Mayo Clinic Specialties Building
(MCS Building)

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FPE 596
Spring 2016
Building Description

- Located in Phoenix, Arizona

- Construction completed in 2004
  - Built/designed under the 2000 edition of the IBC
  - Analysis performed using 2012 IBC

- Connected to an adjoining hospital with walkways on each story

- MCS Building and hospital not considered separate buildings due to 2-hour fire barrier. Need 3-hour rating (IBC Section 706)
Heights and Areas

- Only the MCS Building is analyzed, using the 2012 edition of the IBC
- 63 feet tall (concourse floor to penthouse roof)

<table>
<thead>
<tr>
<th>Floor Areas</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concourse</td>
<td>41,524 sq. ft.</td>
</tr>
<tr>
<td>1st</td>
<td>40,887 sq. ft.</td>
</tr>
<tr>
<td>2nd</td>
<td>40,336 sq. ft.</td>
</tr>
<tr>
<td>3rd</td>
<td>37,634 sq. ft.</td>
</tr>
<tr>
<td>Penthouse</td>
<td>12,395 sq. ft.</td>
</tr>
</tbody>
</table>

Occupancy Classifications

- Building consists mainly of medical offices and outpatient clinics
- IBC: Group B Occupancy (IBC Section 304.1)
- Southwest corner of the concourse level contains in-patient treatment area
- 5 or fewer treated at a time, so R-3 (IBC Section 310.5)
- However, designed to Group I-2 Occupancy
Occupancy Classifications

CONCOURSE FLOOR

LEGEND

- GROUP B (MEDICAL OFFICES, OUTPATIENT CLINICS)
- ACCESSORY OR INCIDENTAL
- ELEVATORS (NOT FOR EGRESS)
- GROUP 1–2 (INPATIENT TREATMENT)
- INTERIOR EXIT STAIRWAYS
- EXIT ACCESS
- HORIZONTAL EXIT
- STAIRWAY (NOT FOR EGRESS)
- GROUP S–2, ACCESSORY TO GROUP B

NOTE: DASHED RED LINE INDICATES HORIZONTAL EXIT DIVIDING FLOOR.
Occupancy Classifications

FIRST FLOOR

LEGEND
- **GROUP B** (MEDICAL OFFICES, OUTPATIENT CLINICS)
- ACCESSORY OR INCIDENTAL
- ELEVATORS (NOT FOR EGRESS)
- GROUP 1-2 (INPATIENT TREATMENT)
- INTERIOR EXIT STAIRWAYS
- EXIT ACCESS
- HORIZONTAL EXIT

NOTE: DASHED RED LINE INDICATES HORIZONTAL EXIT DIVIDING FLOOR.

- STAIRWAY (NOT FOR EGRESS)
- **GROUP S-2**, ACCESSORY TO **GROUP B**
Occupancy Classifications
Construction Type

- MCS Building consists of Type 1-A construction
- Unlimited height, unlimited area (IBC Table 503)
- Primary structure composed of steel elements
## Construction Type

<table>
<thead>
<tr>
<th>Element</th>
<th>Design</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columns</td>
<td>W12 shapes, UL-X771, 3-hour</td>
<td>3 hours</td>
</tr>
<tr>
<td>Floor Structural</td>
<td>W21 &amp; W24 shapes, UL-N708, 3-hour, unrestrained beam rating</td>
<td>3 hours</td>
</tr>
<tr>
<td>Floor Secondary</td>
<td>W16 shapes, UL-D902, 2-hour, restrained assembly</td>
<td>2 hours</td>
</tr>
<tr>
<td>Roof Structural</td>
<td>W21 &amp; W24 shapes, UL-S735, 3-hour, unrestrained beam rating</td>
<td>3 hours</td>
</tr>
<tr>
<td>Roof Secondary</td>
<td>W16 shapes, UL-D902, 2-hour, restrained assembly</td>
<td>1 ½ hours</td>
</tr>
<tr>
<td>Floor/Roof Deck Assemblies</td>
<td>UL-D916, 2-hour, restrained assembly</td>
<td>2 hours</td>
</tr>
<tr>
<td>Exterior Walls</td>
<td>Rating not required, separation greater than 30 feet</td>
<td>N/R</td>
</tr>
<tr>
<td>Typical 2-Hour Walls (horizontal exits, stair enclosures use ½”)</td>
<td>5/8” type-X gypsum wallboard, 2-½” steel studs 24” o.c., face layer 5/8” type-X gypsum wallboard</td>
<td>2 hours</td>
</tr>
</tbody>
</table>
Suppression Systems

- Group I Fire Area: Required to be equipped throughout with an automatic sprinkler system (903.2.6)

- Quick-response sprinklers in light-hazard areas (903.3.2)

- No special hazard systems (kitchen hoods, gaseous suppression, water mist, etc)
Suppression Systems

- Sprinkler system design criteria (wet system)
- Automatic water supply type, connection to public water system
- Water Supply: 75 psi static, 70 psi residual, with 2430 GPM flowing

- **Light Hazard Occupancy**: Offices, exam rooms, corridors
  - 0.1 GPM/1500 sq. ft., 225 sq. ft. head coverage, 165°F temperature rating

- **Ordinary Hazard Group 1**: Elevator machine rooms, mechanical rooms
  - 0.15 GPM/1500 sq. ft., 130 sq. ft. head coverage, 286°F temperature rating

- 100 GPM hose allowance (L.H.), 250 GPM hose allowance (O.H.)
Suppression Systems

THIRD FLOOR
Suppression Systems
Suppression Systems

WATER SUPPLY ANALYSIS
Static: 75.00 psi Resid: 70.00 psi Flow: 2430.0 gpm

LEGEND
1. Available pressure
74.78 psi @ 446.1 gpm
2. Required pressure
69.20 psi @ 446.1 gpm

A. Source Supply Curve
B. System Demand Curve

Note: (1) Dashed Lines indicate extrapolated values from Test Results
(2) On Site pressures are based on hose stream deduction at the source
Egress System (floor basis)

- Each floor has occupant load between 501 and 1,000
- 3+ exits provided for each floor
- 2 enclosed interior exit stairs provided
- The north staircase is NOT used for egress, not an interior exit stairway
- This staircase has a 2-hour separation provided by a horizontal sliding fire door assembly at each level
Egress System (floor basis)

- The horizontal exit to the adjoining hospital is used to satisfy the required number of exits on each floor.

- A horizontal exit is also provided on each floor dividing the floor roughly in half.

- These horizontal exits are included to facilitate evacuation of non-ambulatory patients (possible future hospital expansion).

- Fire doors are automatic-closing in horizontal exits when activated via smoke detection (IBC Section 716.5.9.3).
Third Level
<table>
<thead>
<tr>
<th>Component</th>
<th>Effective Width, ft.</th>
<th>Specific Flow, p/ft²*min</th>
<th>Flow Rate, p/min</th>
<th>Velocity, ft/min</th>
<th>Number of Components</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concourse Floor (541 occupants)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Corridor leading to Stairway or Horizontal Exit</td>
<td>5.08</td>
<td>24.0</td>
<td>121.9</td>
<td>137.4</td>
<td>N/A</td>
</tr>
<tr>
<td>Door through Horizontal Exit</td>
<td>2.50</td>
<td>24.0</td>
<td>60.0</td>
<td>137.4</td>
<td>1</td>
</tr>
<tr>
<td>Door into Southwest and Northeast Stairways</td>
<td>2.00</td>
<td>24.0</td>
<td>48.0</td>
<td>137.4</td>
<td>1 each</td>
</tr>
<tr>
<td>Southwest/Northeast Stairway</td>
<td>2.67</td>
<td>18.5</td>
<td>49.4</td>
<td>105.9</td>
<td>N/A</td>
</tr>
<tr>
<td>Stairway Discharge Door</td>
<td>2.00</td>
<td>24.0</td>
<td>48.0</td>
<td>137.4</td>
<td>1 each</td>
</tr>
<tr>
<td><strong>First Floor (572 occupants)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Corridor leading to Stairway or Horizontal Exit</td>
<td>5.08</td>
<td>24.0</td>
<td>121.9</td>
<td>137.4</td>
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<td>24.0</td>
<td>48.0</td>
<td>137.4</td>
<td>1 each</td>
</tr>
<tr>
<td>Main Building Exit</td>
<td>8.0 (for 4 doors)</td>
<td>24.0 (for a door)</td>
<td>192.0 (total)</td>
<td>137.4</td>
<td>4 doors total</td>
</tr>
<tr>
<td><strong>Second Floor (513 occupants)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Corridor leading to Stairway or Horizontal Exit</td>
<td>5.08</td>
<td>24.0</td>
<td>121.9</td>
<td>137.4</td>
<td>N/A</td>
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</tr>
<tr>
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<td>24.0</td>
<td>48.0</td>
<td>137.4</td>
<td>1 each</td>
</tr>
<tr>
<td><strong>Third Floor (528 occupants)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Corridor leading to Stairway or Horizontal Exit</td>
<td>5.08</td>
<td>24.0</td>
<td>121.9</td>
<td>137.4</td>
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<td>48.0</td>
<td>137.4</td>
<td>1 each</td>
</tr>
</tbody>
</table>
Evacuation Time

- The evacuation procedure relies on total evacuation of a floor

- The horizontal exit to the hospital is accounted for

- Occupants must use the hospital horizontal exit, the interior exit stairways, or main building exit to be considered safe in this analysis
Evacuation Time

- First floor:

\[
\frac{\text{Horizontal exit}}{60 \text{ p/min}} = \frac{\text{Northeast stairway}}{48 \text{ p/min}} = \frac{\text{Southwest stairway}}{48 \text{ p/min}} = \frac{\text{Main exit}}{192 \text{ p/min}}
\]

\[\text{Horizontal exit} + \text{Northeast stairway} + \text{Southwest stairway} + \text{Main exit} = 572\]

- 1.6 minutes for each to evacuate occupant load
Evacuation Time

- Following a similar process:
  - 1.6 minutes for first floor
  - 3.5 minutes for concourse
  - 3.3 minutes for second floor
  - 3.4 minutes for third floor

- Total: $0.5 + 1.6 + 3.5 + 3.3 + 3.4 = 12.3$ minutes
- Pathfinder Calculation, Steering: $10.5$ minutes
- Pathfinder Calculation, SFPE: $13$ minutes
RSET

- From Proulx, Kaufman, Pineau study on page 3-371 in the SFPE Handbook:
  - Pre-movement time from 0 to 5 minutes, mean between 0.6 minutes and 1.1 minutes, for a mid-rise office building
  - A value of 5 minutes used for the MCS Building
  - Detection & alarm: 2 minutes
  - Total RSET: ~20 minutes
Alarms & Detection

- A manual fire alarm system is installed (IBC Section 907.2.2)
  - Pull stations located near stairwell entrances, and main building entrance
  - Type of pull station used is Siemens HMS-D

- Audible and visible notification appliances are provided (IBC Sections 907.5.2.1, 907.5.2.3)
  - Strobes: U-MCS
  - Speakers: S-LP70
  - Horn/Strobes: S-LP70-MCS
Smoke detection is provided (Siemens HFP-11):
- In the Group I-2 Occupancy area (IBC Section 907.2.6.2)
- In areas with many large electrical systems, machinery, and computers
  - Emergency switchgear
  - Linear accelerators
  - Plumbing
  - Main electrical
  - UPS
  - Radiology labs
  - Outside elevator banks
  - Along horizontal exit wall
  - In lab storage rooms
Smoke management system

- Air-handling systems (AHU) in zoned areas turn off supply, return, and exhaust upon smoke detection in multiple zones being served

- Duct smoke detector activation shuts down associated AHU

- Sliding smoke door around north stairway closes on smoke detection and subsequent fire alarm activation

- No stairway pressurization, no elevator pressurization (not high-rise, enclosed elevator lobbies on concourse level, 1/2/3 not Group I-2 Occupancies and sprinklered throughout)
| FIRE ALARM MATRIX | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL | ANNUNCIATE ON FIRE ALARM PANEL |
|------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| SINGLE ZONE AREA SMOKE DETECTOR ACTIVATION | x | | | | | | | | | | | | | | | | | |
| SINGLE ZONE AREA THERMAL DETECTOR ACTIVATION | x | | | | | | | | | | | | | | | | | |
| SINGLE ZONE MANUAL PULL STATION ACTIVATION | x | | | | | | | | | | | | | | | | | |
| SINGLE ZONE ACTIVATION OF SPRINKLER SYSTEM WATER LOW SWITCH | x | | | | | | | | | | | | | | | | | |
| TWO ZONE AREA SMOKE DETECTOR ACTIVATION | x | | | | | | | | | | | | | | | | | |
| TWO ZONE AREA THERMAL DETECTOR ACTIVATION | x | | | | | | | | | | | | | | | | | |
| TWO ZONE MANUAL PULL STATION ACTIVATION | x | | | | | | | | | | | | | | | | | |
| TWO ZONE ACTIVATION OF SPRINKLER SYSTEM WATER LOW SWITCH | x | | | | | | | | | | | | | | | | | |
| ACTIVATION OF DUCT-MOUNTED SMOKE DETECTOR ASSOCIATED WITH MAIN AHU UNITS | x | | | | | | | | | | | | | | | | | |
| ACTIVATION OF DUCT-MOUNTED SMOKE DETECTOR ASSOCIATED WITH FIRESMOKE DAMPERS | x | | | | | | | | | | | | | | | | | |
| ACTIVATION OF TWO 2D CROSS-ZONE DUCT-MOUNTED SMOKE DETECTORS | x | | | | | | | | | | | | | | | | | |
| ELEVATOR LOBBY SMOKE DETECTOR ON FIRST FLOOR | x | | | | | | | | | | | | | | | | | |
| ELEVATOR LOBBY SMOKE DETECTOR OTHER THAN FIRST FLOOR | x | | | | | | | | | | | | | | | | | |
| ELEVATOR MECHANICAL ROOM SMOKE DETECTOR | x | | | | | | | | | | | | | | | | | |
| ELEVATOR MECHANICAL ROOM THERMAL DETECTOR | | | | | | | | | | | | | | | | | | |
| TOP OF ELEVATOR SHAFT SMOKE DETECTOR | | | | | | | | | | | | | | | | | | |
| TOP OF ELEVATOR SHAFT THERMAL DETECTOR | | | | | | | | | | | | | | | | | | |
| TROUBLE CONDITION | | | | | | | | | | | | | | | | | | |
| ACTIVATION OF SPRINKLER SYSTEM TAMPER SWITCH | x | | | | | | | | | | | | | | | | | |
EVACS

- Evacuation Process
  - Pull station, smoke detector: sequence initiated on floor of origin
  - Positive alarm sequencing, 15 sec to acknowledge signal, 3 min to investigate
  - 2nd detector: floor immediately goes into alarm
  - Voice message on fire floor, floor above & below
  - Trained staff evacuate fire floor & standby on other floors
Performance-Based Analysis
Performance-Based Analysis

- Design fire aspects to consider:
  - Location
  - Fuel composition
  - Heat release rate
Performance-Based Analysis

- Worst-case design fire location with respect to...
  - **Egress function**: the major choke point near hospital horizontal exit and west stairway
  - **Fire alarm activation & response initiation**: a room without smoke detection
  - **Suppression**: a relatively large room, taking advantage of maximum sprinkler spacing (large room rule for light-hazard)
Concourse
Performance-Based Analysis

- Worst-case design fire fuel load...

  - **Offices:**
    - No obvious high-flammability fuel loads.
    - Arrangement of desks/tables, chairs, paper products, limited plastics, small electronic appliances.
  
  - **Small storage rooms:**
    - Compressed oxygen cylinders or flammable liquids being stored present a higher flammability hazard than that found in the office.
    - However, fuel load is limited, and sprinkler protection/smoke detection is present.
  
  - **Machinery rooms:**
    - High-powered electrical equipment and machinery presents a higher ignition hazard; flammable oils may be present.
    - However, less dense fuel load than that present in offices, and sprinkler protection/smoke detection is present.

- *Offices typically present the worst-case location and a reasonably dense fuel load in the MCS Building.*
Performance-Based Analysis

- Design Fire Fuel Load:
  - Following 9/11, NIST performed tests investigating the performance of office workstations in fires.
  - The tested workstations were arrangements of desks, chairs, cubicle walls, bulletin boards, computers and computer monitors, stacks of paper, and office supplies.
  - This should closely resemble the typical office set-up in the MCS Building.
Performance-Based Analysis

Source: NIST.
Performance-Based Analysis

Table 2-2. Categories of materials in the generic workstations.

<table>
<thead>
<tr>
<th>Material</th>
<th>Mass (kg)</th>
<th>Fraction of Total Mass</th>
<th>Effective Heat of Combustion (MJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood/laminate</td>
<td>111.5</td>
<td>0.45</td>
<td>14</td>
</tr>
<tr>
<td>Paper</td>
<td>63.7</td>
<td>0.25</td>
<td>14</td>
</tr>
<tr>
<td>Plastics*</td>
<td>39.3</td>
<td>0.16</td>
<td>16 to 38</td>
</tr>
<tr>
<td>Carpet</td>
<td>34.2</td>
<td>0.14</td>
<td>22</td>
</tr>
</tbody>
</table>

a. Includes computer monitor shell (16 MJ/kg), wall fabric (30 MJ/kg), and chair composite (38 MJ/kg).

- Fuel load for purposes of determining product yields will be considered to be 70% cellulosics, 16% plastic, 14% nylon
Performance-Based Analysis

Table 14. Product yields of MCS Building design fires

<table>
<thead>
<tr>
<th>Component</th>
<th>Fraction of Total Mass</th>
<th>Soot Yield</th>
<th>Carbon Monoxide Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulosics (red oak)</td>
<td>70%</td>
<td>0.015</td>
<td>0.004</td>
</tr>
<tr>
<td>Plastics (polystyrene)</td>
<td>16%</td>
<td>0.164</td>
<td>0.060</td>
</tr>
<tr>
<td>Carpet (nylon)</td>
<td>14%</td>
<td>0.075</td>
<td>0.038</td>
</tr>
<tr>
<td>Design Fire</td>
<td>100%</td>
<td>0.047</td>
<td>0.018</td>
</tr>
</tbody>
</table>

Table 15. Chemistry model of MCS Building design fires

<table>
<thead>
<tr>
<th>Component</th>
<th>Fraction of Total Mass</th>
<th>Carbon</th>
<th>Hydrogen</th>
<th>Oxygen</th>
<th>Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulosics (red oak)</td>
<td>70%</td>
<td>1</td>
<td>1.7</td>
<td>0.72</td>
<td>0.001</td>
</tr>
<tr>
<td>Plastics (polystyrene)</td>
<td>16%</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Carpet (nylon)</td>
<td>14%</td>
<td>1</td>
<td>1.8</td>
<td>0.17</td>
<td>0.17</td>
</tr>
<tr>
<td>Design Fire</td>
<td>100%</td>
<td>1</td>
<td>1.6</td>
<td>0.53</td>
<td>0.025</td>
</tr>
</tbody>
</table>
Performance-Based Analysis

![Graph showing Heat Release Rate (MW) over Time from Ignition (s)]
Performance-Based Analysis

Heat Release Rate (kW)

Time (seconds)

Heat Release Rate (kW)

Time (seconds)
Performance-Based Analysis

- Tenability Criteria:
  - **Visibility:**
    - Egress flow approach is used
    - The MCS Building has some large enclosures and large travel distances
    - A 10 meter (about 33 feet) visibility limit is suggested (SFPE Handbook pg. 2-132)
    - If occupants are familiar with the building, a criteria of 25 to 30 feet is suggested (Smoke Control Engineering Handbook, pg. 186)
    - A visibility criteria of 35 feet will be used in combination with the egress flow approach
Performance-Based Analysis

- Tenability Criteria:

  - **Toxicity:**
    - Egress flow approach is used
    - Main toxic products produced include carbon monoxide, carbon dioxide, hydrogen cyanide, and various irritants
    - “Little doubt that CO is most important aphyxiant agent formed”
    - “In practice, yield data from irritants not readily available”
    - “if halogen, sulfur, nitrogen content in fuel is low, contribution from irritant gases is minor” (SFPE Handbook)
    - For light activity, 30,000 ppm*min of CO can cause incapacitation, for 20 minute evacuation, 1500 ppm
    - CO concentration will be kept below 1500 ppm on an egress flow basis
Performance-Based Analysis

- Tenability Criteria:
  - **Heat & Thermal Effects:**
    - Egress flow approach is used
    - If direct contact with a body of gas is an acceptable heat exposure, then thermal radiation exposure some distance away is also acceptable (SCEH, pg. 186)
    - Tolerance time to 150°F dry air is about 25 min
    - From Figure 2-6.27, for an exposure time of ~20 minutes, 120°F humid air should be tolerable
    - Gas temperature will not exceed 120°F on an egress flow basis
Performance-Based Analysis

- **Model Scenarios**

  For concourse, second, third floors:
  - 1) NE stairway compromised, doors closed
  - 2) NE stairway compromised, one door open
  - 3) SW exits compromised, doors closed
  - 4) SW exits compromised, one door open

- Investigate effect of blocking different exits, and effect of floor-dividing horizontal exit integrity
Performance-Based Analysis
Performance-Based Analysis

Fire/Egress Modeling Results: 1st Model Set-up

<table>
<thead>
<tr>
<th></th>
<th>Concourse</th>
<th>Second</th>
<th>Third</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility (35 ft)</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Toxicity (1500 ppm)</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Thermal (120 F)</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Sprinkler Activation</td>
<td>161 sec</td>
<td>158 sec</td>
<td>132 sec</td>
</tr>
<tr>
<td>Peak HRR</td>
<td>400 kw</td>
<td>380 kW</td>
<td>265 kW</td>
</tr>
<tr>
<td>Occupants</td>
<td>541 occ.</td>
<td>513 occ.</td>
<td>528 occ.</td>
</tr>
<tr>
<td>Evacuation Time</td>
<td>382 sec.</td>
<td>402 sec.</td>
<td>392 sec.</td>
</tr>
</tbody>
</table>

Simulation Results: 1st Set
- All horizontal exit doors closed
- Fire disables access to northeast stairway
- NIST workstation fire, fire growth halted by sprinklers
- Fire alarm system activates
- Full occupant load, evenly distributed
Performance-Based Analysis

Northeast Second Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation

Visibility below 35 feet make it difficult for occupants in this area to use the northeast stairway for egress.
Performance-Based Analysis

Fire/Egress Modeling Results: 2\textsuperscript{nd} Model Set-up

<table>
<thead>
<tr>
<th></th>
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<th>Third</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility (35 ft)</td>
<td>Pass</td>
<td><strong>FAIL</strong></td>
</tr>
<tr>
<td>Toxicity (1500 ppm)</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Thermal (120 F)</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Sprinkler Activation</td>
<td>136 sec</td>
<td>123 sec</td>
</tr>
<tr>
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<td>380 kW</td>
<td>265 kW</td>
</tr>
<tr>
<td>Occupants</td>
<td>513 occ.</td>
<td>528 occ.</td>
</tr>
<tr>
<td>Smoke Det. Activation</td>
<td>77 sec.</td>
<td>250 sec.</td>
</tr>
<tr>
<td>Evacuation Time</td>
<td>778 sec.</td>
<td>945 sec.</td>
</tr>
</tbody>
</table>

Simulation Results: 2\textsuperscript{nd} Set

- All horizontal exit doors closed
- **Fire disables access to southwest stairway and west horizontal exit**
- NIST workstation fire, fire growth halted by sprinklers
- Fire alarm system activates
- Full occupant load, evenly distributed
Performance-Based Analysis

Southwest Third Floor Fire Scenario
Horizontal exit doors closed, midway through evacuation

Visibility is an issue here as well, near the queueing occupants for the northeast stairway.

Visibility has fallen below 35 feet in much of this area.
Performance-Based Analysis

Simulation Results: 2nd Set

- ONE horizontal exit door opened
- Fire disables access to southwest stairway and west horizontal exit
- NIST workstation fire, fire growth halted by sprinklers
- Fire alarm system activates
- Full occupant load, evenly distributed

Fire/Egress Modeling Results: 2nd Model Set-up

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</tbody>
</table>

CAL POLY
Performance-Based Analysis

Southwest Third Floor Fire Scenario
Horizontal exit door opened, midway through evacuation

Opened horizontal exit door

Visibility falls below 35 feet in some areas on the “egress side” of the floor-dividing horizontal exit.

Visibility fell below 35 feet in this area, while occupants are queueing for the northeast stairway.
Performance-Based Analysis

Southwest Third Floor Fire Scenario
Horizontal exit door opened, midway through evacuation

Opened horizontal exit door

The temperature tenability criterion of 120°F (49°C) is not violated in this area
Performance-Based Analysis

Southwest Third Floor Fire Scenario
Horizontal exit door opened, midway through evacuation

Opened horizontal exit door

Carbon monoxide concentrations are nowhere near the 1500 ppm tolerability limit (0.0015 mol/mol)
Summary

Prescriptive Analysis

- Structural FP complies with IBC requirements for Type 1-A construction

- Egress systems are compliant with IBC requirements

- Fire alarm system is compliant with IBC requirements, detectors positioned in accordance with NFPA 72

- Fire suppression systems are IBC compliant, sprinkler system designed in accordance with NFPA 13
Summary

Performance-Based Analysis

- Fire blocking access to southwest area of floors increases evacuation times by 2-3x

- 20 min. time for entire building, to 16 min. for ONE FLOOR

- Toxicity and thermal effects are not as concerning as possible visibility issues

- Presence of trained staff and use of EVACS system should help alleviate possible visibility issues
Summary

**Recommendations**

- Test magnetic release of doors regularly
- Adhere to the Fire Safety Management Plan
- Staff training on evacuation procedure
Thank you!

- Questions? Comments?