Culminating Project
U.S. Federal Courthouse
FPE 596 - Spring 2013

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Outline

1 Building Description
2 Applicable Codes and Standards
3 Code Analysis
4 Egress Analysis
5 Fire Alarm Initiation and Notification
6 Fire Suppression
7 Performance Based Analysis
8 Conclusions
1 Building Description

- Building Use: Federal Courthouse
- Construction Cost: $70,000,000
- Area: ~115,000 square feet
- Height: 4 Stories plus basement (71 ft)
- Fully sprinklered
Slide removed for security purposes

4th Floor
Slide removed for security purposes
Slide removed for security purposes

2nd Floor
Slide removed for security purposes

1st Floor
Slide removed for security purposes

Basement
2 Applicable Codes

NFPA 13, Installation of Sprinklers, 2010 edition
NFPA 14, Standpipe and Hose Systems, 2010 edition
NFPA 72, Fire Alarm & Signaling Code, 2010 edition

NFPA 80, Fire Doors & Opening Protectives, 2010 edition
3 Code Analysis
(Ref: IBC and NFPA 101)
## Code Analysis – Occupancy Classification
(Ref: IBC, Chapter 3 and NFPA 101, 6.1.1.1)

<table>
<thead>
<tr>
<th>Fl</th>
<th>Area (sf)</th>
<th>Building Use</th>
<th>IBC</th>
<th>NFPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th</td>
<td>21,875 Offices/Courtrooms</td>
<td>B/A-3</td>
<td></td>
<td>Business/Assembly</td>
</tr>
<tr>
<td>3rd</td>
<td>21,875 Offices/Courtrooms</td>
<td>B/A-3</td>
<td></td>
<td>Business/Assembly</td>
</tr>
<tr>
<td>2nd</td>
<td>24,375 Offices</td>
<td>B</td>
<td></td>
<td>Business</td>
</tr>
<tr>
<td>1st</td>
<td>25,575 Offices/Jury Assembly</td>
<td>B/A-3</td>
<td></td>
<td>Business/Assembly</td>
</tr>
<tr>
<td>B</td>
<td>20,820 Shops/Parking Garage</td>
<td>B/S-2</td>
<td></td>
<td>Business/Storage</td>
</tr>
</tbody>
</table>
Code Analysis – Occupancy Separation
(Ref: IBC, Table 508.4)

<table>
<thead>
<tr>
<th>Occupancies Separated</th>
<th>IBC</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Assembly</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Business/Parking Garage (Storage)</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 508.4 Provided: Rating Provided
## Code Analysis – Height and Area Limitations
(Ref: IBC, Table 503)

**TABLE 503**

**ALLOWABLE HEIGHT AND BUILDING AREAS**

Height limitations shown as stories and feet above grade plane. Area limitations as determined by the definition of “Area, building,” per story.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>HGT(S)</th>
<th>TYPE OF CONSTRUCTION</th>
<th>TYPE I(332)</th>
<th>TYPE II(222)</th>
<th>TYPE III(111)</th>
<th>TYPE II(000)</th>
<th>TYPE III(211)</th>
<th>TYPE III(200)</th>
<th>TYPE IV(2HH)</th>
<th>TYPE V(111)</th>
<th>TYPE V(000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>S</td>
<td>UL</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UL</td>
<td>15,500</td>
<td>8,500</td>
<td>14,000</td>
<td>8,500</td>
<td>15,000</td>
<td>2</td>
<td>2</td>
<td>11,500</td>
<td>5,500</td>
</tr>
<tr>
<td>A-2</td>
<td>S</td>
<td>UL</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>11,500</td>
<td>6,000</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UL</td>
<td>15,500</td>
<td>9,500</td>
<td>14,000</td>
<td>9,500</td>
<td>15,000</td>
<td>2</td>
<td>2</td>
<td>11,500</td>
<td>6,000</td>
</tr>
<tr>
<td>A-3</td>
<td>S</td>
<td>UL</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>11,500</td>
<td>6,000</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UL</td>
<td>15,500</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>11,500</td>
<td>6,000</td>
<td></td>
</tr>
<tr>
<td>A-4</td>
<td>S</td>
<td>UL</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>11,500</td>
<td>6,000</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UL</td>
<td>15,500</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>11,500</td>
<td>6,000</td>
<td></td>
</tr>
<tr>
<td>A-5</td>
<td>S</td>
<td>UL</td>
<td>11</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>18,000</td>
<td>9,000</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UL</td>
<td>15,500</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>11,500</td>
<td>6,000</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>S</td>
<td>UL</td>
<td>11</td>
<td>5</td>
<td>23,000</td>
<td>19,000</td>
<td>18,000</td>
<td>9,000</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UL</td>
<td>37,500</td>
<td>4</td>
<td>28,500</td>
<td>36,000</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-1</td>
<td>S</td>
<td>UL</td>
<td>11</td>
<td>4</td>
<td>26,000</td>
<td>25,500</td>
<td>23,000</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UL</td>
<td>48,000</td>
<td>3</td>
<td>26,000</td>
<td>25,500</td>
<td>23,000</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-2c</td>
<td>S</td>
<td>UL</td>
<td>11</td>
<td>5</td>
<td>26,000</td>
<td>26,000</td>
<td>26,000</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UL</td>
<td>79,000</td>
<td>4</td>
<td>39,000</td>
<td>38,500</td>
<td>38,500</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>S</td>
<td>UL</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UL</td>
<td>35,500</td>
<td>2</td>
<td>8,500</td>
<td>18,000</td>
<td>14,000</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m².
UL = Unlimited, NP = Not permitted.

- a. See the following sections for general exceptions to Table 503:
  1. Section 504.2, Allowable height increase due to automatic sprinkler system installation.
  2. Section 506.2, Allowable area increase due to street frontage.
  3. Section 506.3, Allowable area increase due to automatic sprinkler system installation.
  4. Section 507, Unlimited area buildings.
- b. For open parking structures, see Section 406.3.
- c. For private garages, see Section 406.1.
- d. See Section 415.5 for limitations.

**Notes:**
- NFPA construction types added
- Most stringent
- Meets code
- Meets code w/AS
Code Analysis – Height and Area Limitations
(Ref: IBC, Table 503)

Building Construction
Type I B per IBC
Type II (222) per NFPA 5000/220

Could have used IBC       Type IIA       or    Type IIIA
NFPA 101 Type II(111) or Type III(211)
## Code Analysis – Fire Resistance Ratings
(Ref: IBC, Table 601)

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>A*</td>
<td>B</td>
<td>HT</td>
<td>A*</td>
</tr>
<tr>
<td>Structural frame</td>
<td>3(^b)</td>
<td>2(^b)</td>
<td>1 0</td>
<td>1 0</td>
<td>HT</td>
</tr>
<tr>
<td>Bearing walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior(^b)</td>
<td>3</td>
<td>2</td>
<td>1 0</td>
<td>2 2</td>
<td>2</td>
</tr>
<tr>
<td>Interior(^b)</td>
<td>3(^b)</td>
<td>2(^b)</td>
<td>1 0</td>
<td>1 0</td>
<td>1/HT</td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td></td>
<td>See Table 602</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior(^b)</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
<td>See Section 602.4.6</td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior(^b)</td>
<td>0</td>
<td>0</td>
<td>0 0</td>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>Floor construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Including supporting beams and joists</td>
<td>2</td>
<td>2</td>
<td>1 0</td>
<td>1 0</td>
<td>HT</td>
</tr>
<tr>
<td>Roof construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Including supporting beams and joists</td>
<td>1(\frac{1}{2})</td>
<td>1(\frac{1}{2})</td>
<td>1(\frac{1}{4})</td>
<td>0(\frac{1}{4})</td>
<td>1(\frac{1}{4})</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.

- a. The structural frame shall be considered to be the columns and the girders, beams, trusses and spandrels having direct connections to the columns and bracing members designed to carry gravity loads. The members of floor or roof panels which have no connection to the columns shall be considered secondary members and not a part of the structural frame.
- b. Roof supports: Fire-resistance ratings of structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.
- c. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.
- d. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.
- e. An approved automatic sprinkler system in accordance with Section 903.3.1.1 shall be allowed to be substituted for 1-hour fire-resistance-rated construction, provided such systems are otherwise required by other provisions of the code or used for an allowable area increase in accordance with Section 506.3 or an allowable height increase in accordance with Section 504.2. The 1-hour substitution for the fire resistance of exterior walls shall not be permitted.
- f. Not less than the fire-resistance rating required by other sections of this code.
- g. Not less than the fire-resistance rating based on fire separation distance (see Table 602).
Code Analysis – Fire Resistance Ratings
(Ref: IBC, Table 601)

Building Construction - Type I B or Type II (222)
Structural Frame – 2 hr
Bearing Walls – 2 hr
Floors – 2 hr
Roof – 1 hr
## Code Analysis – Protection of Shaft Enclosures
(Ref: IBC 713.4)

<table>
<thead>
<tr>
<th>Stories Served</th>
<th>Enclosure Fire Resistance Rating</th>
<th>Opening Fire Protection Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;4</td>
<td>2 hrs</td>
<td>1-1/2 hours</td>
</tr>
</tbody>
</table>

for stair, elevator, HVAC and utility shafts
Code Analysis – Protection from Hazards
(Ref: IBC Table 509)

- 1 hour
  - Basement Boiler Rm
  - 1st Floor Locker Rm
Code Analysis – Other Rooms Requiring Protection

1 hour
-Basement Electrical Rm with 112.5 kVA transformer (Ref: NFPA 70, 450.21B)
-1st Floor Fire Command Center (Ref: IBC 508.1.2)

2 hours
-4th Floor Elevator Machine Rooms (Ref: ASME A17.1, 2.7.1.1.1)
Code Analysis – Main Entry (Two Story Atrium)
(Ref: IBC 404)
Code Analysis – Main Entry (Two Story Atrium)  
(Ref: IBC 404)  

Atriums must be separated by 1 hour fire barrier unless:
- a smoke control system is provided

However, for two story atriums, IBC doesn’t require:
- 1 hour fire barrier (712.1.8)  
- smoke control (404.5)

Neither provided…
4 Egress Analysis
(Ref: NFPA 101, Chapter 7)
# Egress Analysis – Occupant Load & Capacity

(Ref: NFPA 101, Tables 7.3.1.2 and 7.3.3.1)

## Table 7.3.3.1 Capacity Factors

<table>
<thead>
<tr>
<th>Area</th>
<th>Stairways (width/person)</th>
<th>Level Components and Ramps (width/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Board and care</td>
<td>0.4 in. 0.2 in.</td>
<td>10 mm 5 mm</td>
</tr>
<tr>
<td>Health care, sprinklered</td>
<td>0.3 in. 0.2 in.</td>
<td>7.6 mm 5 mm</td>
</tr>
<tr>
<td>Health care, nonsprinklered</td>
<td>0.6 in. 0.5 in.</td>
<td>15 mm 13 mm</td>
</tr>
<tr>
<td>High hazard contents</td>
<td>0.7 in. 0.4 in.</td>
<td>18 mm 10 mm</td>
</tr>
<tr>
<td>All others</td>
<td>0.3 in. 0.2 in.</td>
<td>7.6 mm 5 mm</td>
</tr>
</tbody>
</table>

## Stair Analysis

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Stair Width</th>
<th>Stair Capacity</th>
<th>Door Width</th>
<th>Door Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SW</td>
<td>56&quot;</td>
<td>187</td>
<td>36&quot;</td>
<td>180*</td>
</tr>
<tr>
<td>2</td>
<td>NE</td>
<td>56&quot;</td>
<td>187</td>
<td>36&quot;</td>
<td>180*</td>
</tr>
<tr>
<td>3</td>
<td>NW</td>
<td>44&quot;</td>
<td>147*</td>
<td>36&quot;</td>
<td>180</td>
</tr>
</tbody>
</table>

## Floor Exit Analysis

<table>
<thead>
<tr>
<th>FL</th>
<th>Grade Exit Location</th>
<th>No. of Doors</th>
<th>Door Width</th>
<th>Door Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Main Entry</td>
<td>4</td>
<td>36&quot;</td>
<td>720</td>
</tr>
<tr>
<td>1st</td>
<td>Stair 1</td>
<td>1</td>
<td>36&quot;</td>
<td>180</td>
</tr>
<tr>
<td>1st</td>
<td>Stair 2</td>
<td>1</td>
<td>36&quot;</td>
<td>180</td>
</tr>
<tr>
<td>B</td>
<td>Garage</td>
<td>2</td>
<td>36&quot;</td>
<td>360</td>
</tr>
</tbody>
</table>
Egress Analysis – Occupant Load & Capacity
(Ref: NFPA 101, Tables 7.3.1.2 and 7.3.3.1)

<table>
<thead>
<tr>
<th>Use</th>
<th>(ft²/person)*</th>
<th>(m²/person)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assembly Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentrated use, without fixed seating</td>
<td>7 net</td>
<td>0.65 net</td>
</tr>
<tr>
<td>Less concentrated use, without fixed seating</td>
<td>15 net</td>
<td>1.4 net</td>
</tr>
<tr>
<td>Bench-type seating</td>
<td>1 person/18 linear in.</td>
<td>1 person/425 linear mm</td>
</tr>
<tr>
<td>Fixed seating</td>
<td>Use number of fixed seats</td>
<td>Use number of fixed seats</td>
</tr>
<tr>
<td>Waiting spaces</td>
<td>See 12.1.7.2 and 13.1.7.2.</td>
<td>See 12.1.7.2 and 13.1.7.2.</td>
</tr>
<tr>
<td><strong>Business Use (other than below)</strong></td>
<td>100</td>
<td>9.5</td>
</tr>
<tr>
<td>Air traffic control tower observation levels</td>
<td>40</td>
<td>3.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use</th>
<th>(ft²/person)*</th>
<th>(m²/person)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In storage occupancies</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>In mercantile occupancies</td>
<td>300</td>
<td>27.9</td>
</tr>
<tr>
<td>In other than storage and mercantile occupancies</td>
<td>500</td>
<td>46.5</td>
</tr>
<tr>
<td><strong>Mercantile Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales area on street floor</td>
<td>30</td>
<td>2.8</td>
</tr>
<tr>
<td>Sales area on two or more street floors</td>
<td>40</td>
<td>3.7</td>
</tr>
<tr>
<td>Sales area on floor below street floor</td>
<td>30</td>
<td>2.8</td>
</tr>
<tr>
<td>Sales area on floors above street floor</td>
<td>60</td>
<td>5.6</td>
</tr>
<tr>
<td>Floors or portions of floors used only for offices</td>
<td>See business use.</td>
<td>See business use.</td>
</tr>
<tr>
<td>Floors or portions of floors used only for storage, receiving, and shipping, and not open to general public</td>
<td>Mall buildings</td>
<td>Per factors applicable to use of space</td>
</tr>
</tbody>
</table>

NA: Not applicable. The occupant load is the maximum probable number of occupants present at any time.

*All factors are expressed in gross area unless marked "net".
## Egress Analysis – Occupant Load & Capacity
(Ref: NFPA 101, Table 7.3.1.2 and Table 7.3.3.1)

<table>
<thead>
<tr>
<th>Fl</th>
<th>Area (sf)</th>
<th>Occupant Load (OL)</th>
<th>Total OL</th>
<th>Capacity (56” stairs + 44” stair + Exits at grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Business</td>
<td>Other&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Business</td>
<td>Other&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>17,875</td>
<td>4,000</td>
<td>179</td>
<td>83 x 2</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>17,875</td>
<td>4,000</td>
<td>179</td>
<td>72 x 2</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>24,375</td>
<td></td>
<td>244</td>
<td></td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>24,075</td>
<td>1,500</td>
<td>241</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>10,620</td>
<td>10,200</td>
<td>107</td>
<td>21</td>
</tr>
</tbody>
</table>

Occupant Load < Capacity (ok)

---

1 3<sup>rd</sup> & 4<sup>th</sup> floors each have two courtrooms; 1<sup>st</sup> floor has a jury assembly room; basement contains a garage

2 4<sup>th</sup> floor courtrooms each with 90' of benches (1080”/18”pp = 60 occs) + 23 seats;

2 3<sup>rd</sup> floor courtrooms each with 72 seats

2-56” stairs and 1-44” stair; all stair doors are 36” wide (*stair door width dictates capacity of 180, not 187)

Note: calculated occupant loads far exceed the population expected, especially on 3<sup>rd</sup> & 4<sup>th</sup> floors
Egress Analysis – Special Locking of Doors
(Ref: NFPA 101, 7.2.1.5.8 , 7.2.1.6.1)

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# Egress Analysis – Travel Distances, Common Paths of Travel and Dead End Corridors

(Ref: NFPA 101, Table A.7.6)

<table>
<thead>
<tr>
<th>Floor</th>
<th>Common Path</th>
<th>Dead End</th>
<th>Travel Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Max Allowed</td>
<td>Actual</td>
</tr>
<tr>
<td>4th</td>
<td>63/0</td>
<td>&lt;100/&lt;20</td>
<td>25/0</td>
</tr>
<tr>
<td>3rd</td>
<td>63/0</td>
<td>&lt;100/&lt;20</td>
<td>25/0</td>
</tr>
<tr>
<td>2nd</td>
<td>77</td>
<td>&lt;100</td>
<td>0</td>
</tr>
<tr>
<td>1st</td>
<td>47/0</td>
<td>&lt;100/&lt;20</td>
<td>15/0</td>
</tr>
<tr>
<td>B</td>
<td>25/56</td>
<td>&lt;100/&lt;50</td>
<td>0/NA</td>
</tr>
</tbody>
</table>

Business/Assembly (1st, 3rd and 4th floors)
Business/Storage (basement)
Egress Analysis – Common Paths of Travel
(Ref: NFPA 101, Table A.7.6)

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Egress Analysis – Other Requirements
(Ref: NFPA 101)

Number of Exits (7.4)
Arrangement/Remoteness of Exits (7.5.1.3)
Exit Discharge (7.7)
Illumination of Means of Egress (7.8)
Emergency Lighting (7.9)
Marking of Exits (7.10)

All other requirements met
5 Fire Alarm Initiation and Notification
(Ref: IBC Sections 907 and NFPA 72)
Fire Alarm Initiation and Notification – General

- Addressable voice alarm evacuation system
- System designed and installed in accordance with NFPA 72
- Alarm signals transmit to a central station service
- Fire command center on 1st floor
Fire Alarm Initiation and Notification – General (continued)

-Alarm notification via speakers and synchronized strobes

-Full evacuation via temporal 3 signal

-Live voice capability to override pre-recorded message and to convey non-fire emergency messages (e.g., terrorist alert)
Fire Alarm Initiation and Notification – General (continued)

- Manual pull stations adjacent to every exit and located in fire command center

- Smoke detectors only installed in elevator lobbies and elevator machine rooms – initiate elevator recall

- Heat detectors in elevator machine room – initiate shunt trip

- Duct smoke detectors installed in supply air units > 2,000 cfm and return air units > 15,000 cfm per NFPA 90A – initiate HVAC system shutdown
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1st Floor
## Fire Alarm Initiation and Notification – Sequence of Operation Matrix

<table>
<thead>
<tr>
<th>Initiating Device/Operation</th>
<th>Activate speakers</th>
<th>Activate strobes</th>
<th>Shut down HVAC</th>
<th>Unlock doors</th>
<th>Recall elevator to 1st floor</th>
<th>Recall elevator to basement</th>
<th>De-energize elevator power</th>
<th>Transmit alarm to central station</th>
<th>Transmit supervisory signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual pull station</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FACP smoke detector</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duct smoke detector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Elevator lobby smoke detector (B, 2, 3, 4)</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elevator lobby smoke detector (1)</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Elevator machine room smoke detector</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elevator machine room heat detector</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Waterflow switch</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamper switch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6 Fire Suppression
(Ref: IBC Sections 903 & 905, and NFPA 13)
Fire Suppression – General

- Building protected by a wet pipe sprinkler system except for elevator hoistways

- Sprinkler system designed & installed in accordance with NFPA 13

- Quick response sprinklers installed throughout

- Design for light hazard occupancy, except for shops, storage and mechanical rooms

- Calculation are based upon the density/area method
Fire Suppression – General (continued)

- Class I manual wet standpipes installed in all stairs in accordance with NFPA 14

- Sprinkler piping to be schedule 40 black steel pipe

- Dry sidewalls in main entry vestibule & loading dock

- Backflow prevention
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Fire Suppression – Available Water Supply

- Static Pressure – 86 psi
- Residual Pressure – 75 psi
- Flow at Residual Pressure – 1470 gpm
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Basement
Slide removed for security purposes

4th Floor
## Fire Suppression – Sprinkler Demand

### Hydraulically Most Remote Locations

<table>
<thead>
<tr>
<th>Zone</th>
<th>Fl</th>
<th>Use</th>
<th>Hazard Classification</th>
<th>Density (gpm/ft²)</th>
<th>Area (ft²)</th>
<th>Hose (gpm)</th>
<th>Flow (gpm)</th>
<th>Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>SW Office</td>
<td>Light</td>
<td>0.10</td>
<td>1500</td>
<td>100</td>
<td>271</td>
<td>72</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>Mech Rm</td>
<td>Ordinary Gp 1</td>
<td>0.15</td>
<td>644</td>
<td>250</td>
<td>170</td>
<td>64</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>SW Shop</td>
<td>Ordinary Gp 2</td>
<td>0.20</td>
<td>1500</td>
<td>250</td>
<td>544</td>
<td>77</td>
</tr>
</tbody>
</table>

Density, area and hose requirements from NFPA 13, Figure 11.2.3.1.1 and Table 11.2.3.1.2
7 Performance Analysis

Goal: Life Safety

Determine whether the available safe egress time (ASET) exceeds the required safe egress time (RSET) with a sufficient margin of safety, based upon an assumed fire.

Occupants would be considered safe if they are separated from the effects of fire or can safely relocate before products of combustible effect tenability.
RSET vs. ASET

[Diagram showing the comparison between RSET and ASET, with stages such as Ignition, Detection Alarm, Time, Evacuation time, Recognition time, Response time, and Movement time marked.]
Design Scenario 1

Car fire in basement parking garage
Design Scenario 1 (Car Fire) Egress

Maximum travel distance – 94’ (74’ realistically)
Design Scenario 1 (Car Fire) Egress

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Design Scenario 1 (Car Fire) HRR

4.5 MW car fire in basement parking garage
Ref: SFPE Fig 3-1.46
Design Scenario 1 (Car Fire) RSET Results

Sprinkler Activation Time = 178 s = 3.0 min (FDS)

Alarm Time = 30 s = .5 min (waterflow switch delay)

Pre-Movement Time = 30 s = .5 min (elevator occupants)

Movement Time = 1.0 min
= Corridor Travel + Door Flow (3)
= 74’/138’/min + 3 x (8 p/ 48 p/min)

RSET = 5.0  \((3 + .5 + .5 + 1)\)

1.5 x RSET = 7.5 min
Design Scenario 1 (Car Fire) ASET Criteria

a. Temperature < 60°C (140°F) for 1.5 x RSET
   Ref: SFPE Figure 2-6.26

b. CO Concentration < 2500 ppm for 1.5 x RSET
   Ref: SFPE Figure 2-6.14

c. Visibility > 4 m (13 ft) for 1.5 x RSET
   Ref: SFPE Table 2-4.2

Table 2-4.2 Allowable Smoke Densities and Visibility That Permits Safe Escape

<table>
<thead>
<tr>
<th>Degree of Familiarity with Inside Building</th>
<th>Smoke Density (extinction coefficient)</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfamiliar</td>
<td>0.15 1/m</td>
<td>13 m</td>
</tr>
<tr>
<td>Familiar</td>
<td>0.5 1/m</td>
<td>4 m</td>
</tr>
</tbody>
</table>
Design Scenario 1 (Car Fire) ASET Results

a. Temperature < 60°C (140°F) for 1.5 x RSET

\[ t = 7.5 \text{ min (1.5 x RSET)} \]
Design Scenario 1 (Car Fire) ASET Results

b. CO Concentration < 2500 ppm for 1.5 x RSET

\[ t = 7.5 \text{ min (1.5 x RSET)} \]
Design Scenario 1 (Car Fire) ASET Results

**c. Visibility ≥ 4 m (13 ft) for 1.5 x RSET**

- $t = 3.0$ min (sprinkler activation)
- $t = 3.5$ min (alarm notification)
- $t = 4.0$ min (occupants arrive)
- $t = 5.0$ min (RSET)
Design Scenario 1 (Car Fire) RSET vs. ASET

- **Visibility**: < 4 m (3 mins)
- **Sprinkler activation**: 3.0 min
- **Waterflow**
- **Alarm**: 3.5 min
- **Temperature**: < 60°C (7.5 min)
- **CO**: < 2500 ppm (7.5 min)
- **Occupants**
- **Exit**
- **Elevator**
- **RSET**: 57 min
- **ASET**: 5.0 min
- **Evacuation complete**: 5.0 min
- **Tenability limit**: 7.5 min
- **Pre-movement time**: 4.0 min
- **Response time**: 5.0 min
- **Movement time**: 1.5 RSET
Design Scenario 1 (Car Fire) Alternate Scenarios

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Design Scenario 1 (Car Fire) ASET Results

Visibility Levels over time for fire at SE corner

$t = 3.0\ \text{min (sprinkler activation)}$

$t = 3.5\ \text{min (alarm notification)}$

$t = 4.0\ \text{min (occupants arrive)}$

$t = 5.0\ \text{min (RSET)}$
Design Scenario 2

Security equipment fire in entry lobby ("atrium")
Design Scenario 2

Security equipment fire in “atrium”
Design Scenario 2 ("Atrium" Fire) Egress

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Design Scenario 2 (“Atrium” Fire) HRR

600 kW equipment fire in atrium
Ref: SFPE Fig 3-1.14

Figure 3-1.14. Business machine cabinets made from polyphenylene oxide plastic.
Design Scenario 2 ("Atrium" Fire)
Design Scenario 2 ("Atrium" Fire) RSET Results

(Smoke) Detection Time = 107 s = 1.8 min (worse case)
(Manual) Detection Time = 60 s = 1 min (assumed)

Alarm Time = 0 (if automatic detection)
Alarm Time = 30 s = .5 min (if manual detection)

Pre-Movement Time = .5 min (assumed)

Movement Time = 7.4 mins
= Corridor Travel + Initial Stair Fill + Queuing + Stair Fill/Clear
= 1.0 + .36 + 4.66 + 1.35

RSET = 9.7 min  (1.8 + 0 + .5 + 7.4)
1.5 x RSET = 14.6 min
Design Scenario 2 ("Atrium" Fire) RSET Results

(Smoke) Detection Time = 107 s = 1.8 min (worse case)
(Manual) Detection Time = 60 s = 1 min (assumed)

Alarm Time = 0 (if automatic detection)
Alarm Time = 30 s = .5 min (if manual detection)

Pre-Movement Time = .5 min (assumed)

Movement Time = 2.7 mins
= Corridor Travel + Door Flow
= 1.0 + 1.7

RSET = 5.0 min \(= (1.8 + 0 + .5 + 2.7)\)
1.5 x RSET = 7.5 min
Design Scenario 2 ("Atrium" Fire) ASET Criteria

a. Temperature < 60°C (140°F) for 1.5 x RSET
   Ref: SFPE Figure 2-6.26

b. CO Concentration < 1200 ppm for 1.5 x RSET
   Ref: SFPE Figure 2-6.14

c. Visibility > 13 m (42.6 ft) for 1.5 x RSET
   Ref: SFPE Table 2-4.2

---

**Table 2-4.2 Allowable Smoke Densities and Visibility That Permits Safe Escape**

<table>
<thead>
<tr>
<th>Degree of Familiarity with Inside Building</th>
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<td>13 m</td>
</tr>
<tr>
<td>Familiar</td>
<td>0.5 1/m</td>
<td>4 m</td>
</tr>
</tbody>
</table>
Design Scenario 2 ("Atrium" Fire) ASET Results

a. Temperature < 60°C (140°F) for 1.5 x RSET

\[ t = 3.7 \text{ min (worse values)} \]
Design Scenario 2 ("Atrium" Fire) ASET Results

b. CO Concentration < 1200 ppm for 1.5 x RSET

t = 3.7 min (worse values)
Design Scenario 2 ("Atrium" Fire) ASET Results

c. Visibility $\geq 13$ m (42.6 ft) for 1.5 x RSET

$t = 1.8$ min (detection/alarm)

$t = 2.3$ min (movement begins)
Design Scenario 2 ("Atrium" Fire) RSET vs. ASET

- Visibility < 13 m (2.1 min)
- Temperature < 120°C (14.6 min)
- CO < 6000 ppm (14.6 min)

Diagram:
- RSET
- ASET
- Pre-movement time $t_{p\text{m}}$
- Recognition time $t_{r\text{n}}$
- Response time $t_{r\text{t}}$
- Evacuation time
- Movement time $t_{m\text{t}}$

- Ignition
- Detection & alarm activation 1.8 min
- Time
- 2.3 min
- 9.7 min

Legend:
- Detector & alarm activation
Design Scenario 2 ("Atrium" Fire) ASET Results

c. Visibility > 4 m (14 ft) for 1.5 x RSET

t = 1.8 min (detection)

t = 2.3 min (movement)

t = 3 min (visibility < 4 m)
Design Scenario 2 ("Atrium" Fire) RSET vs. ASET

- **Detector & alarm activation**: 1.8 min
- **Visibility < 4 m**: 3 min
- **Temperature < 120°C**: 14.6 min
- **CO < 6000 ppm**: 14.6 min

Diagonal line: 2.3 min

Vertical line: 9.7 min
Conclusions

1. Parking garage doesn’t meet visibility criteria
   • Construct a protected exit passageway from elevator lobby to exit
   • Install a smoke control system
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Conclusions (conclusions)

2. “Atrium” doesn’t meet visibility criteria

- Enclose atrium
- Install a smoke control system
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Conclusions (continued)

Atrium might meet performance for a different fire

Meeting prescriptive requirements does not necessarily guarantee safety
Questions?
Thank you!