Facility Analysis of the ACME Building

Russ Livesay
FPE 596
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Prescriptive Presentation Topics

• Building Overview
• Code Compliance Evaluation
• Fire Suppression Characterization
• Fire Alarm System Description
• Structural Fire Protection Limitations
• Flammability
• Smoke Control Systems
ACME Building
ACME Building

Code of Record

Codes for Analysis
2018 International Building Code
2018 International Fire Code
2019 NFPA 13
2019 NFPA 72
ACME Building

Fully Sprinklered 250,000 ft$^2$ 2-story Mixed-use

- Group-B \[26,000 \text{ ft}^2\]
- Group S-1 \[22,000 \text{ ft}^2\]
- Group F-1 \[200,000 \text{ ft}^2\]

Accessory Occupancies include A-2, A-3, and U
ACME Building

Type VB Construction

(Fails IBC Section 603 for non-combustible)

Not Actual Images
ACME Building: First Floor
### ACME Building Occupant Load Calculations

<table>
<thead>
<tr>
<th>Area (ft²)</th>
<th>Area Use</th>
<th>OLF (ft²/person) [IBC 1004.5]</th>
<th>Occupant Load</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,313</td>
<td>Storage Space</td>
<td>300</td>
<td>8</td>
<td>West high-bay storage</td>
</tr>
<tr>
<td>12,079</td>
<td>Industrial Space</td>
<td>100</td>
<td>121</td>
<td>West high-bay operations</td>
</tr>
<tr>
<td>1,967</td>
<td>Storage Space</td>
<td>300</td>
<td>7</td>
<td>West high-bay storage</td>
</tr>
<tr>
<td>5,447</td>
<td>Industrial Space</td>
<td>100</td>
<td>55</td>
<td>Tool-room operations</td>
</tr>
<tr>
<td>10,675</td>
<td>Storage Space</td>
<td>300</td>
<td>36</td>
<td>Tool-room storage</td>
</tr>
<tr>
<td>2,543</td>
<td>Storage Space</td>
<td>300</td>
<td>9</td>
<td>West high-bay storage</td>
</tr>
<tr>
<td>5,004</td>
<td>Machine shop</td>
<td>100</td>
<td>51</td>
<td>Machine shop</td>
</tr>
<tr>
<td>280</td>
<td>Remote Access</td>
<td>0</td>
<td>0</td>
<td>No Occupancy</td>
</tr>
</tbody>
</table>
### First Floor Occupant Load

<table>
<thead>
<tr>
<th>Applicable Area</th>
<th>211,953 ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupant Load</td>
<td>1881 people</td>
</tr>
</tbody>
</table>

### Second Floor Occupant Load

<table>
<thead>
<tr>
<th>Area</th>
<th>13,093 ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupant Load</td>
<td>228 People</td>
</tr>
</tbody>
</table>
MOE Capacity for 1st floor

Number of 1st floor exterior doors = 27  
Door clear width = 35”  
Door Capacity Factor = 0.15”  

(IBC 1005.3.2 allows 0.15” for sprinklered facilities with EVACS)

MOE Occupant Load = 27 doors * 35”/door / 0.15”/person

6,300 people
MOE Capacity for 2\textsuperscript{nd} floor

Number of 2nd floor exit access stairways = 6
Stairway clear width = 44”
Stairway Capacity Factor = 0.2”/person

(IBC 1005.3.1 allows 0.2” for sprinklered facilities with EVACS)

MOE Occupant Load = 6 * 44” / 0.2”/person

1,320 people
• Interior Finish is Acceptable  
  (IBC Table 803.13)

• Exit Placement is Acceptable
  (>1/3 Diagonal Distance IBC 1007.1.1)

• Common Path of Travel is Acceptable
  (IBC Table 1006.2.1)

• Emergency Lighting is Acceptable
  (IBC 1008.3)

• Exit Sign Placement is Acceptable
  (IBC 1013.1)

• Total Travel Distance is Acceptable
  (IBC Table 1017.2)

• Fire Rating is Acceptable
  (IBC 1020, 1019.3.1)
Exit Sign Placement
Door swing in direction of flow for 50+ occupants

(IBC 1010.1.2.1)
Calculated allowable area (IBC 506.3.2)

40,375 ft²

Unlimited size if sprinklered and surrounded by 60’ public way

Buildings within 40’ (IBC 507.5)

Special Industrial Occupancy (IBC 503.1.1)
Suppression

- SR K5.6
- 165°F
- OH1
- Pipe-schedule
- 9 Risers in Building
  - Riser 3 Worst-case
- Recently replaced per 50-year
Pump rating: 2,000 GPM @ 125 PSI

Churn at 158 PSI

303.4 + 250 GPM at 64 PSI

2,100 GPM at 60 PSI

System 3 water supply requirements at the POC

Water Supply at POC

Water Flow in GPM

Scale X 2

PRESURE (PSI)
Seimens Disego Fire Alarm System (FAS)

- Manual System
- 2015-2016 Installation
- EVACS
FAS Initiating Devices

- Manual Pulls w/in 5’
- Smoke detectors at door closers, above FACP and supervisory in ducts
- Water flow
Structural Fire Limitations

No Fire Rated Protection for Structural Members

Fire rated Barriers are Adequate for Code Compliance but not for an In-depth Fire Safety Strategy

Thermal Barriers (Gypsum) Protects Most Combustible Construction

Majority of Walls are CMU and Provide a General 1-hr Barrier
Flammability

• All wall and ceiling surfaces are Class C or better  [IFC 803.1.2]
• All floor surfaces are Class II or better  [IFC 804.3]
Smoke Controls

- Prohibitions on Smoke Vents
- Smoke detectors automatically trigger ventilation shutoff
- Large banks of HEPA filters are shutdown when smoke detectors activate
Performance-based Presentation

Objectives

• Life safety (primary)
• Property protection (secondary)
Performance-based Analyses

- Design Basis Fires (DBF)
- Suppression Activation
- RSET Estimates
- ASET Estimates
Design Basis Fire (DBF) Locations
DBF1 HRR

Possible Range of the DBF1 Truck HRR

HRR Range for Truck Fire

HFPE Figure 26.94

www.mdpi.com
DBF1 Fire Spread

Combustible Loading \( \sim 100 \text{ MJ/m}^2 \)
Wood crating 3 m from truck (CHF = 10 kW/m\(^2\))

- \( q^{''}_{\text{Upper}} = 73 \text{ kW/m}^2 \)
- \( q^{''}_{\text{Lower}} = 46 \text{ kW/m}^2 \)

Safe distance for combustibles from truck is 13 m (<10 kW/m\(^2\))
DBF1 Sprinkler Activation
\[
\frac{Z}{H} = 1.11 - 0.28 \ln \left( \frac{\text{t} \ \dot{Q}^{\frac{1}{3}} H^{-\frac{4}{3}}}{A / H^2} \right)
\]

(Eq. 51.13 HFPE 5th)
DBF1 Upper HRR Smoke Spread

3 minutes

5 minutes

6.5 minutes

8 minutes

13.7 m

10.6 m

4.9 m

2.5 m
DBF1 Upper HRR Sprinkler Activation

4.5 minutes
- Hand calcs
- FDS

INADEQUATE
\[ t_{\text{pre}} = 1 \text{ minute} \]  

\[ t_{\text{det}} + t_{\text{warn}} + t_{\text{pre}} = 3.25 \text{ minutes} \]

3.25 minutes validated through simulations and exercises as an upper bound
ASET_1 = 10 minutes

RSET_1 = 9.1 minutes \hspace{1cm} \text{(Includes 1.5 SF)}

Based upon a worst-case crane operator location and includes the pre-evacuation time
DBF2

DBF 1

DBF 2

DBF 3

FIRST FLOOR

Cal Poly
Fire Protection Engineering
DBF2
Office
Fire
Composite HRR with Shopvac, Trashcan, Chair and Workstation

Thomas Model Predicts Flashover

DBF2 HRR
DBF2
DBF2 Smokeview from West

Suppression at 3.5 minutes

E-W 2nd Floor Corridor

Office Compartment

E-W 1st Floor Corridor

N-S 1st Floor Corridor
DBF2 Smokeview from South
DBF2 Sprinkler Activation

Sprinkler Initiation at Various HRR Profiles

Range of Sprinkler Activation
DETACT Method

FDS

α=0.003  α=0.02  DBF2 Profile

Time (min)

HRR (kW)

0  100  200  300  400  500  600  700

0.0  0.8  1.7  2.5  3.3  4.2  5.0  5.8  6.7  7.5

Slide 44
DBF2 Smoke Height

Smoke Layer Interface between 3.5 - 5 minutes:

1\textsuperscript{st} floor: 6’
2\textsuperscript{nd} floor: 3’

Smoke interface height at 100 seconds on the 2\textsuperscript{nd} floor corridor is 6’.
5.5 minutes to incapacitation on 2\textsuperscript{nd} floor near stairway.

Historical fire drills show complete evacuation within 3 minutes.
DBF 3 Warehouse Fire
DBF3 Fire Spread

Point Source Evaluation
\[ \dot{q}'' = 2 \text{ kW/m}^2 \]

Radiation Transport Equation Derived from Configuration Factor
\[ \dot{q}'' = 7 \text{ kW/m}^2 \]
DBF3 Suppression  \( (R/H\sim 0.4) \)
General Egress Comparison

Egress Path

514’
Pathfinder
Steering 4 min; Hydraulic 3; Hand 3:14
Recommendations

1. Use steel pallets and containers
2. Increase combustible distance
3. Use 6-sided metal cabinets
4. Eliminate ignition sources
5. Storage islands
6. Train personnel to shut doors in the event of compartment fires.
7. Train personnel to close doors in compartment fires.

[FPH Pg. 18-6]