Maintenance Shop Building
Ted Stanton
FPE 596
MSB Overview

- Two Stories
- 41,624 square feet
- Constructed in 1986
- Part of Large Industrial Facility
  - Private Fire Water System
  - Private Fire Department
- Mixed Occupancy
  - Offices (Business)
  - Library (Assembly)
  - Meeting Rooms (Assembly)
  - Storage Rooms (Storage)
Applicable Codes and Standards

Current Codes:
• 2013 California Building Code (CBC)
• NFPA 72, National Fire Alarm and Signaling Code, 2013
• NFPA 13, Standard for the Installation of Sprinkler Systems, 2013

Code of Record:
• 1982 Uniform Building Code (UBC)
Structural Fire Protection

- Type IIB
- Fully Sprinklered
  - +1 Story
  - +200% Area

- 2 Story
- 41,624 square feet
  - ~21,000 ft² / floor

<table>
<thead>
<tr>
<th>GROUP</th>
<th>TYPE OF CONSTRUCTION (MODIFIED)</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
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<tbody>
<tr>
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<td>A</td>
<td>B</td>
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<td>B</td>
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<td>HEIGHT (feet)</td>
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<td>160</td>
<td>65</td>
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<td>AREA (A)</td>
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<td>4</td>
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<tr>
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<td>3</td>
<td>4</td>
<td>3</td>
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<tr>
<td>A</td>
<td>UL</td>
<td>UL</td>
<td>46,500</td>
<td>28,500</td>
<td>42,000</td>
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</table>
Fire Detection Analysis

- Remote Supervising Station
- Private Fire Brigade

- Heat-Activated Sprinklers
  - 74°C
  - RTI = 100 (m*s)^{1/2}

- Manual Initiation
  - No pull boxes
  - Telephone system
Fire Alarm Control Panel
## Battery Calculation

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity</th>
<th>Supervisory Current (in Amps)</th>
<th>Alarm Current (in Amps)</th>
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<td></td>
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<td>Unit</td>
<td>Total</td>
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<tr>
<td>FACP-300SSC</td>
<td>1</td>
<td>0.13</td>
<td>0.13</td>
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<tr>
<td>50GC</td>
<td>20</td>
<td>0.025</td>
<td>0.5</td>
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<td>Sub-Total</td>
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</tr>
<tr>
<td>Time Factor</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-Totals</td>
<td></td>
<td></td>
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<tr>
<td>Standby A-hrs</td>
<td></td>
<td>15.12</td>
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<tr>
<td>Alarm A-hrs</td>
<td></td>
<td>0.22</td>
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<tr>
<td>System A-hrs</td>
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<td>15.34</td>
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<tr>
<td>+20% derating</td>
<td></td>
<td>3.07</td>
<td></td>
</tr>
<tr>
<td>Total A-hrs</td>
<td></td>
<td>18.41</td>
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<tr>
<td>Battery Capacity</td>
<td></td>
<td>7.00</td>
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</tr>
</tbody>
</table>

- Battery Capacity: 10.8 hours + 5 in alarm
- Requirement: 24 hours + 5 alarm
Alarm / Notification Devices

• Federal Signal 50GC
  • Voice / Tone
  • Exceeds 70 dB in all locations except Mechanical Shop

• Mechanical Shop
  • Min SPL = 72 dBA
  • May not be audible if machinery operating (~85 dBA)
Suppression System

- Designed using “Pipe Schedule Method”
- Overdesigned per Hydraulic Calculations

- Hydraulically Most Demanding Area (Chem Lab, 2nd Floor):
  - 559.2 gpm @ 47.5 psi
  - Hose Stream Allowance = 750 gpm
    - Insurance Requirement
  - 1309.2 gpm @ 47.5 psi

<table>
<thead>
<tr>
<th>Room(s)</th>
<th>Occupancy Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Floor – Mechanical Shop</td>
<td>Ordinary (Group 2)</td>
</tr>
<tr>
<td>1st Floor – Library</td>
<td>Ordinary (Group 2)</td>
</tr>
<tr>
<td>1st and 2nd Floors – Office Spaces</td>
<td>Light</td>
</tr>
<tr>
<td>1st and 2nd Floors – Service Spaces</td>
<td>Light</td>
</tr>
<tr>
<td>2nd Floor – Chemistry Lab</td>
<td>Ordinary (Group 2)</td>
</tr>
<tr>
<td>2nd Floor – Shops, Labs, and Vocational Rooms</td>
<td>Ordinary (Group 1)</td>
</tr>
<tr>
<td>2nd Floor – Assembly Area</td>
<td>Light</td>
</tr>
</tbody>
</table>
Flow Test Summary

- 400, 168 Shutoff
- 2000, 140 Rated
- 3000, 91 150%
- 559, 47.5 no HSA
- 1309, 47.5 w/ HSA

Pressure (psi) vs. Flow (gpm) graph.
Fire Water Supply

Private Supply (site-wide)
Egress: Occupant Characteristics

- Healthy, working-age adults
- Working hours only
  - No bunking facilities
- Sensibility
  - Awake / alert
- Reactivity
  - Industrial Safety Training Culture
  - Most occupants employees
- Mobility
  - Dominated by queuing
- Susceptibility
  - Healthy adults
Occupancy & Egress Analysis

- Vocational Training Rooms
  - Assembly Use (Less Conc.)
  - Industrial Use

- Assembly: 278
- Industrial: 57

- Process Control Shop
  - Assembly: 50
  - Industrial: 8

- Mechanical Shop
  - Assembly: 278
  - Industrial: 57
Mechanical Shop
MSB 1st Floor – Occupancy & Egress Summary

1st Floor: 220 (541)
Floor Egress Capacity: 1440
Building Tot: 407 (1093)
* Excludes Roll-Up Doors

74’ Occupancy / Egress: 159 (382) / 360
82’ Occupancy / Egress: 61 (159) / 1080

First Floor Plan
Area: 21,000 sq.ft.
MSB 2nd Floor – Occupancy & Egress

Floor: 187 (552)

or Egress Capacity: 473

Iding Tot: 407 (1093)
Escape Time Analysis Results

Assembly Occupancy

- Hydraulic Model
  - Each 44” Stair: 45.6 persons/min
  - 36” Door: 48 persons/min
  - Travel Time (2nd to 1st fl): 0.49 min
  - Total: 4 minutes 28 seconds
- Pathfinder
  - 5 minutes 39 seconds
- Delay Time ~ 36 seconds
- RSET = 6 minutes, 15 seconds (375s)

Industrial Occupancy

- Hydraulic Model
  - 1 minute 51 seconds
- Delay Time ~ 36 seconds

Cal Poly
Fire Protection Engineering
Pathfinder

1st Floor

2nd Floor (Assembly Use)
Pathfinder

30 seconds

120 seconds
Summary: Prescriptive Compliance

• Structural: Compliant
• Detection / Alarm: Not Compliant
  • Mechanical Shop Alarm
  • Battery Capacity
• Suppression: Compliant
• Egress:
  • Compliant (Industrial)
  • Not Compliant (Assembly)
Performance-Based Fire Protection

- Performance Criterion:
  - Occupant not intimate with ignition shall not be exposed to untenable conditions
NFPA 101 Scenarios

Design Fire 1: Occupancy-Specific
DF 2: Fire in primary egress, interior doors open
DF 3: Normally unoccupied room
DF 4: Concealed wall / ceiling

DF 5: Shielded from suppression
DF 6: Most severe fire
DF 7: Outside exposure
DF 8: Ordinary fire, no detection or suppression
NFPA 101 Scenarios

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Tenability Criteria

- Visibility at eye level (1.8m)
  - 5m visibility
- Temperature
  - 60 °C
- Carbon Monoxide
  - 1400 ppm
Scenario 1: Atrium
Scenario 1: Atrium Fire

- Design Fire 2
- Small Space
- Scenario:
  - Trash Can Fire
- No Sprinklers
- Challenge:
  - Evacuation
  - Lost Exit (higher RSET)
Scenario 1: Atrium Fire

FDS Modeled Area

Fire
Scenario 1: Atrium Egress 30 seconds
Scenario 1: Atrium Egress 7 minutes

Last Occupant Out @ 583 seconds
Scenario 1: Atrium – FDS Results

Visibility
583 seconds
Yellow ~ 10 m

16.5 minutes
Halls ~ 7 m

Temperature
3.5 minutes
Peak ~ 90 °C
Blue = 15-30 °C
Scenario 1 Conclusion

- RSET = 583 seconds
- ASET > 1000 seconds
- Acceptance Criterion met
- Comments:
  - Trash Can fire
  - No Sprinklers
  - No Ventilation
Scenario 2: Storage
Scenario 2: Storage Room Door

The Door
Scenario 2: Storage Room Fire

- Design Fire 3
- Sprinklered
  - Assume sprinklers limit peak
  - Actuation time 161s (DETACT)
- Scenario:
  - Storage Shelf Fire
  - SFPE HB Figure 3-1.13

SFPE HB, 3rd Ed.
Fig. 3-1.13, Storage Units
Scenario 2: Egress

Last occupant out @ 352 seconds

Exit Door “Locks” at 90 seconds
Scenario 2: Storage Room
Scenario 2: Storage Room – FDS Results

Top View: 90 sec

Side View: 30 sec
Scenario 2: Storage Room – FDS Results

Temperature
140 seconds
Black = 60 °C

Temperature
5 minutes
Black = 60 °C
Scenario 2: Storage Room – FDS Results

Visibility
140 seconds
Black = 5 m

Visibility
4 minutes
Black = 5 m
Scenario 2 Conclusion

- RSET (corridor) = 140 seconds
- ASET = 240 seconds
- Acceptance Criterion met
Summary: Performance-Based Analysis

• Both scenarios successful
• Use Performance-Based results to supplement prescriptive results
Recommendations

• Prescriptive Recommendations
  • Egress (Assembly) Fails
    • Insufficient 2nd Floor Exits
  • Alarm Fails in Mech Shop
    • Improve alarm audibility
  • Larger Battery
    • 24 hour backup

• Performance-Based Recommendations
  • Successful Egress
  • Use per LSC to demonstrate compliance

Work with AHJ to resolve
Occupancy Question:
Industrial Occupancy
This Room Is Equipped With Edison Electric Light.

Do not attempt to light with match. Simply turn key on wall by the door.

The use of Electricity for lighting is in no way harmful to health, nor does it affect the soundness of sleep.
Scenario 1: Atrium – FDS Results

30 seconds

583 seconds
## DETACT – Storage Rm

### DETACT - Scenario Results

- **Gas temp**
- **Det. temp**
- **HRR**

### INPUT PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<td>Calculation reset</td>
<td>1 0 or 1</td>
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<tr>
<td>R/H</td>
<td>0.35</td>
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<tr>
<td>Ceiling height (H)</td>
<td>4.572 m</td>
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<td>W/H</td>
<td>2.3333</td>
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<td>Room width (W)</td>
<td>10.668 m</td>
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<td>Temperature factor</td>
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<td>Radial distance (R)</td>
<td>1.6 m</td>
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<td>Velocity factor</td>
<td>0.4798</td>
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<td>Ambient temperature (To)</td>
<td>20 C</td>
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<td>Calculation time (t)</td>
<td>701 s</td>
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<td>Actuation temperature (Ta)</td>
<td>74 C</td>
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<td>Fire HRR (Q)</td>
<td>23096 kW</td>
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<tr>
<td>Rate of rise rating (ROR)</td>
<td>8 C/min</td>
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<tr>
<td>Gas temperature (Tg)</td>
<td>677.42 C</td>
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<td>Response time index (RTI)</td>
<td>100 (m-s)1/2</td>
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<td>Gas velocity (Ug)</td>
<td>8.2318 m/s</td>
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<td>Fire growth power (n)</td>
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<td>75.046 C/min</td>
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### CALCULATION RESULTS

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<td>Slow</td>
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<td>Transport lag time (tI)</td>
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<td>Medium</td>
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<td>Detection time (td)</td>
<td>161 s</td>
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<td>Fast</td>
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<td>HRR at detection (Qd)</td>
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<td>Ultrafast</td>
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<tr>
<td>HRR with transport lag (QI+d)</td>
<td>1355 112 kW</td>
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### FIRE PROTECTION ENGINEERING

- Fire Protection Engineering