Fire Safety Review

of

The Performing Arts Center (PAC)

Building 006 – The Christopher Cohan Center

by

David Phillips

Image From: <http://fasttimesaslo.files.wordpress.com/2011/01/dscn0510.jpg>

Image From: Cal Poly Campus Map. <http://maps.calpoly.edu/flashmap/CalPolyMap.html>

Alex and Faye
Spanos Theatre

HP Davidson
Music Center

Performing Arts
Center San
Luis Obispo

Christopher
Cohan Center

Grand Ave

Grand Ave

Approach

Prescriptive

- Floor plans, occupancy classifications, and exits
- Building photos
- Structural Protection
- Other protection features
- Hazards, unique features

Performance

- Design fire scenarios
- Analysis
- Results
- Conclusions

Occupancy Classifications

Equipment/Storage S

Assembly A-1

Assembly A-2

Assembly A-3

Business B

Kitchen

Occupancy Classifications

Occupancy Classifications

Occupancy Classifications

Occupancy Classifications

Lower Level Exterior Exits

Main Level Exits

Map

Traffic

Main Level Exits

Image From: <http://fasttimesaslo.files.wordpress.com/2011/01/dscn0510.jpg>

Structural Protection

Protected Corridors

Hall Exits

Main Level Exits

Balcony and Gallery Exits

Harman Hall

Max Capacity: 1282

Image by: Malcolm Carlaw

<http://www.flickr.com/photos/lightsamples/5555005874/sizes/o/in/photostream/>

Main Floor: 808
Dress Circle: 153
Balcony: 169
Gallery: 152

Image by: Malcolm Carlaw

<http://www.flickr.com/photos/lightsamples/5555005874/sizes/o/in/photostream/>

Harman Hall

Image from: <http://www.calpoly.edu/~ezabala/harmanhall.jpg>

Other Required Features

Fully Sprinklered, NFPA 13 Compliant

- B, A-1, and A-3 Occupancies – Light Hazard
 - Storage, Kitchen, and Mechanical Rooms – Ordinary Hazard 1
 - Stage and Orchestra Pit – Ordinary Hazard 2
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- Gravity vents over stage – Fusible link and manual activation**
 - Fire curtain – Manual activation, rate of rise heat detector, and fusible link**
 - Voice occupant notification system**
 - Emergency power provided by a generator**

Automatic Detection System

NFPA 72 Compliant

Device	Speaker, Strobe, and Voice	Loading Dock Bell	Signal Security / Engineering	Magnetic Doors Released	Dampers Close	Elevator Accordion Doors	Supervisory Signal
Manual Pull Station	X		X	X	X	X	
Smoke Detector	X		X	X	X	X	
Heat Detector	X		X	X	X	X	
Duct Detector	X		X	X	X	X	
Water Flow Alarm	X	X	X	X	X	X	
Tamper Switch							X

Hazards and Features

Kitchen is equipped with an ANSUL range suppression system

Pipe organ is protected with a double interlock sprinkler system

Central station monitoring of an alarm panel annunciator

Performance Based Analysis

Scenarios selected from NFPA 101, the Life Safety Code

5.5.3.8 A fire originating in ordinary combustibles in a room or area with each passive or active fire protection system independently rendered ineffective.

- Assume fire curtain fails to deploy
- Fire growth modeled as a fast t^2 , NFPA Handbook Figure 3.7.2
- Heat of combustion, soot yield, and CO yield based on average of materials likely present for which such data is available
- Evacuation may not start immediately, because fog and smoke effects on stage may mask the presence of the early fire

Performance Based Analysis

Second Scenario

5.5.3.2 An ultrafast-developing fire, in the primary means of egress, with interior doors open at the start of the fire.

- Fuel properties from the SFPE Handbook
- Assume 1 gallon of the liquid fuel, calculate burn out time based on heat of combustion and dictated HRR
- Assume fire spreads to seating, after which growth is a medium t^2 fire, based on NFPA Handbook Figure 3.7.2

FIGURE 3.7.2 Set of t -Squared Growth Curves

Fuel Properties

Scenario 1

Source: SFPE Handbook Table 3-4.14

Material	Net heat of combustion (kJ/g)	Soot yield (g/g)	CO yield (g/g)	Radiant Fraction
Woods				
Red Oak	12.4	0.015	0.004	0.371
Fir	13.0		0.004	0.377
Pine	12.4		0.005	0.298
Fiber board	14.0		0.015	
Average of known values	12.9	0.015	0.007	0.349

Tenability Criteria

Visibility: 10m or greater

- 12m maximum from any point on the balcony to an exit.
- 10m visibility decreases chances of turn back behavior. (John L. Bryan, NFPA Handbook)

Temperature: Less than 60°C.

- Limit at which 100% humid air can be breathed. (David Purser, SFPE Handbook)

Toxicity: CO exposure less than 35,000 ppm * min

- Exposures to CO greater than this can cause incapacitation. (Richard G. Gann, Nelson P. Bryner, NFPA Handbook)

Heat Flux: Less than 2.5kW/m²

- Severe skin pain in 1 second of exposure. (David Purser, SFPE Handbook)

RSET

Evacuation time determined by Pathfinder and compared with SFPE method hand calculations.

Main Seating – Two 72 inch doors and two 44 inch doors available

- SFPE method, spreadsheet– 2.5 minutes
- Pathfinder steering mode – 2.0 minutes
- Pathfinder SFPE mode, collisions enabled - **2.6 minutes**

Main Seating – One 72 inch door unavailable

- Pathfinder SFPE mode, collisions enabled - **3.9 minutes**

Gallery Seating – Four 36 inch doors available

- Pathfinder SFPE mode, collisions enabled – **1.4 minutes**

Gallery Seating – Three 36 inch doors available

- Pathfinder SFPE mode, collisions enabled – **1.5 minutes**

Pathfinder

Scenario One Results

Tenability using CFAST

ASET for 10 m visibility criteria is about 4 minutes for the gallery level, using the SFPE mass optical density method.

Smoke layer has descended to 6ft above gallery seating in 3.8 minutes.

Scenario One Results

Tenability using FDS

ASET for 10 m visibility criteria is not reached for the illuminated sign over the gallery seating in 15 minutes.

Smoke layer has descended to 6ft above gallery seating in 6.8 minutes.

Scenario One Results

Tenability using CFAST

At 2.5 minutes, the upper layer in the CFAST model had just lowered to the top of the proscenium arch, so no visibility or CO tenability criteria would have been met.

Scenario One Results

Tenability using FDS

At 4 minutes, smoke is just beginning to escape beneath the proscenium wall.

Scenario Two Results

Tenability using CFAST

ASET for 10 m visibility criteria is about 3.2 minutes for the gallery level, using the SFPE mass optical density method.

Smoke layer has descended to 6ft above gallery seating in 1.2 minutes.

Sign Visibility

◆ Reflective Sign ■ Emitting Sign ▲ Layer Height

Scenario Two Results

Tenability using FDS

ASET for 10 m visibility criteria is reached for the illuminated sign over the gallery seating in 7.6 minutes.

Smoke layer has descended to 6ft above gallery seating in 2.2 minutes.

Scenario Two

CFAST vs. FDS

Transport lag about 22 seconds

Smokeview 5.6 - Oct 29 2010

Frame: 19

Time: 22.8

mesh: 1

Scenario Two

CFAST vs. FDS

70 seconds

Smokeview 5.6 - Oct 29 2010

mesh: 1

Frame: 50

Time: 69.6

Scenario Two

CFAST vs. FDS

130 seconds

Results

Scenario 1					
Criteria and Location	RSET (minutes)	CFAST ASET (minutes)	FDS ASET (minutes)	Margin CFAST (minutes)	Margin FDS (minutes)
Layer Gallery	1.4	3.8	6.8	2.4	5.4
Visibility Gallery	1.4	4	> 15	2.6	> 13.6
Visibility Floor	2.6	7	> 15	4.4	> 12.4
Temp Gallery	1.4	9	> 15	7.6	> 13.6
Temp Floor	2.6	9	> 15	6.4	> 12.4

Results

Scenario 2					
Criteria and Location	RSET (minutes)	CFAST ASET (minutes)	FDS ASET (minutes)	Margin CFAST (minutes)	Margin FDS (minutes)
Layer Gallery	1.5	1.2	2.2	-0.3	0.7
Visibility Gallery	1.5	3.2	3.7	1.7	2.2
Visibility Floor	3.9	7	> 17	3.1	> 13.1
Temp Gallery	1.5	4	11.1	2.5	9.6
Temp Floor	3.9	7.3	> 17	3.4	> 13.1

Summary

Prescriptive

- Building compliancy with investigated code issues

Performance

• Scenario 1

- Greater than 2.5 minutes for detection and pre-movement

• Scenario 2

- Little to no margin for detection and pre-movement before smoke layer reaches occupants
- Small margin between visibility criteria and evacuation

Models

- CFAST model neglects transport lag and has greater entrainment when compared to the FDS model