Bonderson Engineering Projects Center

Fire and life safety analysis of Bonderson Labs at Cal Poly
Presentation Overview

Building Introduction
Prescriptive Analysis
Egress Systems
Detection and Alarm Systems
Suppression Systems
Performance Based Analysis
Egress Systems
Structural Fire Protection
Conclusion and Recommendations
Protection Features and Systems

2 levels in height with atrium in corridor
18,575 ft² of enclosed space
Concrete and steel frame construction
Sprinklered and Smoke detection through
8000 ft² partially covered work area
## Codes and Standards

### Code of Record
- Americans with Disabilities Act
- California Code of Regulations (CCR), Including Titles 19 & 24
- California Building Code, 2001 (As amended and included in CCR Title 24)

### Code used in this analysis
- California Building Code, 2010
- NFPA 101, 2009
- NFPA 72, 2010
- NFPA 13, 2010
Prescriptive Analysis

Egress Systems
gress Systems

LEVEL 1 CORRIDOR AND EXITS

Single primary corridor on both levels

Open lobby and interior stair form an atrium in the corridor

Three 72” exits from the level corridor

Three 36” exits from the enclosed work area
gress Systems

LEVEL 2 CORRIDOR AND EXITS

- Open lobby and interior stair form an atrium in the corridor
- Lounge area – Accessory to the corridor
- Two 56" stairs provide egress path from second level
  - Stair 1 – Open interior stair discharges into level 1 corridor
  - Stair 2 – Discharges to Public Way

2 Vect 2 CORRIDOR AND EXITS
### Occupancy Classification and Loading Factors

**Table 7.3.1.2**

<table>
<thead>
<tr>
<th>Occupancy Classification</th>
<th>Load Factor (ft²/Pers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly Use – Less concentrated use, without fixed seating</td>
<td>15 net</td>
</tr>
<tr>
<td>Business Use</td>
<td>100 gross</td>
</tr>
<tr>
<td>Vocational Use – Shops, laboratories, vocational rooms</td>
<td>50 net</td>
</tr>
<tr>
<td>Industrial Use – General Industrial Occupancy</td>
<td>100 gross</td>
</tr>
<tr>
<td>Storage Use – Ordinary Hazard Contents</td>
<td>500 gross</td>
</tr>
</tbody>
</table>
gress Systems

LEVEL 1 OCCUPANCY CLASSIFICATION

- Corridor
- Industrial
- Vocational/Lab
- Assembly
- Business
- Storage
- Elevator
- Restroom
- Mech/Mech
### Progress Capacity

<table>
<thead>
<tr>
<th>Door/Exit</th>
<th>Occupant Load (Persons)</th>
<th>Exit Width</th>
<th>Exit Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>296</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vertical Exits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stair 1</td>
<td>40</td>
<td>56”</td>
<td>187</td>
</tr>
<tr>
<td>Stair2</td>
<td>40</td>
<td>56”</td>
<td>180*</td>
</tr>
<tr>
<td><strong>Exits to Public Way</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exit 01</td>
<td>70</td>
<td>72”</td>
<td>360</td>
</tr>
<tr>
<td>Exit 02</td>
<td>70</td>
<td>72”</td>
<td>360</td>
</tr>
<tr>
<td>Exit 03</td>
<td>53</td>
<td>72”</td>
<td>360</td>
</tr>
<tr>
<td>Exit 04</td>
<td>50</td>
<td>36”</td>
<td>180</td>
</tr>
<tr>
<td>Exit 05</td>
<td>50</td>
<td>36”</td>
<td>180</td>
</tr>
<tr>
<td>Exit 06</td>
<td>42</td>
<td>36”</td>
<td>180</td>
</tr>
</tbody>
</table>

*Exit capacity through Stair 2 is governed by the 36” door used to access the stair, and is therefore limited to 180 persons.*
## Required Separation of Mixed Occupancies

### FROM NFPA 101 TABLE 6.1.14.4.1(B)

<table>
<thead>
<tr>
<th>Occupancy Separation</th>
<th>Required Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business from Industrial – General Hazard</td>
<td>1-hour with sprinklers</td>
</tr>
<tr>
<td>Assembly from Industrial – General Hazard</td>
<td>1-hour with sprinklers</td>
</tr>
</tbody>
</table>

### FROM CBC TABLE 508.4

<table>
<thead>
<tr>
<th>Occupancy Separation</th>
<th>Required Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business from Factory Industrial – Moderate Hazard</td>
<td>None</td>
</tr>
<tr>
<td>Assembly from Factory Industrial – Moderate Hazard</td>
<td>1-hour with sprinklers</td>
</tr>
</tbody>
</table>
RATED SEPARATION

LEVEL 1 FIRE RATED SEPARATION

Corridor separated from industrial use areas by 1-hour rated separation
Where industrial occupancies are open to second level, 1-hour separation to the corridor and business occupancies exists.
Rounded Separation
### Other Egress Considerations

<table>
<thead>
<tr>
<th>Description</th>
<th>NFPA 101 Sections</th>
<th>Complies?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior Finish</td>
<td>7.1.4, XX.3.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Dead End Corridor</td>
<td>XX.2.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Common Path of Travel</td>
<td>XX.2.5</td>
<td>Room 104 - No</td>
</tr>
<tr>
<td>Travel Distance to Exit</td>
<td>XX.2.6</td>
<td>Yes</td>
</tr>
<tr>
<td>Egress Path Lighting</td>
<td>7.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Marking of Means of Egress</td>
<td>7.10</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Arrangement of Means of Egress

Assembly Use Room 104 and NFPA 101 Requirements

More than 50 occupants

Between Section 4.5.3 and Section 12.2.5.1.2, this space requires two exits

Space meets remoteness requirements of 7.5.1.3.3

Does not meet 7.2.1.4.2(1) for door swing direction or 2.2.2.2.3 for panic hardware

Room 104 was apparently not intended for Assembly Use
Prescriptive Analysis
Detection and Alarm Systems
Detection and Alarm System

CAMPUS ALARM OVERVIEW

Cal Poly features a campus-wide fire alarm and security system that transmits information to a Proprietary Supervising Station.

Windows-based Software from Security Information & Management Systems (SIMS) is utilized for monitoring a majority of the protected buildings on campus.

Due to the large number of student residences on campus, smoke alarm actuations are dealt with on a daily basis. Most of these alarms are due to burning of food in microwaves.

The Bonderson features a Honeywell Notifier NFS-640 which is an addressable system utilizing Signaling Line Circuit (SLC)
Detection and Alarm System

**PA 72 Required Smoke Detector Spacing**

<table>
<thead>
<tr>
<th>Ceiling Type</th>
<th>Required Detector Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth Ceilings</td>
<td>30 feet (Section 17.7.3.2.3.1)</td>
</tr>
<tr>
<td>Solid Joist, Depth &lt; 0.1H</td>
<td>30 feet (Section 17.7.3.2.4.2)</td>
</tr>
</tbody>
</table>

**PA 72 Required Visual Notification Spacing Per NFPA 72 Table 18.5.4.3.1(a)**

<table>
<thead>
<tr>
<th>Strobe Type</th>
<th>Strobe Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 cd, wall or ceiling mount</td>
<td>20’ by 20’</td>
</tr>
<tr>
<td>20 cd, wall mount</td>
<td>28’ by 28’</td>
</tr>
<tr>
<td>5 cd, wall mount</td>
<td>45’ by 45’</td>
</tr>
<tr>
<td>5 cd, wall mount, Corridor Coverage</td>
<td>20’ by 50’</td>
</tr>
</tbody>
</table>
## Detection and Alarm System

### INITIATING DEVICE TYPE AND QUANTITY

<table>
<thead>
<tr>
<th>First Floor</th>
<th>Second Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ionization: 26 (10 Harsh)</td>
<td>Ionization: 22 (2 Harsh)</td>
</tr>
<tr>
<td>Heat: 1</td>
<td>Duct Smoke: 2</td>
</tr>
<tr>
<td>Pull Station: 3</td>
<td>Heat: 1</td>
</tr>
<tr>
<td>Water Flow: 1</td>
<td>Pull Station: 1</td>
</tr>
</tbody>
</table>

### NOTIFICATION DEVICE TYPE AND QUANTITY

<table>
<thead>
<tr>
<th>First Floor</th>
<th>Second Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strobe: 21</td>
<td>Strobe: 11</td>
</tr>
<tr>
<td>Horn: 10</td>
<td>Horn: 5</td>
</tr>
<tr>
<td>Siren: 1</td>
<td></td>
</tr>
</tbody>
</table>
Detection and Alarm System

LEVEL 1 DETECTION AND VISUAL DEVICE COVERAGE
Prescriptive Analysis

Fire Suppression Systems
Suppression System

TEM WATER SUPPLY

Noteable water supply from 1,000,000 gallon tank on hill East of campus

Pressure drop from test location to OC at sprinkler riser is negligible at least a few psi

<table>
<thead>
<tr>
<th>Hydrant Number:</th>
<th>I-05-06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Pressure:</td>
<td>80 PSI</td>
</tr>
<tr>
<td>Residual Pressure:</td>
<td>60 PSI</td>
</tr>
<tr>
<td>Observed Flow:</td>
<td>1210 GPM</td>
</tr>
<tr>
<td>Calculated Flow at 20 PSI:</td>
<td>2190 GPM</td>
</tr>
<tr>
<td>Test Date:</td>
<td>09/03/02</td>
</tr>
<tr>
<td>Data Provided By:</td>
<td>F.P.C.P. – Cal Poly</td>
</tr>
</tbody>
</table>
Suppression System

Full Building Wet-Pipe Sprinkler

Single 4” Riser in South-West corner
# Suppression System

## RINKLER TYPES

<table>
<thead>
<tr>
<th>FG/Model</th>
<th>Finish</th>
<th>K</th>
<th>Degree</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyco TY-FRB Pendant on 1” Drop</td>
<td>Chrome</td>
<td>5.6</td>
<td>155</td>
<td>24</td>
</tr>
<tr>
<td>Tyco TY-FRB Upright on 28” Sprig</td>
<td>Brass</td>
<td>5.6</td>
<td>200</td>
<td>208</td>
</tr>
<tr>
<td>Tyco TY-FRB Upright</td>
<td>Brass</td>
<td>5.6</td>
<td>200</td>
<td>38</td>
</tr>
<tr>
<td>Tyco TY-FRB Horiz Sidewall</td>
<td>Brass</td>
<td>5.6</td>
<td>155</td>
<td>1</td>
</tr>
</tbody>
</table>
Two cases considered using method outlined in Section 22.4 of the Automatic Sprinkler Systems Handbook, 2010

### Floor Ordinary Hazard Occupancy
- Number of Sprinklers: 15
- Density: 0.20 gpm/ft²
- Designed Area of Discharge: 1500 ft²
- Water Flow Rate: 312 gpm
- Residual Pressure at BOR: 39.9 psi

### Second Floor Light Hazard Occupancy
- Number of Sprinklers: 13
- Density: 0.10 gpm
- Designed Area of Discharge: 1500 ft²
- Water Flow Rate: 186 gpm
- Residual Pressure at BOR: 43.4 psi
Supply at hydrant is much greater than the demand of the system.
Prescriptive Analysis

Structural Fire Protection System
Structural Fire Protection

Construction Elements

Columns and beams are constructed using unprotected wide Flange I-Beams ranging in sizes of W12x14 to 21x50.

Floor assemblies are constructed of light-weight concrete over 20 gauge decking.

Roof is constructed with welded 20 gauge decking.

Exterior wall assemblies include Glass curtain wall stem, reinforced concrete, and Gypsum on steel studs with a suspended 5/16 inch cement board on the exterior.
Non Combustible Construction allows for Type I or Type II

Type II-B meets building height and area requirements without crediting sprinklers

Type II-B does not require that any of the construction elements have rated construction

Therefore, unprotected structural members and unrated walls/floors is acceptable

<table>
<thead>
<tr>
<th>DING 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>Structural members</td>
<td>3(^a)</td>
<td>2(^a)</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(see Section 202)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-bearing walls</td>
<td>3(^a)</td>
<td>2(^a)</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>interior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary members (see Section 202)</td>
<td>2(^b), 1(^b), 0(^c)</td>
<td>1(^b), 0(^c)</td>
<td>0</td>
<td>HT</td>
<td>1(^b), 0(^c)</td>
</tr>
<tr>
<td>Construction members (see Section 202)</td>
<td>1(^{1/2}), 1(^b), 1(^b), 0(^c)</td>
<td>1(^b), 0(^c)</td>
<td>0</td>
<td>HT</td>
<td>1(^b), 0(^c)</td>
</tr>
</tbody>
</table>

See Table 602
Performance Based Analysis

Fire Scenario 1 – Lounge Area
Upholstered Seating
Scenario 1

**HOLSTERED SEATING FIRE**

The in lounge area seating modeled as a sofa fire per SFPE Handbook Figure 3-1.52, item 2

Lounge is an accessory to the level 2 corridor

Evaluate Time to

Alarm actuation

Sprinkler actuation

Untenable conditions

Compare to calculated availableress time
scenario 1

HOLSTERED SEATING FIRE
Scenario 1

Holstered Seating Fire
scenario 1

HOLSTERED SEATING FIRE
scenario 1

Outline of Scenario Inputs

Fire modeled as a sofa fire per SFPE handbook Figure 3-1.52, item F32
Smoke Detector modeled in actual location, sensitivity from device cut-sheet (%/ft)
Pre-movement time based on NFPA Handbook Table 4.2.1, assumed to be 60 sec
Movement time determined using PathFinder with egress path(s) near fire block
Sprinklers modeled and activation times noted, but do not affect fire
Time when conditions become untenable
Termination of Simulation
**Scenario 1**

**Timeline**

- **Smoke Detector Actuates**: 20 s
- **Occupant movement begins**: 80 s
- **Last out at**: 170 s
- **RSET**:
- **ASET**: First Sprinkler Actuates: 206 s, Visibility Drops below 20 ft: 241 s, Temperature at 6 ft above 60 °C: 200 s, Maximum Temp of 270 °C: 310 s
- **Smoke Temperature**: 241 s
- **Temperature of 270 °C**: 310 s

**Heat Release Rate**

- **Time (s)**: 0, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, 1000, 1050, 1100, 1150, 1200, 1250, 1300, 1350, 1400, 1450, 1500, 1550, 1600, 1650, 1700, 1750, 1800, 1850, 1900, 1950, 2000, 2050, 2100, 2150, 2200, 2250, 2300, 2350, 2400, 2450, 2500, 2550, 2600, 2650, 2700, 2750, 2800, 2850, 2900, 2950, 3000, 3050, 3100, 3150, 3200, 3250, 3300, 3350, 3400, 3450, 3500, 3550, 3600
- **Value of Heat Release Rate**: 0, 50, 100, 150, 200, 250, 300, 350, 400
scenario 1

OKEVIEW SCREENSHOTS

Frame: 456
Time: 200.7

Frame: 540
Time: 241.1
Performance Based Analysis

Fire Scenario 2 – Project Integration
Flammable Liquid Fire
scenario 2

flammable Liquid – Acetonitrile is a solvent Similar to Acetone

Class 1A flammable liquid with a flash point of 2 °C

maximum quantity allowed in this occupancy is 30 gallons, exceeding this quantity would require an H-2 classification

Boxes at 2.12 Liters each is approximately 25 gallons
Scenario 2

FLAMMABLE LIQUID FIRE

Modeled as a three Acetone pool fires totaling 25 gallons R of 4.6 MW and duration 410 s found using the FDT pool fires evaluate

Time to Detector actuation
Time to sprinkler actuation
Maximum temperatures compare to failure
Temperature of steel at 538 °C
scenario 2

flammable liquid fire
SCENARIO 2

**Timeline**

- **Smoke Detector Actuates**: 6 s
- **First Sprinkler Actuates**: 52 s
- **Maximum Temp of 290 °C**: 270 s
- **Simulation Terminated**: 440 s

**Scenario 2 Heat Release Rate**
scenario 2

Smokeview 5.6 – Oct 29 2010
Performance Based Analysis

Fire Scenario 4 – Assembly Use
Room 104 Trashcan Fire
Scenario 4

TRASHCAN FIRE

Trashcan fire modeled per PE handbook Figure 3-1.49, sizing of trash

Evaluate Time to
Alarm actuation
Sprinkler actuation
Untenable conditions

Compare to calculated available egress time
## PATHFINDER SCREENSHOTS

Fire Scenario | Pathfinder Mode | Last Out (seconds)
--- | --- | ---
4 | Steering | 78
Scenario 4

- Smoke Detector Actuates, Occupant Movement Begins 14 s
- First Sprinkler Actuates 85 s
- Last out at 92 s
- Maximum Temp of 85 °C at ceiling 150 s

Tenability Criteria not Reached

Simulation Terminated 400 s
Conclusion and Recommendations

The BEPC largely exceeds the requirements of NFPA 101 and the California Building Code for egress systems, however the following recommendations were identified:

Room 104 is often used for Assembly Use and the doors should be modified to comply with NFPA 101 or the California Building Code if the space is to be continued to be used in this manner.

Administrative controls of storage and types of materials should be improved due to the multi-purpose nature of the building. Storage of materials in no storage areas and long-term storage of flammable liquids were identified.

The fast turn-over of student projects creates a lot of different materials being brought into the Bonderson. Student training should be performed on what is allowed to be brought into the building and where it can be stored.