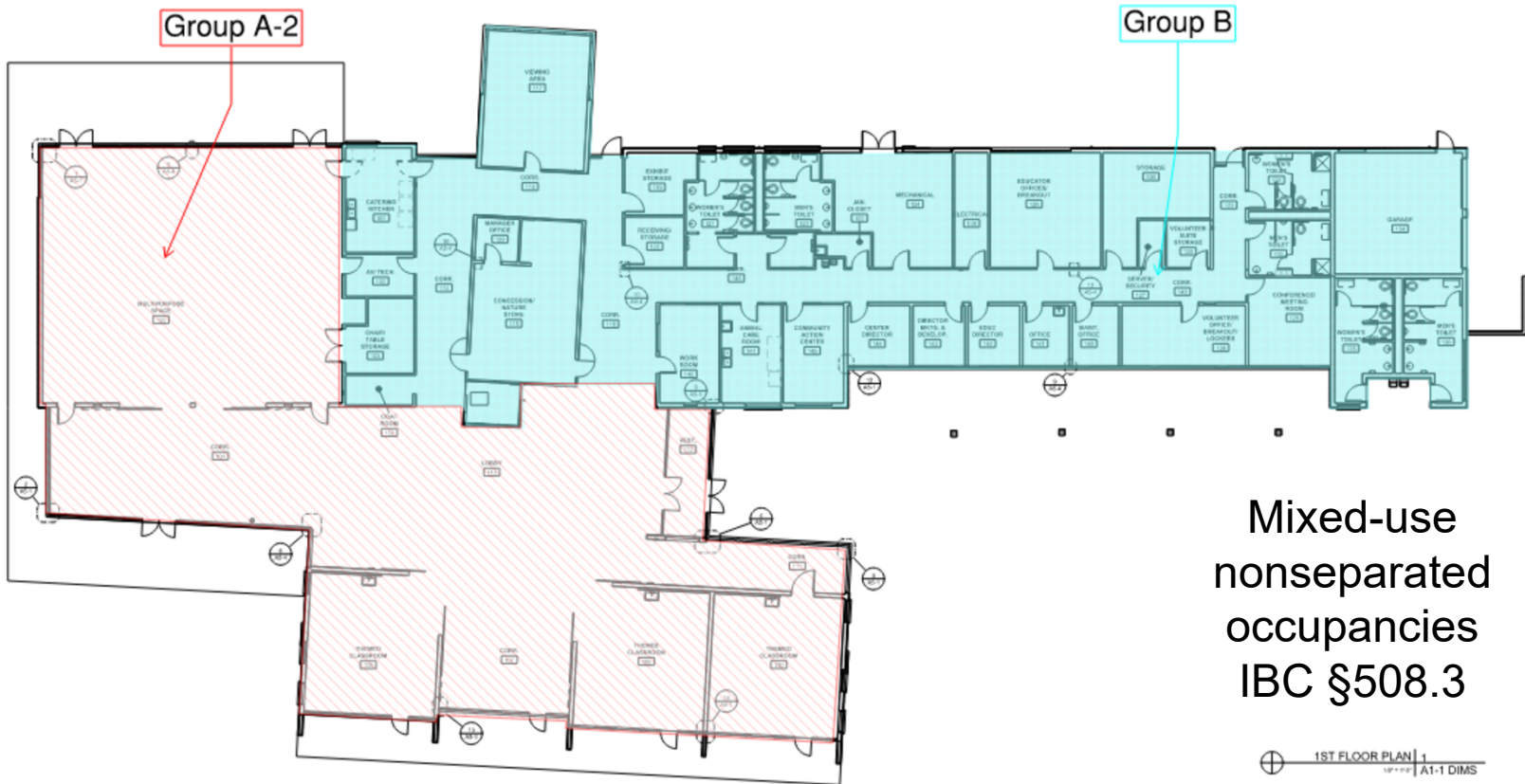
# Authority Having Jurisdiction



- ↕ 2017 Columbus Building Code (amended 2015 International Building Code)
- ↕ 2017 Ohio Fire Code (amended 2015 International Fire Code)
- ↕ NFPA 13-16
- ↕ NFPA 72-16

<https://www.columbus.gov/bzs/getting-started/Codes/>

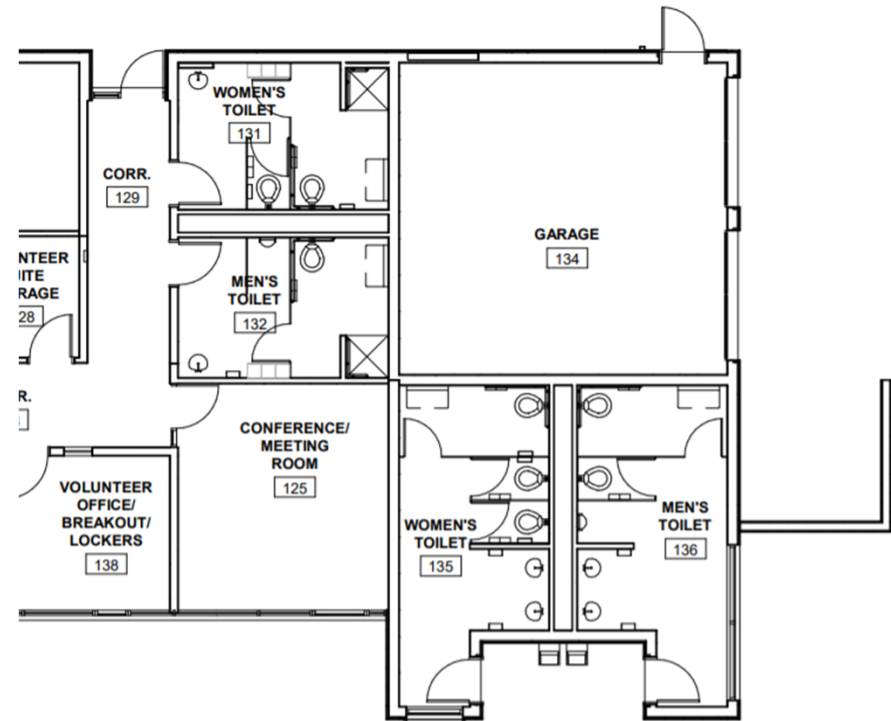
# Occupancy Classifications



Mixed-use  
nonseparated  
occupancies  
IBC §508.3

# Special Use Occupancy: Private Car Port (§406)

- ↑▼ 7' clear height
- ↑▼ Non-combustible and non-absorbent floor surfaces
- ↑▼ No fuel dispensing
- ↑▼ No more than 1,000 sf
- ↑▼ Separation from building in accordance with §508.1.



# Construction: IIB

Non-combustible unprotected primary structural frame  
Fire Separation Distance > 30'  
No rated members required per Table 602



Component	Materials
Columns	Unprotected Steel Square Tube
Beams	Unprotected Steel I-Beams
Floor	Cast-In-Place Concrete
Roof	Fire-Treated Wood Paneling
Exterior Walls	Fire-Treated Wood-Panel on Metal Stud and Non-Rated Glazing
Interior Walls	Gypsum Wall Board
Partitions	8" Fire-Treated Wood

Fire-treated-wood wall and ceiling construction present in non-bearing exterior walls and roof construction, per §603.1.



# Allowable Height and Areas

Most Restrictive  
Occupancy: A-2  
Construction Type: IIB  
Single Story, Sprinkler  
Protected per NFPA 13

Measurement	Allowable	Actual
Height [ft]	75	21
Height [stories]	3	1
Area [sf]	38,000	17,717



1. REFER TO THE COVER SHEET FOR ARCHITECTURAL GENERAL NOTES.
2. CONTRACTOR TO PROVIDE BLOCKING IN PARTITIONS FOR PARTITIONING.
3. INDICATED ITEMS AS INDICATED. CONTRACTOR ALSO TO DETERMINE QUANTITY AND LOCATIONS WITH THE OWNER FOR OWNER FURNISHED / CONTRACTOR INSTALLED ITEMS.
4. PARTITIONING ARE TYPE PL UNLESS NOTED OTHERWISE.
5. PARTITIONING TYPES ARE INDICATED BY PL, PL, ETC. AS SHOWN ON THE SCHEDULED PLANS. SEE #4 FOR PARTITION TYPES AND DETAILS.
6. FLOOR ACCESSORY TYPES ARE INDICATED BY TUM AS SHOWN ON THE CALCULATED PLANS, RESUME ON DIMENSIONAL PLANS, AND/OR ON THE EXTERIOR ELEVATIONS. REFER TO SPECIFICATION SECTION 05 20 FOR SCHEDULES AND ALL OTHER SCHEDULES FOR FINISHES, CEILING HEIGHTS, AND OTHER CEILING INFORMATION.
7. SEE #4 SCHEDULES FOR FINISHES, CEILING HEIGHTS, AND OTHER CEILING INFORMATION.
8. REFER TO SHEET #02 FOR EXTERIOR SCHEDULES AND ALL OTHER SCHEDULES FOR FINISHES, CEILING HEIGHTS, AND OTHER CEILING INFORMATION.
9. USE EXTERIOR ELEVATIONS FOR EXTENT OF EXTERIOR GLAZING.
10. ALL WOOD BLOCKING TO BE FIRE TREATED, TYP.

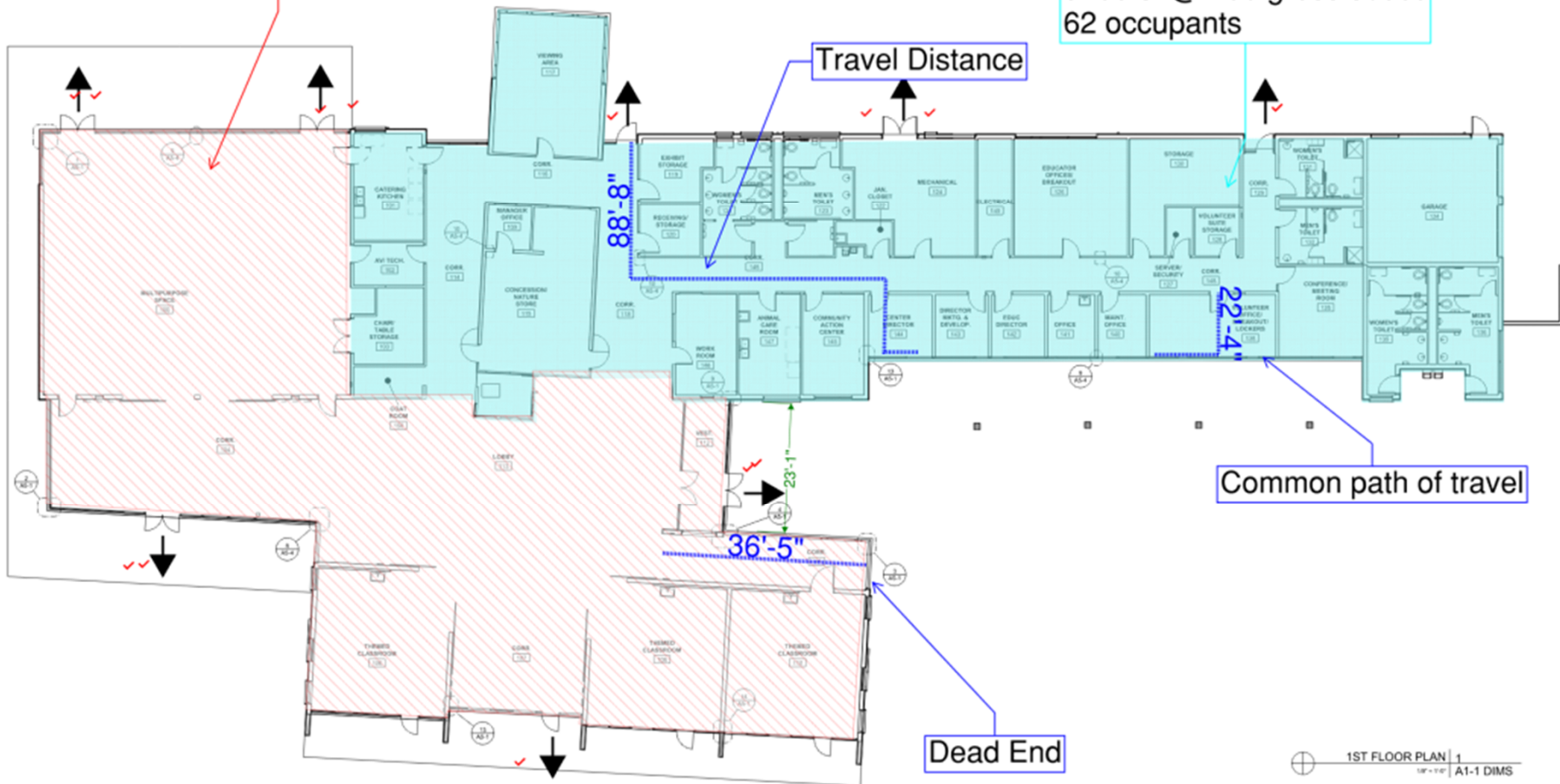
# Egress Systems

632 occupants total -> 3 exits required  
 0.2 in/occ -> 127" of exit width required  
 8 exits provided with 320"

Egress Component Limits  
 Travel Distance = 250'  
 Common Path of Travel 75'  
 Dead-End Corridor = 20'

Unconcentrated Tables and Chairs  
 8,551 sf @ 15 net sf/occ  
 570 occupants

Business Areas  
 9155 sf @ 150 gross sf/occ  
 62 occupants



# Fire Alarm System

Group A with greater than 300 occupants but fewer than 1000 occupants

→ Manual Fire Alarm System required (§907.2.1)



## Initiating Devices:

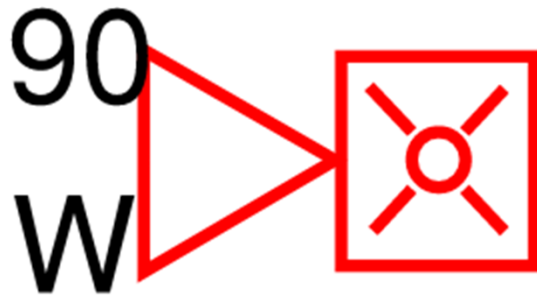
Manual pull station, flow detectors, and smoke detection for FACP

## Notification Devices:

Audible and visual

# FA: Audible Appliances

15 dBA above average  
sound level



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

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



# FA: Visual Appliances

Visual devices will be installed in all public use and common areas.

Single occupant offices do not require visual notification

Corridor strobes spaced apart 100' maximum, at 185 cd.



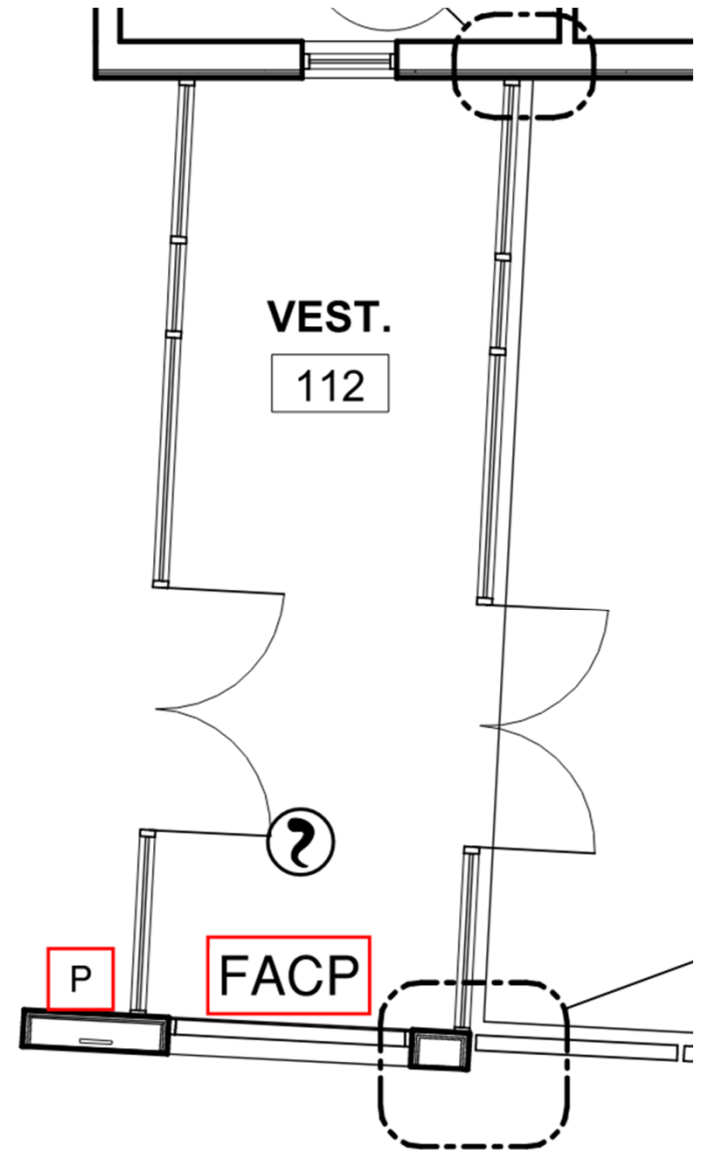
# FA: Control Panel

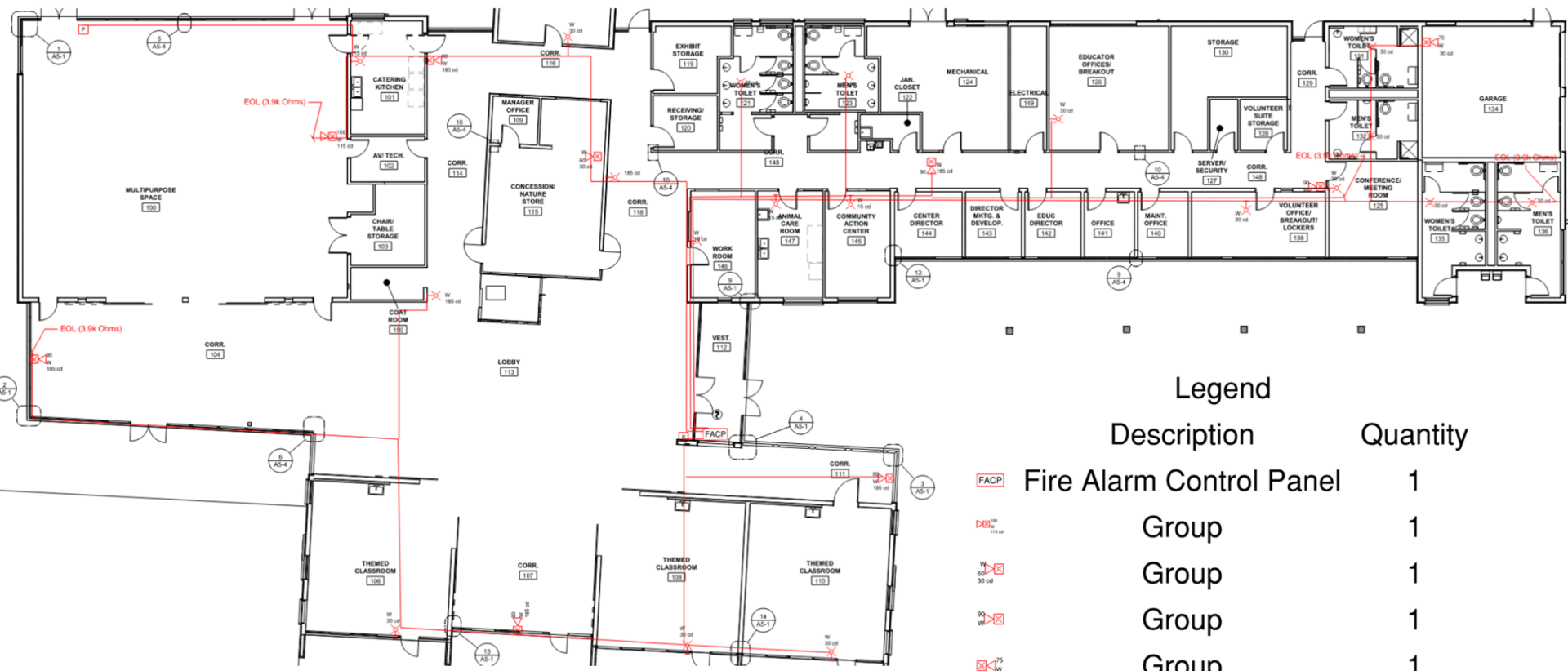
Monitors initiating signals and relays activation of all notification appliances

No zoned activation

Able to display supervisory and trouble signals as needed

Building map and egress paths posted on wall





### Legend

Description	Quantity
FACP	1
Group	1
Group	1
Group	1
Group	1
Group	2
Group	3
Manual Pull Station	2
Smoke Detector	1
Strobe (Wall Mount)	13
Strobe Only	6

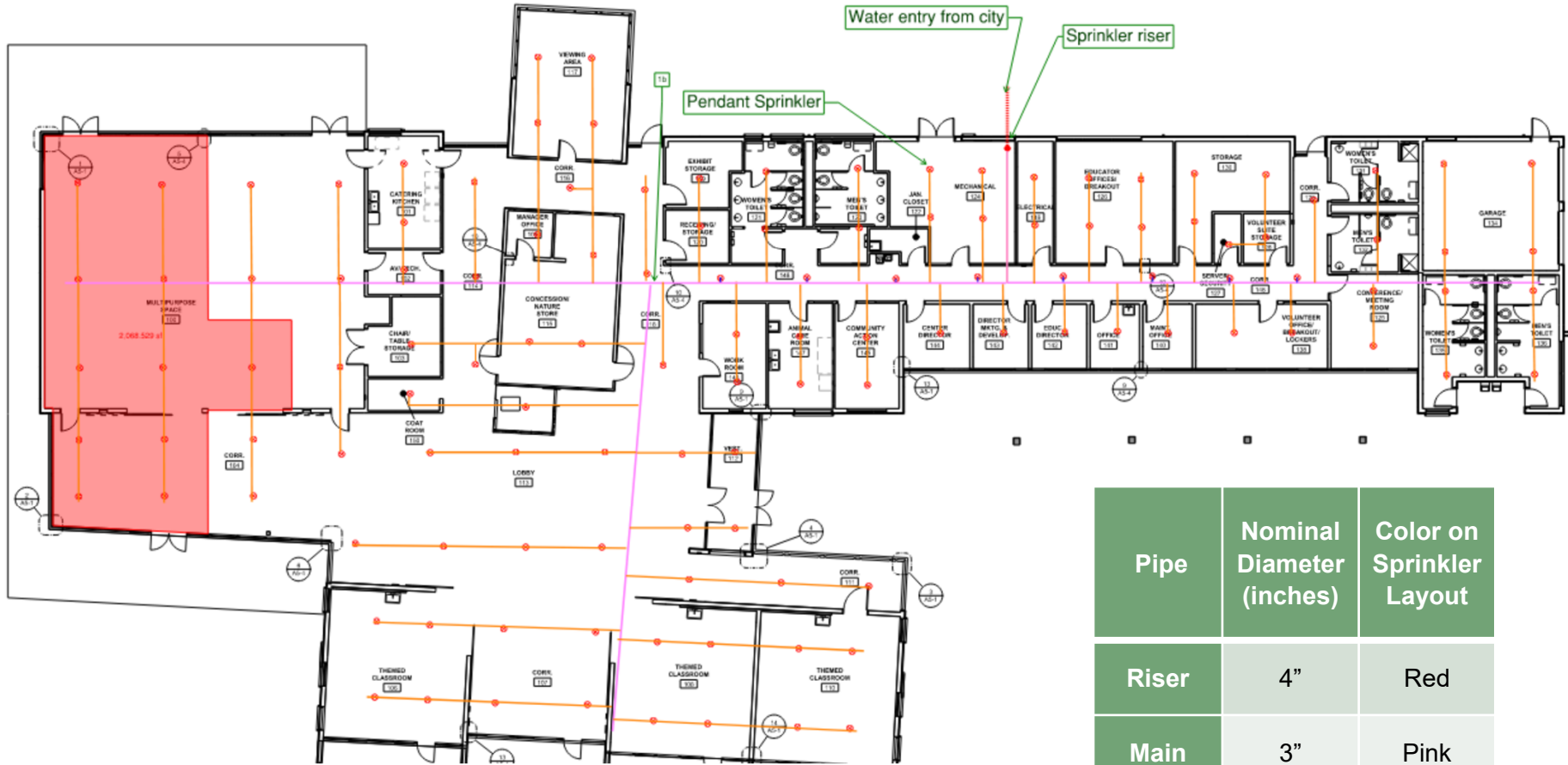
# Fire Suppression System

	Light Hazard	Ordinary Hazard Group 1
Uses or Functions	Lobbies, Areas	Mechanical/Electrical, Storage Use (under 8')
Design Density (gpm/ft <sup>2</sup> ) :	0.10	0.15
Area of Operation (ft <sup>2</sup> ) :	1500	1500
Hose Demand (gpm) :	100	250
Duration (min) :	30	60





# Fire Suppression System



Pipe	Nominal Diameter (inches)	Color on Sprinkler Layout
Riser	4"	Red
Main	3"	Pink
Branches	1.25"	Orange

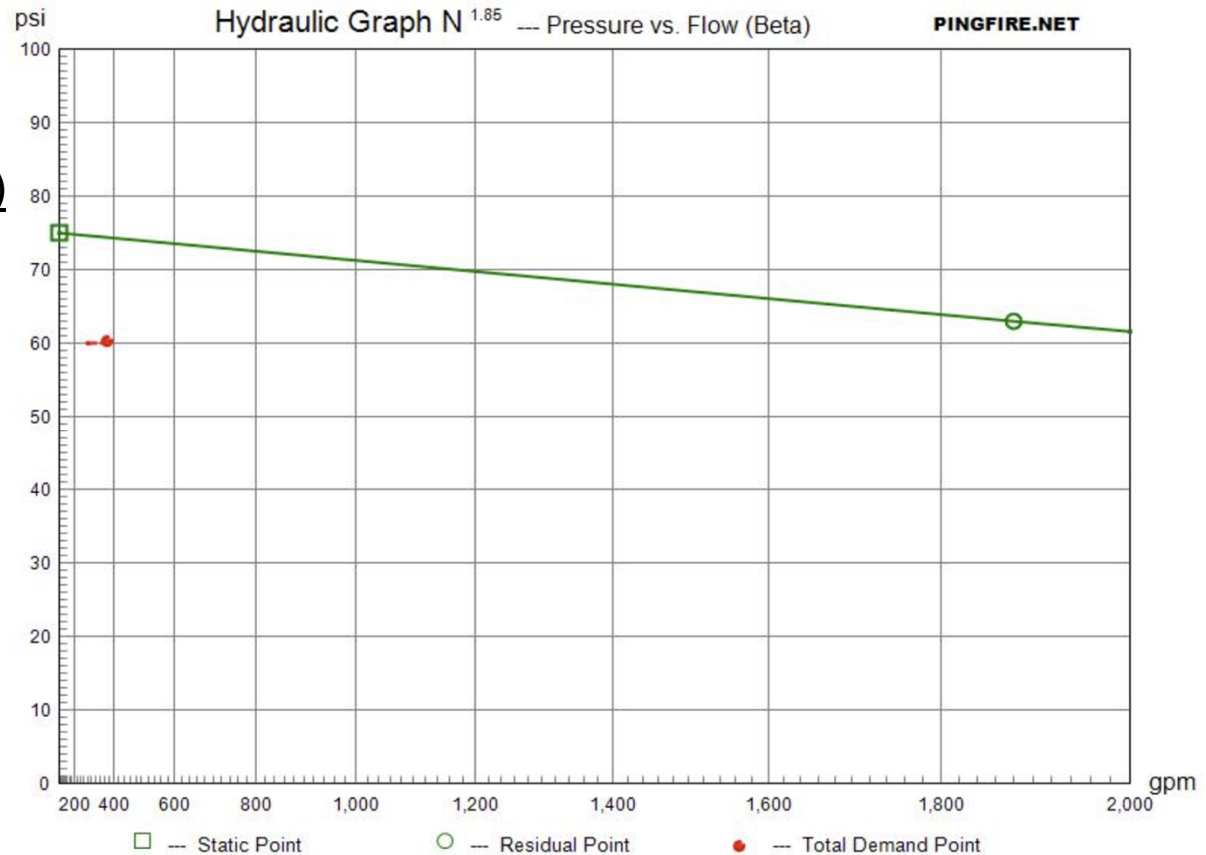
# Fire Suppression System

## Available Water (w/ 10% Pressure Reduction)

75 psi Static  
63 psi Residual @ 1880 gpm

## Required Water

60 psi @ 281 gpm  
+100 gpm hose stream



# Smoke Control System

None Required

# Interior Finish

Wall and Ceiling Finish: ASTM E84 Flame Spread Index

Floor Covering: NFPA 253 Critical Radiant Flux

Occupancy Group	Corridors	Rooms & Enclosed Spaces
A-2	B II	C II
B	C II	C II

# Summary

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## Performance Based

- Design Fires
- Fire Modeling
- Egress Modeling
- RSET vs ASET



# Performance Based Analysis Goals and Objectives

## ▶ NFPA 101

### ◦ Section 4.1: Goals

- Protection of occupants not intimate with the initial fire development
- Improvement of the survivability of occupants intimate with the initial fire development

### ◦ Section 4.2: Objectives

- Occupant Protection
- Structural Integrity
- Hazardous Material Emergencies
- Security Features
- Systems Effectiveness

# Design Fires

- ▶ DF1: Multipurpose Room Table Fire
  - Highest fuel load
  - Longest sprinkler activation time
- ▶ DF2: Kitchen Cabinet Fire
  - Most like scenario
- ▶ DF3: Lobby Furniture Fire
  - Impedes egress
  - Highest soot yields
- ▶ Varying Heat Release Rates and Byproducts

# Performance Based Analysis

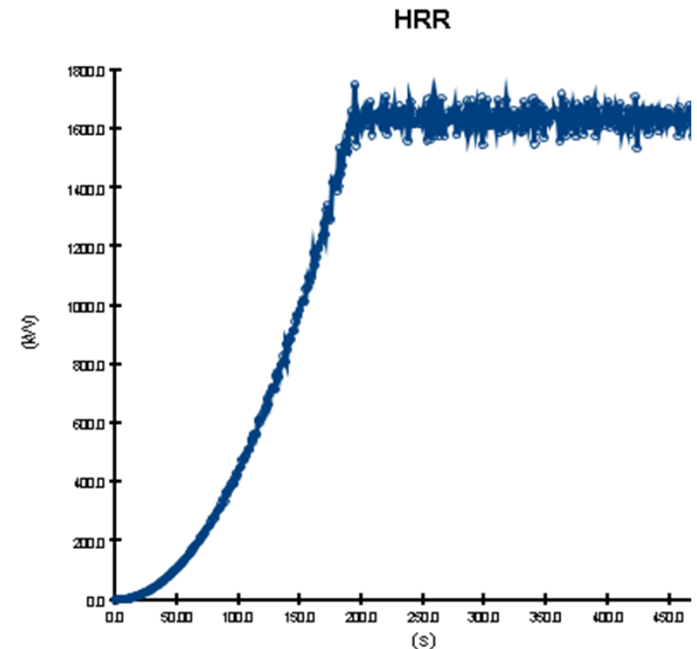
## Design Fire 1



# Performance Based Analysis

## Design Fire 1

- ▶ Heat Release Rate
  - “Fast” t-squared growth rate
    - $\alpha = 0.0444 \text{ kW/s}^2$
  - Sprinkler Controlled
- ▶ Byproduct Yields
  - Polyethylene (SFPE HB A.39)
  - CO = 0.007 g/g
  - Soot = 0.060 g/g

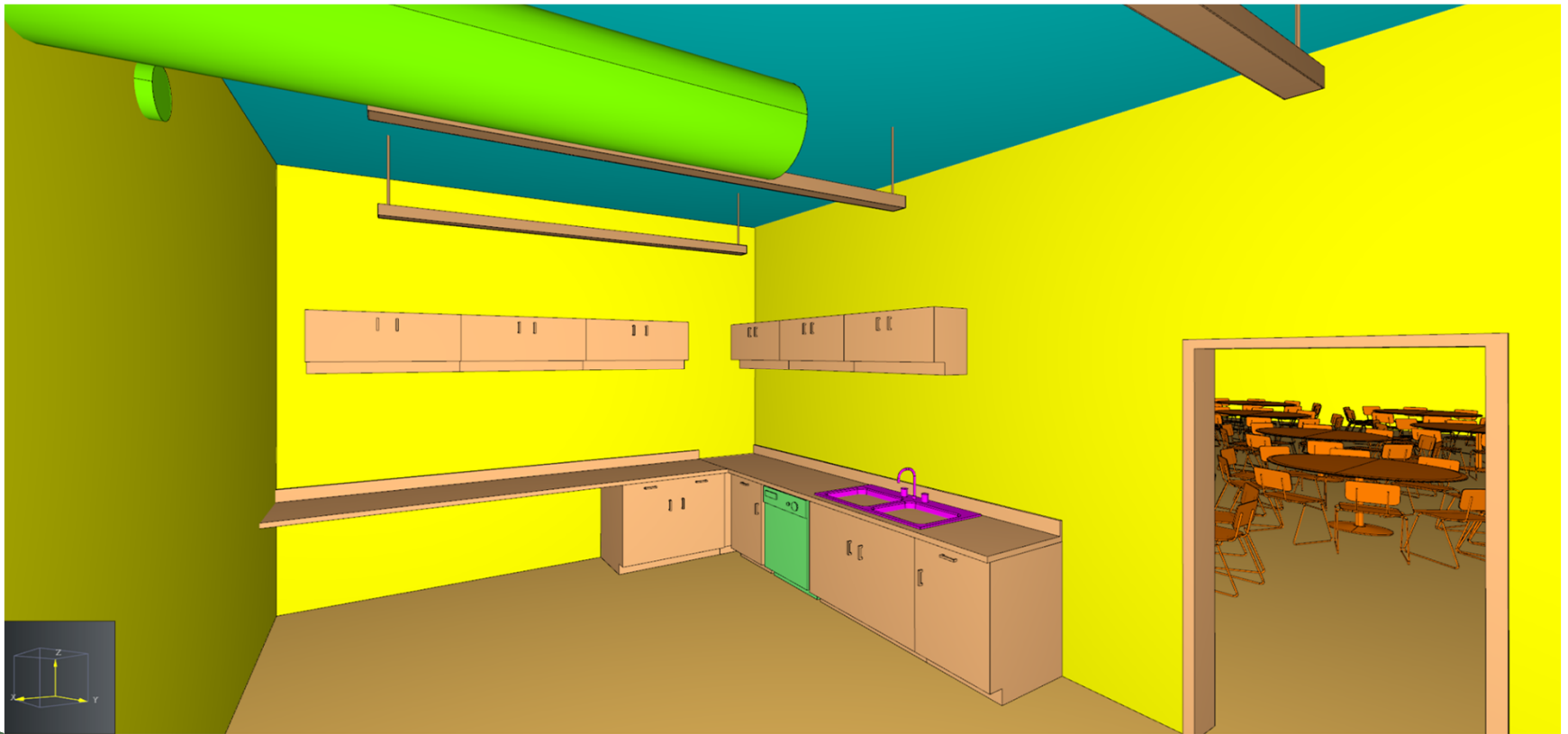


*Synthetic materials–solids* (abbreviations/names in the nomenclature)

ABS <sup>b</sup>	–	–	–	–	0.105	30.0	–	–
POM	15.4	1.40	0.001	0.001	–	14.4	11.2	3.2
PMMA	25.2	2.12	0.010	0.001	0.022	24.2	16.6	7.6
PE	43.6	2.76	0.024	0.007	0.060	38.4	21.8	16.6

# Performance Based Analysis

## Design Fire 2







## Byproduct Yields

CO = 0.052 g/g (NIST FCD)

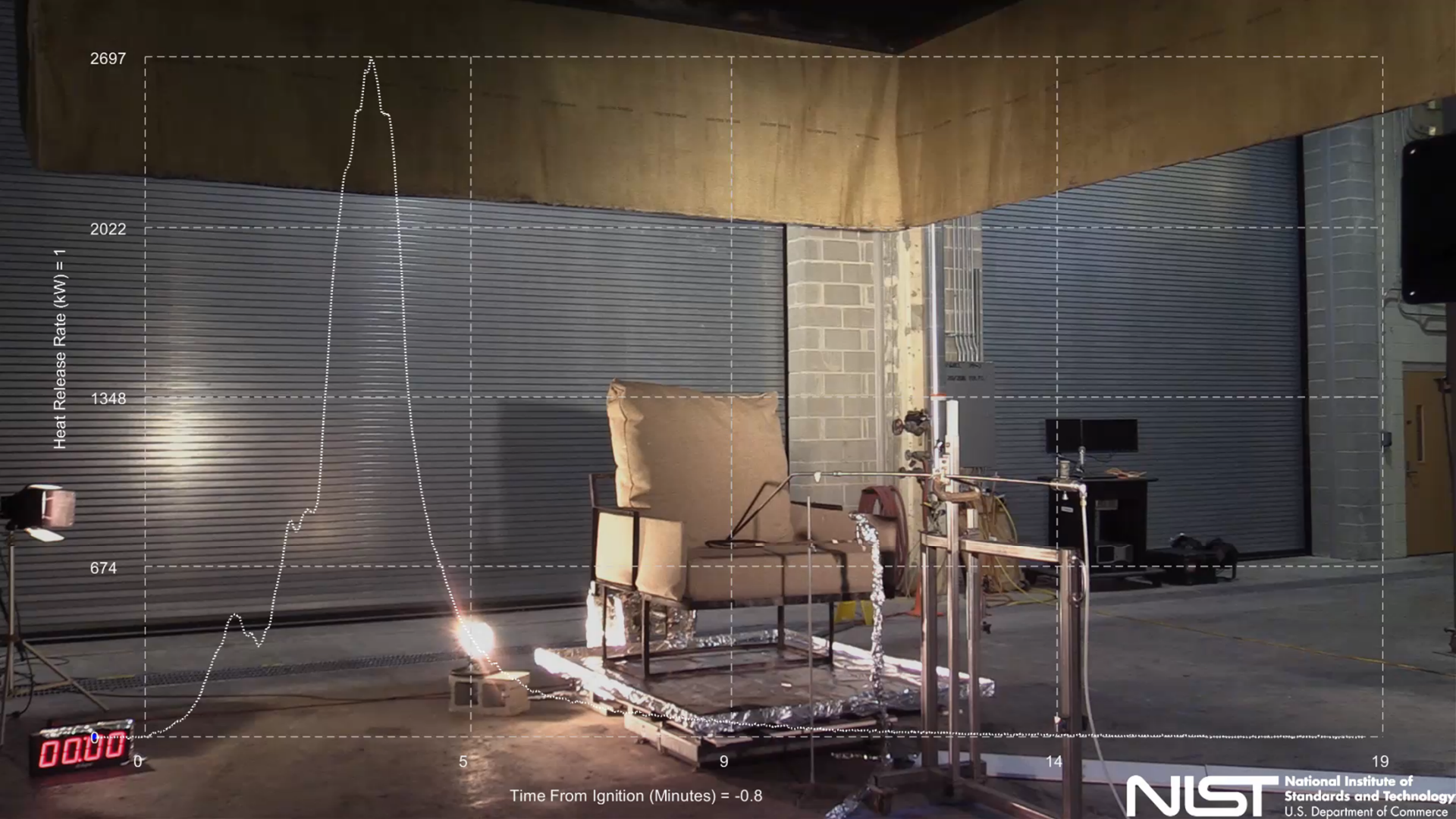
Soot = 0.015 g/g (SFPE HB Table A.39)

# Performance Based Analysis

## Design Fire 3





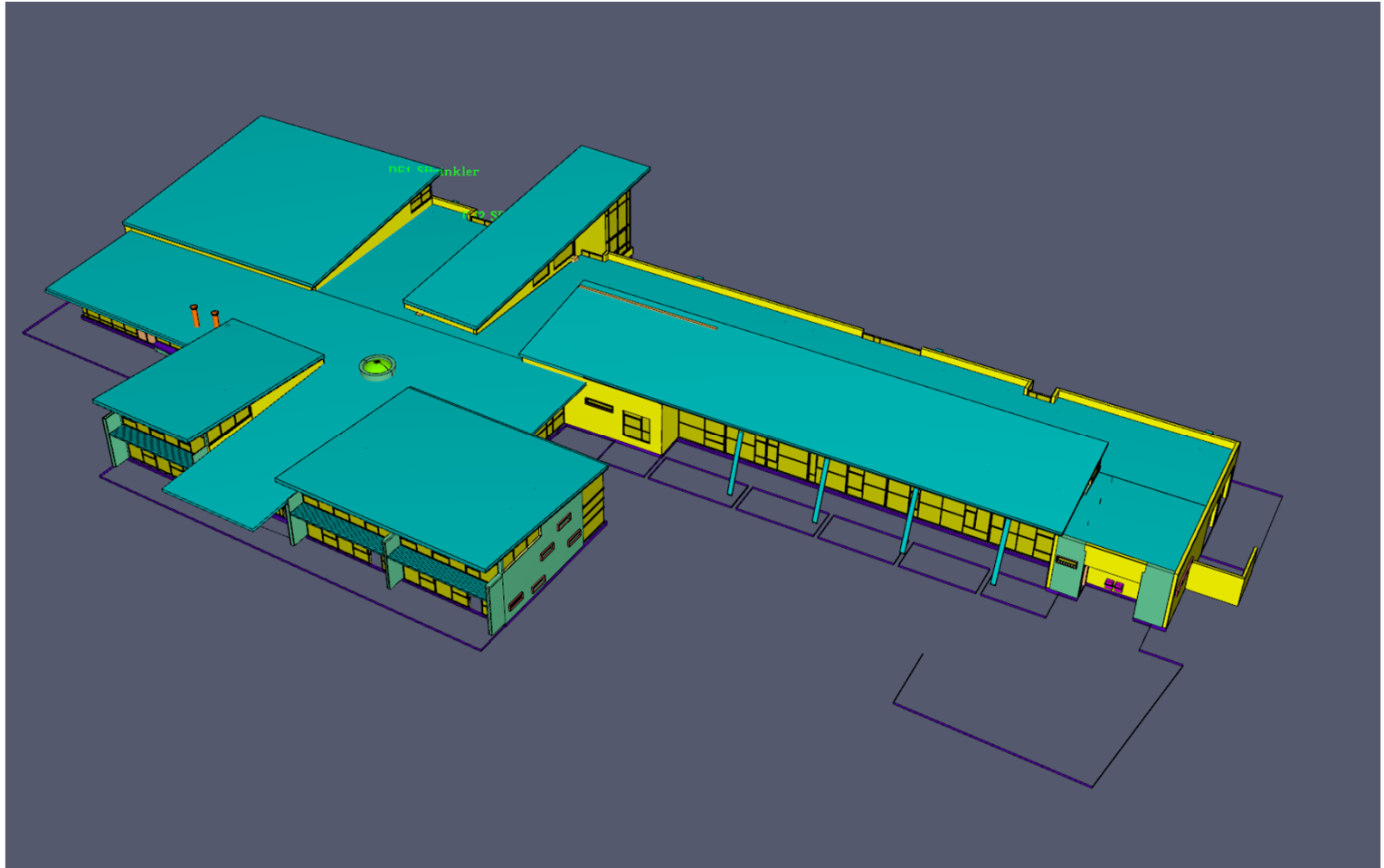


### Byproduct Yields (NIST FCD)

CO = 0.02124 g/g

Soot = 0.083

# Performance Based Analysis (Pyrosim)



# Pyrosim

$$D^* = \left( \frac{\dot{Q}}{\rho_\infty c_p T_\infty \sqrt{g}} \right)^{2/5}$$

Enter the x, y, z dimensions (meters) and your expected HRR

X <sub>min</sub>	<input type="text" value="0"/>	X <sub>max</sub>	<input type="text" value="84"/>
Y <sub>min</sub>	<input type="text" value="0"/>	Y <sub>max</sub>	<input type="text" value="45"/>
Z <sub>min</sub>	<input type="text" value="0"/>	Z <sub>max</sub>	<input type="text" value="6.5"/>

Heat Release Rate (Q)  kW

Density (ρ<sub>∞</sub>)  kg / m<sup>3</sup>

Specific Heat (c<sub>p</sub>)  kJ / kg-K

Ambient Temperature (T<sub>∞</sub>)  K

Gravity (g)  m / s<sup>2</sup>

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The characteristic fire diameter D\* is 1.488

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## Coarse



When D\*/dx = 4: the suggested coarse cell size is 37.2 cm

Your MESH line for FDS is:

**&MESH IJK=225,120,18, XB=0,84,0,45,0,6.5 /**

You entered:

X<sub>min</sub>: 0 X<sub>max</sub>: 84

Y<sub>min</sub>: 0 Y<sub>max</sub>: 45

Z<sub>min</sub>: 0 Z<sub>max</sub>: 6.5

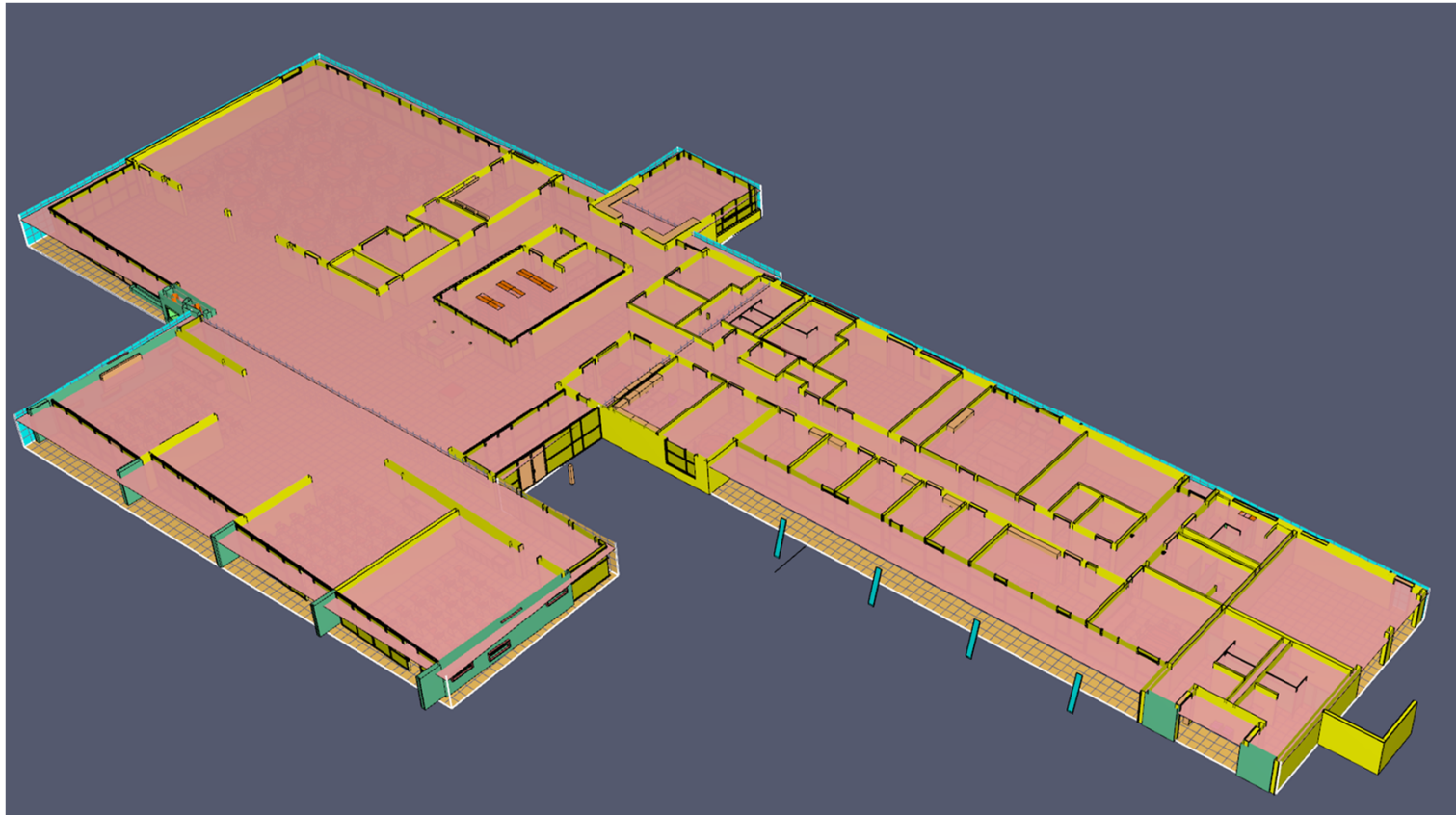
dx: 0.372

Near Combustion Reaction: 0.1 m Grid Size  
Away From Reaction: 0.2 m Grid Size



# Pyrosim

## Slice Files



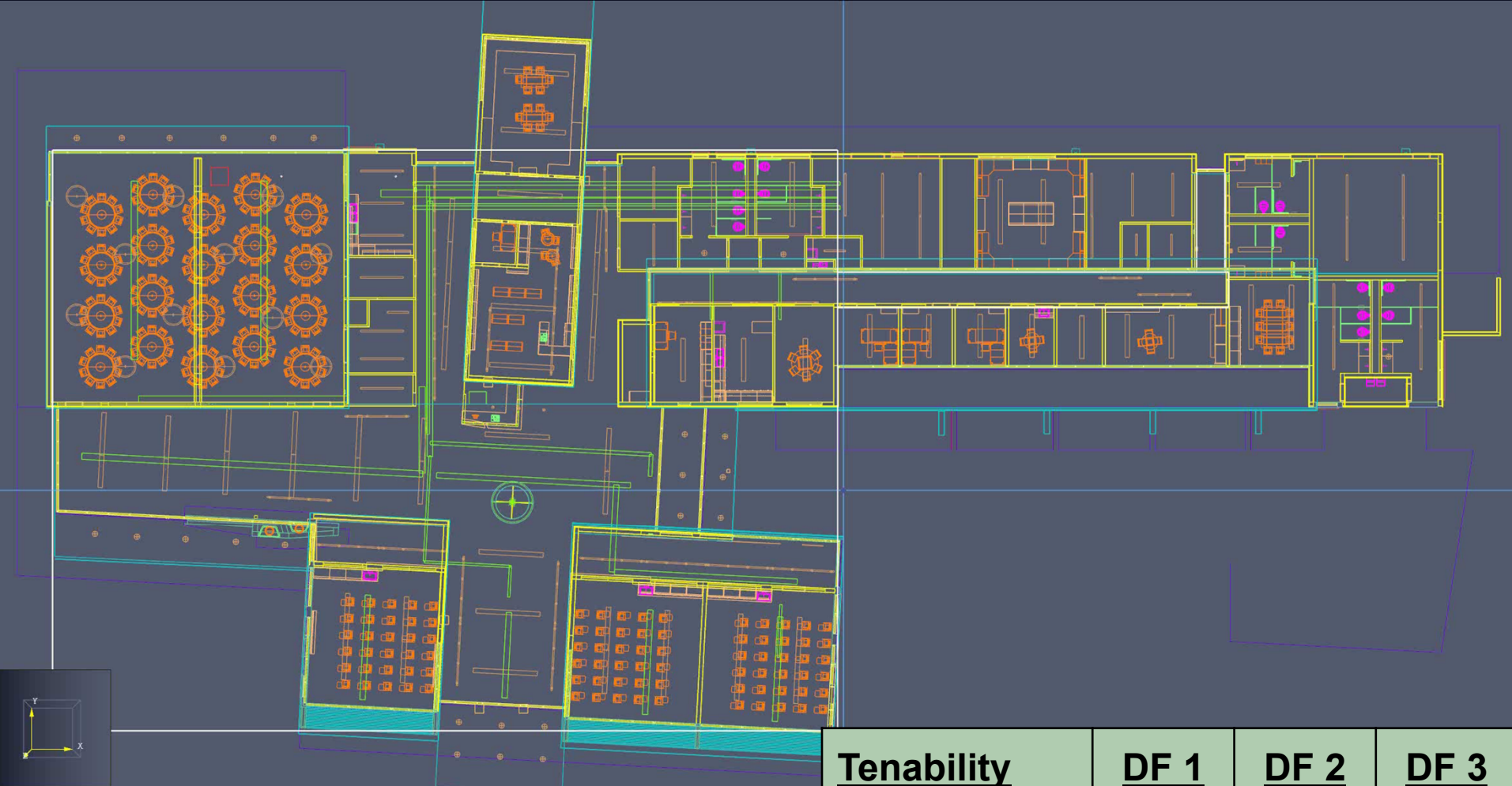
# Tenability Criteria

## SFPE Guide To Human Behavior In Fire

“Simply selecting a fixed... threshold does not provide engineering certainty that an individual can or cannot escape or evacuate through smoke”

### Conservative Values Selected

<u>Criteria</u>	<u>Threshold</u>	<u>Source</u>
Temperature	60 °C	Table 7.6
Carbon Monoxide Concentration	1750 ppm	Table 7.1
Visibility	10 m	Section 5.2

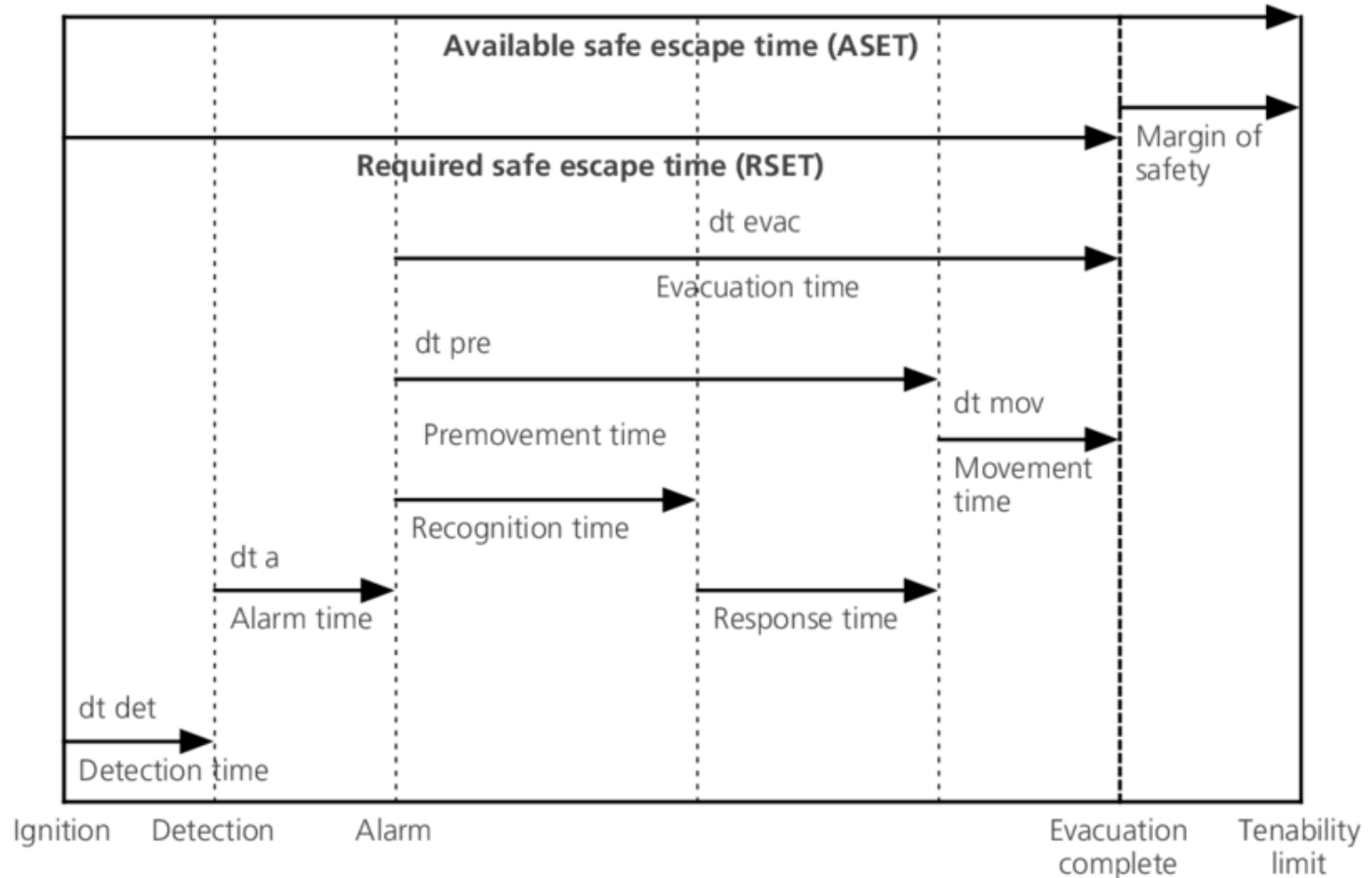


# Fire Modeling Results

<b>Tenability</b>	<b><u>DF 1</u></b>	<b><u>DF 2</u></b>	<b><u>DF 3</u></b>
Temperature	N/A	N/A	N/A
CO Concentration	N/A	N/A	N/A
Visibility	3	N/A	2.5

**All units in minutes**

# Performance Based Analysis (RSET vs ASET)



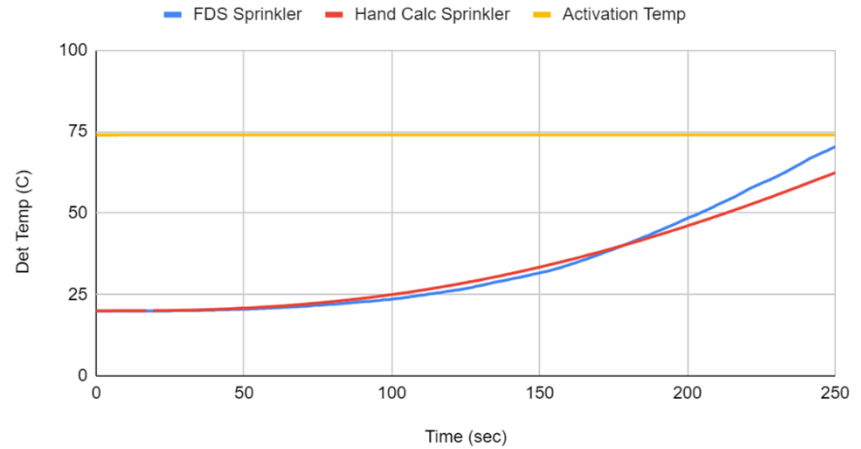
# Performance Based Analysis (Device Activation)

## Sprinkler Water Flow Switches

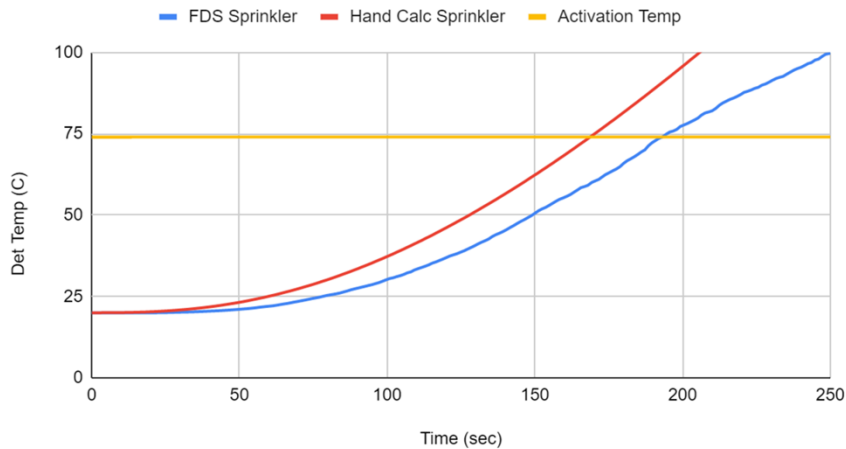
RTI = 50 ms<sup>1/2</sup>

Act. Temp = 135 °F

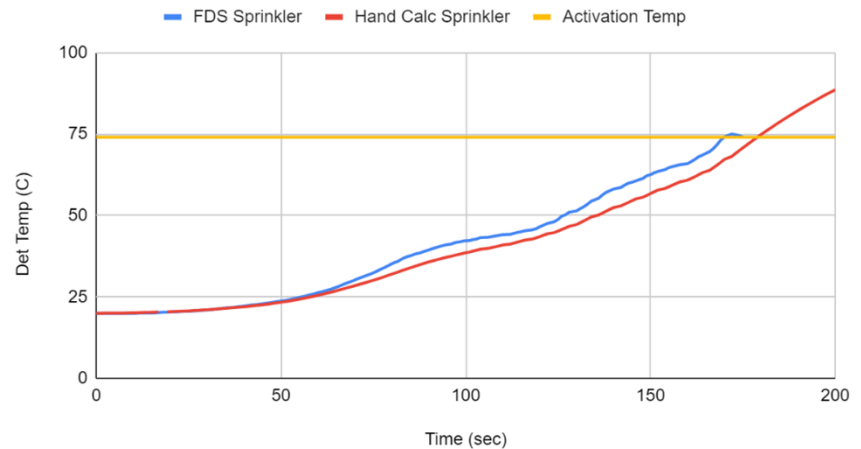
DF2



DF1



DF3





# Performance Based Analysis (Egress Modeling)

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

Event description	N	Min	1st Q	Median	3rd Q	Max	Mean	Factors
High-rise hotel	536	0	3.3	60.0	130.9	290	NA	MGM Grand Hotel fire, no alarm notification, grouped data from questionnaires
High-rise hotel	47	0	2.0	5.0	17.5	120	NA	Westchase Hilton Hotel fire, no alarm in early stages, grouped data from questionnaires
High-rise office building	85	0	2.0	5.0	10.0	245	11.3	World Trade Center explosion and fire, no alarm notification (building closer to explosion)
High-rise office building	46	0	4.5	10.0	31.5	185	28.4	World Trade Center explosion and fire, no alarm notification (building farther from blast)
High-rise office building	107	1.0	1.0	1.0	1.0	≈6.0	NA	Fire incident, no alarms, data from interviews with occupants of four floors of building (11 interviewees were trapped)
High-rise office building	12	0.5	NA	1.0	NA	2.3	1.2	Unannounced drill on three floors; data for first person to reach each of four stairwell doors to wait for voice instruction; trained staff; data from video recordings
Mid-rise office building	92	0	0.4	0.6	0.8	<4	0.6	Unannounced drill, good alarm performance; fire wardens; warm day
Mid-rise office building	161	0	0.5	0.9	1.4	<5	1.1	Unannounced drill, good alarm performance; fire wardens; cool day
One-story department store	95	1	0.2	0.3	0.5	0.9	0.4	Unannounced drill; trained staff; data here derived from grouped data for 95 participants
Three-story department store	122	0.05	NA	NA	NA	1.6	0.6	Unannounced drill; trained staff; times distilled from analysis of videotapes
One-story department store	122	0.07	NA	NA	NA	1.7	0.5	Unannounced drill; trained staff; times distilled from analysis of videotapes
One-story department store	71	0.03	NA	NA	NA	1.0	0.4	Unannounced drill; trained staff; times distilled from analysis of videotapes
High-rise apartment building	NA	0	NA	NA	NA	NA	10.5	Forest Laneway fire; for occupants who attempted to evacuate in the first hour, based on questionnaire responses
	219	0	NA	187.8	NA	720	190.8	Forest Laneway fire, for all occupants
High-rise apartment building	33	0.3	0.8	1.3	4.4	10.2	2.8	Unannounced drill; good alarm performance
High-rise apartment building	93	0.4	1.5	3.6	6.9	18.6	5.3	Unannounced drill; good alarm performance; heavy snow during drill
High-rise apartment building	27	1.0	2.0	8.0	14.0	>20	NA	Fire incident in early morning, alarm functioned, fewer than half the occupants evacuated
Mid-rise apartment building	42	0.6	1.0	1.4	3.0	>14	2.5	Unannounced drill; good alarm performance
Mid-rise apartment building	55	>0.5	1.6	4.4	13.5	>21	8.4	Unannounced drill; poor alarm performance
Mid-rise apartment building	77	>0.3	1.9	7.7	19.1	>24	9.7	Unannounced drill; poor alarm performance
Mid-rise apartment building	80	>0.3	1.2	2.5	3.7	>12	3.1	Unannounced drill; good alarm performance
Training facility	566	<0.2	0.7	1.1	1.5	>5	NA	Testing sleeping subjects at a training facility

NA not reported

# Performance Based Analysis (Egress Modeling)

Exited: 0 / 539



# Performance Based Analysis (RSET vs ASET)

<u>RSET</u>	<u>DF 1</u>	<u>DF 2</u>	<u>DF 3</u>
Detection	193	260	172
Alarm	10	10	10
Premovement	30	30	30
Movement	75.8	75.8	108.8
<b>Total (x1.5 SF)</b>	<b>7.5 min</b>	<b>9.1 min</b>	<b>7.8 min</b>
<u>ASET</u>	<u>DF 1</u>	<u>DF 2</u>	<u>DF 3</u>
	>20 min	>20 min	>20 min
All units in seconds unless otherwise specified			

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# Recommendations

- ▶ Prescriptive
  - Dead-end corridor
  - Maintain regular ITM frequency
- ▶ Performance Based
  - Measure ambient sound levels
  - Potential blocking of exits
  - Avoid open flames / burners



# Questions/Comments?

