FIRE AND LIFE SAFETY ANALYSIS

CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

California Polytechnic State University, San Luis Obispo

Laura Radle

June 11, 2013

Acknowledgements

Special thanks to:

Professor Fred Mowrer
Professor Christopher Pascual
Professor David Rich
Professor Lonny Simonian
Professor Thomas Korman
Professor Chris Lautenberger
Professor Francisco Joglar
Northern California / Nevada Society of Fire Protection Engineers
California Polytechnic State University, College of Architecture and Environmental Design
Tri-En Corporation, Engineering Services
Deep Blue Integration, Inc.

Statement of Disclaimer

This project report is a result of a class assignment; it has been graded and accepted as fulfillment of the course requirements. Acceptance of this report in fulfillment of the course requirements does not imply technical accuracy or reliability. Any use of information in this report is done at the risk of the user. These risks may include, but may not be limited to, catastrophic failure of the device or infringement of patent or copyright laws. California Polytechnic State University at San Luis Obispo and its staff cannot be held liable for any use or misuse of the project.

Search Keywords

Fire and Life Safety Analysis

Executive Summary

The purpose of this fire and life safety analysis is to determine whether Cal Poly's Center for Science and Mathematics (CSM) meets fire safety goals. The primary fire safety goal is to provide building occupants with an environment that is reasonably safe from fire. This goal can be achieved by protecting the occupants not intimate with the initial fire development and improving survivability of those occupants intimate with the initial fire development, (NFPA 101, 2006).

A prescriptive-based design approach and a performance-based design approach are used to evaluate building safety. The prescriptive-based approach is used to evaluate the building's structural fire protection systems, fire detection and alarm systems, fire suppression systems and egress design.

The performance-based design approach is used to analyze how the building will perform in the event of a fire. The performance-based approach evaluates the building based on the required safe egress time (RSET) and available safe egress time (ASET) for occupants to evacuate the building safely in the event of a fire.

A Smoke Management Study was conducted to predict the effects of fire within the atrium space of the CSM using natural ventilation to control smoke. The study is evaluated in this report using hand calculation methods and two computer software programs, Fire Dynamics Simulator (FDS) and Pathfinder to determine if occupant safety is sufficient.

Recommendations to improve building fire safety are discussed based on the results of this fire and life safety analysis.

Table of Contents

Acknowledgements.....	i
Executive Summary.....	ii
List of Figures	1
List of Tables	2
Acronyms and Abbreviations	3
1.0 Introduction	4
2.0 Code Requirements.....	5
3.0 Building Details	6
3.1 Building Occupancy Classification.....	6
3.2 Building Square Footage	6
3.3 Building Height.....	7
3.4 Site Access.....	7
3.5 Construction Type	8
3.6 Construction Images	9
3.7 Stakeholders	10
4.0 Prescriptive-Based Design.....	10
4.1 Structural Fire Protection.....	10
4.2 Fire Detection, Alarm and Communication Systems	15
4.3 Fire Suppression Systems.....	30
4.4 Egress Analysis	34
5.0 Performance-Based Design	42
5.1 Methodology.....	43
5.2 Design Fire Development.....	45
5.3 Tenability Criteria.....	48
5.4 Required Safe Egress Time.....	49
5.5 Available Safe Egress Time.....	54
5.6 Results	55
6.0 Conclusion.....	56
7.0 Recommendations	56
References	57
Bibliography	60
Appendix A: Fire-Resistance Ratings.....	62
Appendix B: Occupancy Classifications.....	68
Appendix C: Travel Distance to Exits.....	74
Appendix D: Fire Detection Devices.....	80
Appendix E: Sprinkler Design Layout	87
Appendix F: Sprinkler Control Calculations.....	93
Appendix G: Fire Safety Management Plan	97
Appendix H: Smoke Control System	103
Appendix I: Flammable and Combustible Liquids.....	123
Appendix J: Pathfinder Computer Evacuation Models- Atrium Space	124
Attachment 1: Data Sheets	140
Attachment 2: Fire Alarm and Voice Evacuation System	179
Attachment 3: Smoke Management Study.....	195

List of Figures

- Figure 1: Construction Site
- Figure 2: New Site Orientation
- Figure 3: Site Access Arrangement
- Figure 4: Fire Hydrant Flow Test
- Figure 5: CSM View Looking Northeast
- Figure 6: CSM View Looking Northwest
- Figure 7: Recommended Building Zones for Phased Evacuation
- Figure 8: OSID Spacing Requirements
- Figure 9: Alignment of 90° OSID Imager to Emitter
- Figure 10: Location of Risers
- Figure 11: Design Area Reduction for Quick-Response Sprinklers
- Figure 12: Exit Discharge to Public Way
- Figure 13: Chevron-Type Indicator
- Figure 14: Relation of t^2_{Fire} to Some Fire Tests
- Figure 15: Location of Design Fire Scenarios
- Figure 16: Sequence of Occupant Response to Fire
- Figure 17: Evacuation Speed as a Function of Density
- Figure 18: RSET vs. ASET

List of Tables

Table 1: Occupancy Types
Table 2: Building Square Footage
Table 3: Fire-Resistance Rating Requirements
Table 4: CSM Occupancy Separation
Table 5: Flame Spread and Smoke Development
Table 6: Building Service Code Requirements
Table 7: Performance of SLCs and NACs
Table 8: Sequence of Operations Matrix
Table 9: System Details
Table 10: System Specifications
Table 11: OSID Available Fields of View and Detection Ranges
Table 12: Design Criteria and Water Supply
Table 13: Riser Details
Table 14: System Demand
Table 15: Occupant Load Factor
Table 16: Occupant Load for Each Floor
Table 17: Number of Exits
Table 18: Travel Distance to Exits
Table 19: Illumination Requirements
Table 20: Emergency Lighting Requirements
Table 21: Age Demographics
Table 22: Limitations That Could Impede Evacuation
Table 23: Occupant Walking Speeds
Table 24: Summary of Design Fires
Table 25: Tenability Criteria
Table 26: Estimated Delay Time to Start Evacuation
Table 27: Travel Time to Evacuate Atrium Space (Zone 1)
Table 28: Pathfinder Occupant Characteristics
Table 29: Evacuation Travel Time, Hand Calculations Compared With Computer Models
Table 30: Total Evacuation Times
Table 31: Ventilation Openings
Table 32: ASET Summary
Table 33: RSET vs. ASET

Acronyms and Abbreviations

AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
ARC	Alarm Receipt Capability
ASET	Available Safe Egress Time
ASFP	Association for Specialist Fire Protection
ASME	American Society of Mechanical Engineers
Cal Poly	California Polytechnic State University
CBC	California Building Code
CFC	California Fire Code
CFD	Computational Fluid Dynamics
CIBSE	Chartered Institution of Building Services Engineers
CMOS	Complementary Metal-Oxide Semiconductor
CPSU	California Polytechnic State University
CPU	Central Processing Unit
CSFM	California State Fire Marshal
CSM	Center for Science and Mathematics
DF1,2,3,4	Design Fire #1, 2, 3, 4
EOL	End of Line
EPSS	Emergency Power Supply System
FACP	Fire Alarm Control Panel
FATC	Fire Alarm Terminal Cabinet
FDS	Fire Dynamic Simulator
FM	Factory Mutual
FVM	Finite Volume Method
GPM	Gallons Per Minute
HRR	Heat Release Rate
IR	Infrared
ITM	Inspection, Testing and Maintenance
LES	Large Eddy Simulation
LSC	Life Safety Code
NAC	Notification Appliance Circuit
NFPA	National Fire Protection Association
NIST	National Institute of Technology
OSID	Open-area Smoke Imaging Detection
PSI	Pounds per Square Inch
RNPS	Remote Notification Power Supply
RSET	Required Safe Egress Time
SFPE	Society of Fire Protection Engineers
SLC	Signal Line Circuit
STEPS	Simulation of Transient Evacuation and Pedestrian movements
UDACT	Universal Digital Alarm Communicator Transmitter
UL	Underwriter Laboratory
UV	Ultraviolet

1.0 Introduction

The Center for Science and Mathematics (CSM) is a new construction project funded by California Polytechnic State University of San Luis Obispo, CA, (Cal Poly). The CSM is replacing the north wings of the current science building currently known as the Spider Building. The new building is located at the center of the Cal Poly campus and is expected to open in May 2013.

The CSM consists of a 5 level central structure devoted to offices and student spaces with wings on either side that house classrooms and laboratories. The central entrance on Level 2 connects to Centennial Park on the south side and to a major pedestrian artery on the north. These entrances access offices and conference rooms for Chemistry and Biochemistry, Physics, and Earth and Soil Science. In addition to this main entrance, there are two additional entrances, Level 1 on the west end for the University classrooms and Level 3 on the east end. Levels 3-6 are faculty offices and student study spaces, (College of Science and Mathematics, 2012).

Figure 1 shows the construction site for the new CSM building relative to the north wings of the old Spider Building. Figure 2 shows the new construction building with a central entrance on Level 2 connecting to Centennial Park on the south side and illustrates the flow of pedestrians through the site.

Figure 1: Construction Site

Reference: Zimmer, 2009

Figure 2: New Site Orientation

Reference: Cal Poly, 2010

2.0 Code Requirements

The CSM was designed to meet the following major codes, standards and regulations:

- California Code of Regulations
 - Title 24, Part 1: Building Standards Administrative Code, 2007
 - Title 24, Part 2: California Building Code (CBC), 2007
 - Title 24, Part 3: California Electrical Code (CEC), 2007
 - Title 24, Part 4: California Mechanical Code (CMC), 2007
 - Title 24, Part 5: California Plumbing Code (CPC), 2007
 - Title 24, Part 6: California Energy Code, 2007
 - Title 24, Part 7: California Elevator Safety Construction Code, 2010
 - Title 24, Part 8: California Historical Building Code, 2007
 - Title 24, Part 9: California Fire Code (CFC), 2007
 - Title 24, Part 12: California Referenced Standards Code, 2007
- Applicable Standards and Guides
 - NFPA 13: Standard for the Installation of Sprinkler Systems, 2007
 - NFPA 20: Standard for the Installation of Stationary Pumps for Fire Protection, 2007
 - NFPA 70: National Electric Code, 2005
 - NFPA 72: National Fire Alarm Code, 2007
 - NFPA 90A: Standard for Installation of Air-Conditioning, 2002
 - NFPA 90B: Standard for Installation of Warm Air Heating, 2006
 - NFPA 101: Life Safety Code (LSC), 2006

This report focuses on the prescriptive-based and performance-based approaches to fire protection design as described in the Life Safety Code, (NFPA 101, 2006).

The following life safety goals are specified in NFPA 101:

Section 4.1: The primary fire safety goal is to provide building occupants with an environment that is reasonably safe from fire by protecting the occupants not intimate with the initial fire development and improving survivability of those occupants intimate with the initial fire development, (NFPA 101, 2006).

Section 4.2: The primary objectives used to achieve this goal include protecting occupants, maintaining structural integrity and maintaining system reliability for the time needed to evacuate, relocate, or defend in place. The Life Safety Code provides two compliance options to meet these goals and objectives: (1) Prescriptive-based and (2) Performance-based, (NFPA 101, 2006).

Section 4.2.2: A prescriptive-based approach to life safety design must be in accordance with Chapters 1-4, 6-11 and 38 of the Life Safety Code, (NFPA 101, 2006).

Section 4.2.3: A performance-based approach to life safety design must be in accordance with Chapters 1-5 of the Life Safety Code, (NFPA 101, 2006).

Specific code requirements pertaining to prescriptive-based and performance-based design will be discussed in their respective sections of this report.

3.0 Building Details

3.1 Building Occupancy Classification

The CSM is classified as a Group B, Business Occupancy, defined as an occupancy used for the transaction of business other than mercantile, (NFPA 101, 2006, Section 6.1.11.1). The CBC further defines a business occupancy as a building used for offices, professionals or service-type transactions including educational occupancies for students above the 12th grade, (CBC, 2007, Section 304). The different occupancy uses within the CSM are shown in Table 1.

Table 1: Occupancy Types		
Use	Occupancy Type	Occupancy Definition
Lobbies, Lecture Halls	A-3	Assembly uses intended for worship, recreation or amusement and other assembly uses not classified elsewhere in Group A
Offices, Laboratories, Conference Rooms (<i>less than 50 occupants</i>)	B	Facilities for office, professional or service-type transactions
Electrical, Mechanical and Telephone/Data	S-1	Facilities used for moderate hazard storage and not classified as a hazardous occupancy.
Storage	S-2	Facilities used for low hazard storage and not classified as a hazardous occupancy.
Storage	H-3	Facilities containing materials that readily support combustion or that pose a physical hazard, including: Class I, II or IIIA flammable or combustible liquid that are used or stored in normally closed containers or systems pressurized at 15 pounds per square inch gauge or less. Restrictions on flammable or combustible liquids relating to the CSM are detailed in Appendix I.
<i>Reference: CBC, 2007, Chapter 3</i>		

3.2 Building Square Footage

The CSM contains six levels with the following gross square footage:

Table 2: Building Square Footage	
Building Level	Gross Square Footage (G.S.F.)
Level 1	23,146
Level 2	43,458
Level 3	43,209
Level 4	33,307
Level 5	25,294
Level 6	19,958
TOTAL	188,372
<i>Reference: Zimmer, 2009</i>	

3.3 Building Height

The actual building height of the CSM is 108'-0" including six stories and a penthouse. The defined building height of the CSM is 64'-0" to the top of highest occupied floor/level above building access.

The CSM is not considered a "high-rise structure" because there are no floors used for human occupancy located more than 75 feet above the lowest floor level having building access, (CBC, 2007 Section 403.1 Exception [SFM] 403.1.2).

3.4 Site Access

The nearest Fire Department is located approximately 1.5 miles from the CSM building. Fire access roads are provided within 150 feet of all portions of the CSM building. The fire code official is authorized to increase the dimension of 150 feet when the building is equipped throughout with an approved automatic sprinkler system, (CBC, 2007, Section 503.1.1, Exception 1).

Figure 3 demonstrates the site access arrangement for emergency response vehicles and shows that distances do not exceed 150 feet. The access walkway leading from exterior exits on the south facing side of the CSM to the access roads may exceed distances of 150 feet and require approval from the fire code official, (CBC, 2007, Section 504).

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

An approved water supply capable of supplying the required fire flow for fire protection must be provided and a water supply test must document the approval of the water supply system, (CBC 2007, Section 508).

Figure 4 shows the results of a fire hydrant flow test performed during the initial stages of building construction. The static and residual pressures were measured at fire hydrant #63 and the flow was measured at fire hydrant #64. An updated water supply test is required prior to final approval of the building.

3.5 Construction Type

The CSM is Type 1B, Fire-Resistive construction. The fire-resistive rating requirements for building elements are shown in Table 3:

Table 3: Fire-Resistance Rating Requirements	
Building Element	Fire-Resistive Rating
Structural Frame	2 hours (1 hour permitted where supporting a roof only)
Exterior Bearing Walls	2 hours
Interior Bearing Walls	2 hours (1 hour permitted where supporting a roof only)
Interior Nonbearing Walls	Non-rated
Floor Construction	2 hours
Roof Construction	1 hour
Exterior Separation < 30 Feet	2 hour for occupancies H & L 1 hour for all other occupancies

Reference: CBC, 2007, Table 601 and Table 602

3.6 Construction Images

Figure 5: CSM View Looking Northeast

Reference: <http://www.flickr.com/photos/calpolyscience/sets/72157628917516905/show/>

Figure 6: CSM View Looking Northwest

Reference: <http://www.flickr.com/photos/calpolyscience/sets/72157628917516905/show/>

3.7 Stakeholders

Stakeholders represent individuals or representatives of individuals who have an interest in the successful completion of a project. Stakeholders for the CSM include:

- Building Owner
 - California Polytechnic State University (CPSU)
 - Facilities Planning and Capital Projects
- Authority Having Jurisdiction (AHJ)
 - Fire Official of CPSU
 - Building Official of CSM
- Accreditation Agencies
- Construction Teams
- Tenants
 - Cal Poly employees
 - Faculty members
 - Students
 - Visitors
- Building Operations and Maintenance
 - The CSM will be maintained by Cal Poly's Facilities Department. The Facilities Department is responsible for maintaining safe conditions in the building once construction is complete and the building is commissioned for use.
- Risk Managers and Insurance Underwriters are used to guard against catastrophe and protect against risk.

4.0 Prescriptive-Based Design

Section 4.2.2: A prescriptive-based approach to life safety design must be in accordance with Chapters 1-4, 6-11 and 38 of the Life Safety Code. When specific requirements contained in Chapter 38 differ from general requirements contained in Chapters 1-4, 6-11, the requirements of Chapter 38 will govern, (NFPA 101, 2006).

Chapter 38 pertains to life safety requirements for all New Business Occupancies, (NFPA 101, 2006, Section 38.1.1.1). Chapter 38 references Chapters 1-4, 6-11 as required.

4.1 Structural Fire Protection

Structural fire protection uses products to insulate the structural frame of a building to allow it to retain its required load bearing strength or limit the core temperature for a required period of time, (ASFP, 2013). The time periods are defined by fire-resistive ratings given in hours. The fire-resistive rating requirements depend on the building construction type. The CSM is Type 1B, Fire-Resistive construction and the fire-resistive rating requirements are given in Table 3 of this report.

The CSM is considered a Multiple Occupancy because the building has two or more classes of occupancy types, (reference Table 1). The CSM is further classified as a Separated Occupancy because the various occupancy types are separated by fire resistance-rated assemblies, (NFPA 101, 2006, Section 6.1.14.1.1(2) and 6.1.14.2.3).

Table 4 shows the fire-rating requirements for different occupancy separations within the CSM.

Table 4: CSM Occupancy Separation	
Occupancy Separation	Fire-Rating
B to A-3	1 hour
B to H-3	1 hour
B to S-1	No separation required
B to S-2	1 hour
S-1 to H-3	1 hour
S-1 to S-2	1 hour
<i>Reference: CBC, 2007, Table 508.3.3</i>	

Appendix A illustrates the floor plans and fire-resistance ratings between occupancy boundaries.

4.1.1 Protection of Vertical Openings

A vertical opening is defined as an opening through a floor or roof, (NFPA 101, 2006, Section 3.3.254). The CSM contains vertical openings that are enclosed or protected in accordance with Section 8.6 of the Life Safety Code, 2006 Edition.

4.1.1.1 Floor Smoke Barriers

Every floor in the CSM that separates stories is required to be constructed as a smoke barrier in accordance with Section 8.5 except for the atrium space which is permitted to have openings in accordance with Section 8.6.7, (NFPA 101, 2006, Section 8.6.1).

4.1.1.2 Continuity

The CSM requires openings through floors to be enclosed with fire barrier walls that are continuous from floor to floor, or floor to roof, and protected by a 2 hour fire resistant barrier, (NFPA 101, 2006 Section 8.6.2). The CSM has an expansion joint that must be designed to prevent the penetration of fire. The expansion joint must prove to have a fire resistance rating not less than 2 hours when tested in accordance with UL 2079, *Standard for Tests of Fire Resistance of Building Joint Systems*, (NFPA 101, 2006, Section 8.6.3(4))

4.1.1.3 Fire Resistance Rating

Floor opening enclosures connecting four stories or more must have a fire resistance rating of at least 2 hours. Floor opening enclosures connecting three stories or less must have a fire resistance rating of at least 1 hour, (NFPA 101, 2006, Section 8.6.5). The CSM contains 2 hour fire resistant barriers between stories.

4.1.1.3.1 Smoke Barriers

Smoke barriers are provided to subdivide building spaces for the purpose of restricting the movement of smoke. Vertical openings in the CSM that separate stories are required to be constructed as a smoke barrier except for the atrium opening. The CSM uses fire barriers instead of smoke barriers to comply with Section 8.5 of the Life Safety Code, (NFPA 101, 2006, Section 8.5.3). The fire barriers in the CSM must maintain continuity and protect openings (including doors, windows, ducts and air-transfer openings, barrier penetrations and expansion joints) in order to meet the requirements of smoke barriers as defined in Section 8.5 of the Life Safety Code.

4.1.1.3.2 Atrium

The CSM atrium meets the requirements in NFPA 101, 2006, Section 8.6.7:

- (1) The Life Safety Code requires at least 1 hour fire resistance rating separating atriums from adjacent spaces. The atrium in the CSM is considered a 'Control Area' and is separated from adjacent spaces by fire barriers of 2 hour fire resistance rating, (CBC, 2007, Section 714.2.4).
- (2) The CSM provides access from the atrium to exits and exit discharge via horizontal exits and an area of refuge.
- (3) The occupancy within the atrium is considered ordinary hazard.
- (4) The entire CSM is protected throughout by an approved, supervised automatic sprinkler system.
- (5) A Smoke Management Study was conducted to demonstrate that the atrium is designed to keep the smoke layer interface above the highest unprotected opening to adjoining spaces, or 6 feet above the highest floor level of exit access open to the atrium, for a period equal to 1.5 times the calculated egress time or 20 minutes, whichever is less.
- (6) The atrium is designed for natural ventilation of smoke; no exhaust system is currently required.

4.1.2 Interior Finish

Interior finish of the CSM must comply with Section 38.3.3 and Section 10.2 of the Life Safety Code, 2006 Edition. Interior wall and ceiling finish material must be Class A or Class B in exits and in exit access corridors. Interior wall and ceiling finishes can be Class A, Class B, or Class C in areas other than in exits and in exit access corridors. Interior floor finish in exit enclosures must be Class I or Class II.

Class A, Class B and Class C interior wall or ceiling finishes are classified based on test results from the following codes:

- NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*
- ASTM E 84, *Standard Test Method of Surface Burning Characteristics of Building Materials*
- UL 723, *Standard for Test of Surface Burning Characteristics of Building Materials*
- NFPA 286, *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth*
 - Flames cannot spread to the ceiling during the 40 kW exposure
 - During the 160 kW exposure, flames cannot spread to the outer extremities of the sample on the 8 x 12 foot wall and flashover cannot occur
 - The peak heat release rate throughout the test cannot exceed 800 kW
 - The total smoke release throughout the test cannot exceed 100 m²

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Table 5 shows the flame spread and smoke development test requirements for Class A, Class B and Class C interior wall and ceiling finishes.

Table 5: Flame Spread and Smoke Development			
Classification	Flame Spread	Smoke Development	Notes
Class A	0-25	0-450	No continued propagation of fire in any element thereof when tested
Class B	26-75	0-450	N/A
Class C	76-200	0-450	N/A
Reference: NFPA 101, 2006, Section 10.2.3.4			

4.1.2.1 Specific Materials

Since the CSM is protected throughout by an approved automatic sprinkler system, textile wall/ceiling materials and expanded vinyl wall/ceiling materials that are rated Class A are permitted, (alternative criteria available), (NFPA 101, 2006, Section 10.2.4.1 and Section 10.2.4.2).

Cellular or foamed plastic materials are not allowed to be used as interior wall and ceiling finish in the CSM unless the materials is subjected to large-scale fire tests that substantiate combustibility characteristics for the use intended under actual fire conditions, (NFPA 101, 2006, Section 10.2.4.3.1). Cellular or foamed plastic is allowed for trim less than 10% of the wall or ceiling area, provided that it is not less than 20 lb/ft³ in density, less than ½ inches thick, and less than 4 inches in width, and complies with the requirements for Class A or Class B interior wall and ceiling finish, (excluding the smoke development factor), (NFPA 101, 2006, Section 10.2.4.3).

Light-transmitting plastics, decorations, furnishings and metal ceiling and wall panels are further described in Section 10.2.4 of the Life Safety Code, 2006 Edition.

4.1.2.2 Trim and Incidental Finish

Interior wall and ceiling trim less than 10% of the aggregate wall and ceiling areas of any room or space can be Class C materials in the CSM. Wall base used at the junction of the wall and the floor to provide a functional or decorative border cannot exceed 6 inches in height and must meet the requirements of Class II interior floor finish. Bulletin boards, posters and paper attached directly to the wall cannot exceed 20% of the aggregate wall area to which it is applied, (NFPA 101, 2006, Section 10.2.5).

4.1.2.3 Interior Floor Finish Testing and Classification

Interior floor finishes are classified based on test results from NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*. Interior floor finishes are classified in accordance with the critical radiant flux ratings, (NFPA 101, 2006, Section 10.2.7.4):

1. Class I interior floor finish is characterized by a critical radiant flux not less than 0.45 W/cm²
2. Class II interior floor finish is characterized by a critical radiant flux not less than 0.22 W/cm² but less than 0.45 W/cm²

4.1.3 Corridors

The CSM does not require 1 hour separation between corridors and areas of use because the building is protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems* and therefore, (NFPA 101, 2006, Section 38.3.6)

4.1.4 Building Services

The CSM must comply with Section 38.5 of the Life Safety Code, 2006 Edition, which includes building services for utilities, heating, ventilating and air-conditioning and elevator services.

Table 6 shows the NFPA code required for different building services.

Table 6: Building Service Code Requirements	
Utilities	Required Code
Gas, related gas piping	NFPA 54, <i>National Fuel Gas Code</i> , or NFPA 58, <i>Liquefied Petroleum Gas Code</i>
Electrical wiring and equipment	NFPA 70, <i>National Electrical Code</i>
Emergency generators and standby power systems	ITM in accordance with NFPA 110, <i>Standard for Emergency and Standby Power Systems</i>
Stored electrical energy systems	ITM in accordance with NFPA 111, <i>Standard on Stored Electrical Energy Emergency and Standby Power Systems</i>
Heating, Ventilating, and Air-Conditioning	Required Code
Ventilating and heat-producing equipment	NFPA 70, <i>National Electrical Code</i>
Ventilating systems in laboratories using chemicals	NFPA 45, <i>Standard on Fire Protection for Laboratories Using Chemicals</i>
Elevators	Required Code
Elevators	ASME A17.1, <i>Safety Code for Elevators and Escalators</i> <ul style="list-style-type: none"> ○ Fire Fighters' Emergency Operations (monthly operation tests) ○ Periodic inspections and tests
<i>Reference: NFPA 101, 2006, Chapter 9</i>	

4.1.5 Operating Features

The CSM has a fire drill plan in accordance with the Life Safety Code, (NFPA 101, 2006, Section 38.7.1 and Section 4.7) and the California Fire Code, (CFC, 2007, Section 405).

To familiarize occupants with the drill procedure and to establish conduct of the drill as a matter of routine, emergency evacuation and relocation drills must be conducted at least annually. Drills are designed in cooperation with the local authorities. When conducting drills, emphasis shall be placed on orderly evacuation rather than on speed. Drills are held at expected and unexpected times and under varying conditions to simulate the unusual conditions that can occur in an actual emergency. Drill participants must relocate to a predetermined location (Lot H11 on CPSU campus) and remain at this location until dismissal is given, (Figure G.1). Records must be maintained of required emergency evacuation drills and include the following information:

1. Identity of the person conducting the drill
2. Date and time of the drill
3. Notification method used
4. Staff members on duty and participating

5. Number of occupants evacuated
6. Special conditions simulated
7. Problems encountered
8. Weather conditions when occupants were evacuated
9. Time required to accomplish complete evacuation

Designated employees of the CSM must be periodically instructed in the use of portable fire extinguishers, (NFPA 101, 2006, Section 38.7.2).

4.2 Fire Detection, Alarm and Communication Systems

The CSM is required to have a manual fire alarm system installed because it is a Group B occupancy having an occupant load of 500 or more persons or more than 100 persons above or below the lowest level of exit discharge. The CSM is not required to have manual fire alarm boxes or heat detection because the building is equipped throughout with an automatic sprinkler system and the alarm notification appliances will activate upon sprinkler water flow, (CBC, 2007, Section 907.2.).

The fire alarm system complies with Section 9.6 of the Life Safety Code, (NFPA 101, 2006, Section 38.3.4) because it is designed to be installed, tested, and maintained in accordance with NFPA 70, *National Electrical Code*, and NFPA 72, *National Fire Alarm Code*, (NFPA 101, 2006, Section 9.6.1.3).

A complete fire alarm system must provide the following functions, (NFPA 101, 2006, Section 9.6.1.7):

- *Initiation:* provides the input signal to the system
- *Notification:* means by which the system advises that human action is required in response to a particular condition
- *Control:* provides outputs to control building equipment to enhance protection of life

The CSM contains a fire alarm system classified as Class B, addressable and manual. The fire alarm system is considered "Selective Coverage" due to the fact detection is only required where codes, standards, laws or AHJ's require the protection of selected areas, (NFPA 72, 2007, Section 5.5.2.2). Detection in the following areas is required to comply with NFPA 72, 2007:

- **Fire Fighters' Service Elevator Recall (Section 6.16.3)**
 - Smoke detector required within 21 feet of the centerline of each elevator door
- **Door Releasing Service (Section 5.16.5.6.1.3)**
 - Smoke detectors are required on both sides of a door releasing service when the height above the door to the ceiling is greater than 24 inches on both sides of the door
- **Elevator Shutdown (Section 6.16.4)**
 - Heat detectors used to shut down elevator power prior to sprinkler operation must be located within 3 feet of each sprinkler head and have both a lower temperature rating and a higher sensitivity as compared to the sprinkler

If the fire alarm system is out of service for more than 4 hours in a 24-hour period, the AHJ, (Fire Official of CPSU) must be notified and the building must be evacuated or an approved fire watch be provided for all parties left unprotected by the shutdown until the fire alarm system has been returned to service.

4.2.1 Signal Initiation

The fire alarm system will initiate by means of an approved automatic sprinkler system that provides protection throughout the building. Manual fire alarm boxes, (i.e. pull stations), are used for fire protective signaling purposes only. Manual pull stations are provided in the natural exit access path near each required exit from an area. Each manual pull station must be accessible, unobstructed and visible. The fire alarm system initiates a signal when the sprinkler system provides automatic detection that the flow of water is equal to or greater than that from a single automatic sprinkler, (NFPA 101, 2006, Section 38.3.4 and 9.6.2). Appendix D shows the location of fire detection devices throughout the CSM.

Smoke alarms in the CSM receive their operating power from the Fire Alarm Control Panel (FACP) which is powered by the building's electrical system, (NFPA 101, 2006, Section 9.6.2.9.2).

4.2.2 Occupant Notification

During all times that the CSM is occupied, the required fire alarm system, once initiated, must activate an alarm signal in a continuously attended location for the purpose of initiating emergency action, by personnel trained to respond to emergencies. The alarm signal for the CSM consists of an automated public address system announcement in lieu of a live voice public address system announcement, (NFPA 101, 2006, Section 38.3.4.3(2)(c)).

Notification signals for occupants to evacuate must be audible and visible signals in accordance with NFPA 72, *National Fire Alarm Code*, and ICC / ANSI A117.1, *American National Standard for Accessible and Usable Buildings and Facilities*. Visible signals are not required in exit stair enclosures or elevator cars. The general evacuation alarm signal must operate throughout the entire building with the exception of exit stair enclosures and elevator cars. Audible alarm notification appliances must be distributed so they are effectively heard above the average ambient sound level that exists under normal conditions of occupancy. Business occupancies and places of assembly are assumed to have an average ambient sound level of 55 decibels (dBA), (NFPA 72, 2007, Table A.7.4.2). To ensure that audible signals are clearly heard, a sound level of at least 15 dB above the average ambient sound level or 5 dB above the maximum sound level having a duration of at least 60 seconds, whichever is greater, measured 1.5 meters (5 feet) above the floor in the area required to be served by the system using the A-weighted scale (dBA), (NFPA 72, 2007, Section 7.4.2.1). The audible alarm signal must be distinctive from audible signals used for other purposes in the CSM. Automatically transmitted evacuation or relocation instructions are permitted to be used to notify occupants and must be in accordance with NFPA 72, *National Fire Alarm Code*. Audible and visible fire alarm notification appliances must be used exclusively for fire alarm system or other emergency purposes unless the AHJ approves the system to be used for other purposes, in which case the fire alarm system takes precedence over all other signals, (NFPA 101, 2006, Section 9.6.3).

4.2.3 Fire Safety Functions, Location of Controls and Extinguishment Requirements

Fire safety functions must be installed in accordance with NFPA 72, *National Fire Alarm Code*. Operator controls, alarm indicators, and manual communications capability must be installed at a convenient location acceptable to the AHJ, (NFPA 101, 2006, Section 9.6.5 and Section 9.6.6). Portable fire extinguishers are required in the CSM in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*, (NFPA 101, 2006, Section 38.3.5 and Section 9.7.4.1).

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

4.2.4 Annunciation

If total evacuation of occupants is impractical due to building configuration, only the occupants in the affected zones must be notified initially. Provisions must be made to selectively notify occupants in other zones to ensure orderly evacuation of the entire building. Depending on the location of a fire in the CSM, the building configuration may inhibit total evacuation of occupants. The atrium space contains a horizontal exit and area of refuge that is recommended to be used as “phased evacuation” in the event of a fire, (NFPA 101, 2006, Section 9.6.3.6.2).

The floor area of each zone may not exceed 22,500ft², and the length of any single fire alarm zone may not exceed 300 feet in any direction. However, the CSM is protected by an automatic sprinkler system and therefore the area of the fire alarm zone is permitted to coincide with the allowable area of the sprinkler system. The sprinkler system is permitted to be annunciated on the fire alarm system as a single zone, (NFPA 101, 2006, Section 9.6.7).

Figure 7 shows an example of recommended building zones within the CSM. A fire located within the atrium space would initially evacuate all occupants, Levels 2 through Levels 6 from the atrium area of the building, (Zone 1) and the entirety of Level 1, (Zone 4) simultaneously since the evacuation paths of travel do not overlap. After evacuation of personnel in Zones 1 & 4, the remainder of the building should be evacuated, including the East and West wings, (Zones 2 & 3).

4.2.5 System Design

The CSM Fire Alarm and Voice Evacuation System evaluated for purposes of this report was the latest design as of February 2012. The system design is currently a work in progress and may not accurately reflect the system installed in May 2013. Attachment 2 of this report shows the Fire Alarm and Voice Evacuation System design as of February 2012. The system includes the audible and visible devices distributed throughout the building and their associated decibel and candela ratings required per square foot of area covered.

The system type is Class B, addressable and manual. Class B circuits do not transmit an alarm or supervisory signal for signaling line circuits and do not allow connected devices to operate during a single open or a simultaneous single ground fault on any circuit conductor for the Notification Appliance Circuit (NAC), (NFPA 72, 2007, Section 6.4.2.1.1(2)).

Table 7 shows the Alarm, Trouble, and Alarm Receipt Capability (ARC) during abnormal conditions for Class B Signaling Line Circuits (SLCs) and Notification Appliance Circuits (NACs).

Table 7: Performance of SLCs and NACs				
Signaling Line Circuits (SLCs)				
	Class	B		
	Style	4		
		Alm	Trbl	ARC
	Abnormal Condition	1	2	3
	Single open	—	X	—
	Single ground	—	X	R
	Wire-to-wire short	—	X	—
	Wire-to-wire short & open	—	X	—
	Wire-to-wire short & ground	—	X	—
	Open and ground	—	X	—
Loss of carrier (if used)/channel interface	—	X	—	
Notification Appliance Circuits (NACs)				
	Class	B		
		Trouble Indication at Protected Premises	Alarm Capability During Abnormal Conditions	
	Abnormal Condition	1	2	
	Single open	X	—	
	Single ground	X	R	
	Wire-to-wire short	X	—	

Reference: NFPA 101, 2006, Table 6.6.1 (SLCs) and Table 6.7 (NACs)

Alm: Alarm, Trbl: Trouble, ARC: Alarm receipt capability during abnormal conditions, X: Indication required at protected premises, R: Required capabilities

Table 8 shows the sequence of operations matrix for the fire alarm system.

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Table 8: Sequence of Operations Matrix

EVENT	ACTION												
	Supervisory Condition at FACP	Trouble Condition at FACP	Alarm Condition at FACP	Activate Fire Alarm Audiovisual Devices	Display Text on LCD Annunciator	Activate Shunt Trip Relay	Shutdown Air Handler Unit	Activate Elevator Recall	Shutdown Individual Associated Dampers	Deactivate Magnetic Door Holders	Activate Supervisory Signal to Central Station	Activate Trouble Signal to Central Station	Activate Alarm Signal to Central Station
Panel Supervisory Condition (Test Bypass) on ACM 24 AT	X				X						X		X
Panel Trouble Condition		X			X							X	
Panel Alarm Condition			X	X	X		X			X			X
Manual Pull Station Activation			X	X	X								X
Spot Smoke Detector Activation			X	X	X					X			X
Duct Smoke Detector Activation			X	X	X				X	X			X
Air Handling Unit Duct Smoke Detector Activation			X	X	X		X						X
Sprinkler Tamper Switch	X		X	X	X			X		X			X
Sprinkler Water Flow Activation	X				X						X		
Fire Pump Running	X				X						X		
Fire Pump Loss of Phase	X	X			X						X		
Fire Pump Phase Reversal	X				X						X		X
Heat Detector Activation (Elevator Equipment)			X	X	X	X							X
Elevator Lobby/Emergency Smoke			X	X	X			X		X			X
Shunt Trip Power Supervision	X				X						X		

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Table 9 shows the different circuits, components and associated California State Fire Marshal (CSFM) listings for the design of the Fire Alarm and Voice Evacuation System.

Table 9: System Details				
System Devices			# of Devices	CSFM Listing #
Fire Alarm Control Panel (FACP)			1	7165-0028:0224
Remote Notification Power Supply (RNPS)			5	7315-0028:248
Fire Alarm Terminal Cabinet (FATC)			3	N/A
End of Line Resistor (EOL)			32	N/A
Circuit	Wire (or equivalent)	Device Description	# of Devices	CSFM Listing #
SLC, Class B, Style 4	16/2 Gauge West Penn D990	Smoke Detector	16	7272-0028:206
		Duct Smoke Detector	61	3242-1653:209
		Heat Detector	2	7270-0028:196
		Beam Detector*	0	7260-1728:0121
		Manual Pull Station	29	7150-0028:0199
		Addressable Module	62	7300-0028:0219
		Relay Module	6	7300-0028:0219
		Dual Monitor Module	18	7300-0028:0219
		Digital Audio Amplifier	4	7170-0028:223
		Bell	1	BY OTHERS
		Magnetic Door Holder	8	BY OTHERS
		Water Flow Switch	16	BY OTHERS
		Valve Tamper Switch	16	BY OTHERS
NAC Visual	14 Gauge THHN	Strobe	223	7320-1653:201
NAC Speaker Class B	16/2 Gauge West Penn D991	Speaker	163	7320-1653:201
Annunciator	16/4 Gauge West Penn 993	Remote Annunciator	2	7120-0028:209
Fire Fighter Phone	14/2 Gauge West Penn D995	Fire Fighters Phone Jack	12	7300-1652:0182
Reference: Deep Blue Integration, 2012				
*A possible new modification to the Fire Alarm and Detection System is the addition of a beam detector.				

4.2.6 System Specifications

Table 10 shows an image of each device and describes the specifications used in the Fire Alarm and Voice Evacuation System. Data sheets for each fire detection and voice evacuation device are located in Attachment 1 of this report.

Table 10: System Specifications		
Device	Specifications	Picture
Fire Alarm Control Panel (FACP)	Notifier / Honeywell CAB-4 Series Cabinets: ONYX Series Backboxed with Locking Doors. Fabricated from 16-gauge steel, the cabinet assembly consists of two basic parts: a backbox and a locking door. Complies with seismic requirements of CBC 2007. Located on Level 1 in the Main Electrical Room.	<p>NFS2-3030 and DVC in "C" sized CAB-4 cabinet</p> <p>UL Listed: S635 FM Approved</p>
Remote Notification Power Supply (RNPS)	Notifier / Honeywell ACPS-610(E) An auxiliary power supply with a battery charging option. Provides 6 amps of shared power to four outputs while charging batteries from 12 to 200 AH, or 10 amps of shared power when the unit is configured for use with an external battery charger. Four individually addressable outputs can be independently configured for auxiliary power or NACs. Located on Levels 2, 3, 4, 5 in the East Wing, and Level 4 West Wing.	<p>UL Listed: S635 FM Approved</p>
Fire Alarm Terminal Cabinet (FATC)	N/A for system design of the CSM. Image shown is a typical fire alarm terminal cabinet.
End of Line Resistor (EOL)	N/A for system design of the CSM. Image shown is a typical end of line resistor.
Smoke Detector	FAPT-851(A) Acclimate Plus Multi-Sensor Low-Profile Intelligent Detector. An intelligent, addressable, multi-sensing, low-profile detector that uses a combination of photoelectric and thermal sensing technologies to increase immunity to false alarms. The Acclimate Plus detector has a microprocessor in the detector head that processes alarm data. As a result, the Acclimate Plus detector adjusts its sensitivity automatically, without operator intervention or control panel programming.	<p>UL Listed: S1115 FM Approved</p>

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Table 10: System Specifications		
Device	Specifications	Picture
Duct Smoke Detector	Intelligent Non-relay Photoelectric Duct Smoke Detector. Photoelectric, integrated low-flow technology, air velocity rating from 300 ft/min to 4000 ft/min, operating temperature (-4°F to 158°F) and humidity (0% to 95% non-condensing). Remote testing capability requires com line power only.	<p>UL Listed: 2911 FM Approved</p>
Heat Detector	FST-851 Series Intelligent Thermal (Heat) Detector with FlashScan. Point ID capability allows each detector's address to be set with address switches, providing exact detector locations. Series thermal detectors use an innovative thermistor sensing circuit to produce 135°F / 57°C fixed-temperature (FST-851) and rate-of-rise thermal detection (FST-851R) in a low-profile package. FlashScan is a communication protocol developed by Notifier Engineering that greatly enhances the speed of communication between analog intelligent devices and certain NOTIFIER systems. Intelligent devices communicate in a grouped fashion. If one of the devices within the group has new information, the panel's CPU stops the group poll and concentrates on single points. The net effect is a response speed greater than five times that of earlier designs.	<p>UL Listed: S747 FM Approved</p>
Beam Detector*	Open-area Smoke Imaging Detection (OSID) by Xtralis is a new innovation in projected beam smoke detection technology. By using advanced dual wavelength projected beams and optical imaging technology for early warning smoke detection, OSID provides a low-cost, reliable and easy-to-install solution that overcomes typical beam detection issues such as false alarm incidents and alignment difficulties. *Possible addition to the Fire Alarm and Detection System	<p>UL Listed</p>
Manual Pull Station	NBG-12LX Addressable Manual Pull Station by Notifier / Honeywell. Because the NBG-12LX is addressable, the control panel can display the exact location of the activated manual station. This leads personnel quickly to the location of the alarm.	<p>UL Listed: S692 FM Approved</p>
Addressable Module	The FCM-1(A) addressable control module provides Notifier intelligent fire alarm control panels a circuit for Notification Appliances (strobes, speakers, etc.). Addressability allows the FCM-1(A) to be activated, either manually or through panel programming, on a select (zone or area of coverage) basis.

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Table 10: System Specifications		
Device	Specifications	Picture
		UL Listed: S635 FM Approved.
Relay Module	The FRM-1(A) Addressable relay module provides the system with a dry-contact output for activating a variety of auxiliary devices, such as fans, dampers, control equipment, etc. Addressability allows the dry contact to be activated either manually or through panel programming, on a selected basis.	See image for Addressable module. UL Listed: S635 FM Approved.
Dual Monitor Module	FMM-1(A), FMM-101(A), FZM-1(A) & FDM-1(A) Monitor Modules with FlashScan. Monitor modules supervise a circuit of dry-contact input devices, such as conventional heat detectors and pull stations, or monitor and power a circuit of two-wire smoke detectors.	UL Listed: S635 FM Approved
Digital Audio Amplifier	DAA2 Series Digital Audio Amplifiers. Multi-featured amplifiers with digital audio functionality. Each DAA2 is capable of accessing and processing one of up to eight audio channels on the DVC audio loop, amplifying the signal, and distributing it via four Class B outputs. DAA2 amplifiers can store backup alarm and trouble messages, and provide an adjustable background music input.	UL Listed: S635
Bell	By others. Image shown is a typical fire alarm bell.
Magnetic Door Holder	By others. Image shown is a typical magnetic door holder.
Water Flow Switch	By others. Image shown is a typical water flow switch.

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Table 10: System Specifications		
Device	Specifications	Picture
Valve Tamper Switch	By others. Image shown is a typical valve tamper switch.
Strobe	SpectrAlert Advance- Indoor Selectable Output Speaker Strobes by Notifier / Honeywell. Designed to reduce ground faults.	UL Listed: S4048 FM Approved
Speaker	SpectrAlert Advance- Indoor Selectable Output Dual Voltage Evacuation Speakers by Notifier / Honeywell. Designed to reduce ground faults. The low total harmonic distortion of the SP speaker offers high fidelity sound output while the SPV speaker offers high volume sound output for use in high ambient noise applications.	UL Listed: S4048 FM Approved
Remote Annunciator	FDU-80, 80 Character Liquid Crystal Display. Compact, cost-effective, 80-character, backlit LCD remote Fire Annunciator. The FDU-80 mimics the display of the control panel and displays complete system point status information. Up to 32 FDS-80's may be connected directly with the EIA-485 terminal port of each FACP.	UL Listed: S635 FM Approved
Fire Fighters Phone Jack	FTM-1(A) Firephone Control Module FlashScan Mode Only. The FTM-1(A) gives the FACP the capability to monitor and control a circuit of up to two firefighter phones. The FTM-1(A) has the ability to differentiate between normal, off-hook, and trouble conditions. This module is used to connect a remote firefighter telephone to a centralized telephone console. A ringing sound is provided at each off-hook handset until it is connected to the console. The user can then connect that off-hook phone to the main riser for the voice evacuation system.	UL Listed: S635 FM Approved
Reference: Notifier, 2012, Xtralis, 2011 and miscellaneous Google searches for images by others		

*4.2.7 Beam Detector

As of February 2012 when the design was reviewed by the Fire Official at CPSU for the first time, the design did not include any beam detection. As of March 2013, the designed was updated to include an open-area smoke imaging detector (OSID), also known as a beam detector. OSID smoke detection is a

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

new technology that is still pending major agency approvals. However, an OSID system is unique in that it measures the level of smoke entering beams of light projected over an area of projection. A single OSID Imager can detect up to seven Emitters to provide a wide coverage area. Two innovations in smoke detection technology have been developed for the revolutionary OSID smoke detector, (Xtralis, 2011).

1. **Dual Wavelength Particle Detection-** The beam projected from each Emitter contains a unique sequence of ultraviolet (UV) and infrared (IR) pulses that are synchronized with the Imager and enable the rejection of any unwanted light sources. By using two wavelengths of light to detect particles, the system is able to distinguish between particle sizes. The shorter UV wavelength interacts strongly with both small and large particles while the longer IR wavelength is affected only by larger particles. Dual wavelength path loss measurements enable the detector to provide repeatable smoke obscuration measurements, while rejecting the presence of dust particles or solid intruding objects.
2. **Optical Imaging with a CMOS Imaging Chip-** An optical imaging array in the OSID Imager provides the detector with a wide viewing angle to locate and track multiple Emitters. Consequently, the system can tolerate a much less precise installation and can compensate for the drift caused by natural shifts in building structures. Optical filtering, high-speed image acquisition and intelligent software algorithms also enable the OSID system to provide new levels of stability and sensitivity with greater immunity to high level lighting variability.

OSID systems may be configured to suit a range of detection spaces by selecting the number of Emitters and type of Imager. Each type of Imager differs by the lens used in the unit, which determines the field of view and range of the system.

Table 11 shows the configuration options, available field of view and detection ranges for OSID:

Table 11: OSID Available Fields of View and Detection Ranges							
Imager Lens Type	Usable Field of View		Detection Range				Max. Number of Emitters
	Horizontal	Vertical	Standard Power		High Power		
			Min	Max	Min	Max	
10°	7°	4°	30 m (98 ft)	150 m (492 ft)	- -	- -	1
45°	38°	19°	15 m (49 ft)	60 m (197 ft)	30 m (98 ft)	120 m (393 ft)	7
90°	80°	48°	6 m (20 ft)	34 m (111 ft) (see note 4)	12 m (39 ft)	68 m (223 ft) (see note 4)	7

Reference,: Xtralis Table 3-1, 2011

Spacing Requirements of the OSID detector system should comply with national and regional installation codes. In any OSID system, the line of protection between the Imager and an Emitter is recognized by many standards to be equivalent to a traditional beam detector. For areas that require multiple lines of protection (i.e. the atrium in the CSM building), the Emitters should be located and spaced according to the following recommendations to provide full coverage of the protected space.

Figure 8 shows Emitter spacing requirements for rooms with flat ceilings. Emitters should be positioned within a distance of H below the ceiling. For flat ceilings, this value is generally between 1 to 23.6 inches, (AS1670.1 and BS5839.1 International Standards), NFPA 72 does not specify a specific distance from the ceiling. The value of H will vary according to regional specifications, geometry of the ceiling and specific requirements of the installation for the protected atrium space within the CSM. Measured horizontally, Emitters can be spaced a maximum distance of S apart, with one half that spacing from beams and the sidewall. The maximum spacing value of S is 18.3 meters (60 feet) in NFPA 72, *National Fire Alarm Code*.

Figure 9 illustrates the horizontal and vertical field of view for a 90° Imager with multiple Emitters, a similar design to the expected use in the CSM building, Level 3 atrium space.

Figure 9: Alignment of 90° OSID Imager to Emitter

4.2.8 Battery Capacity

The fire alarm and detection system is designed with six separate power supplies, one Fire Alarm Control Panel (FACP) located on Level 1, and five Remote Notification Power Supplies (RNPS) located on Levels 2-6. The FACP supplies battery power capacity to the five RNPS. The FACP requires 51.8 amp-hours of battery capacity and each RNPS requires between 3.8 and 4.3 amp-hours of battery capacity. These battery calculations include an 18% safety factor and are based on the fire alarm and voice evacuation system as designed in Attachment 2 of this report.

4.2.9 Inspection, Testing and Maintenance

To ensure operational integrity, the fire alarm system is required to have an inspection, testing, and maintenance program. The program must satisfy the requirements of NFPA 72, 2007 and the equipment manufacturer's published instructions and verify correct operation of the fire alarm system. The building owner (CPSU) is responsible for inspection, testing, and maintenance of the system and for alterations or additions to the system. If a defect or malfunction is not corrected at the conclusion of system inspection, testing, or maintenance, the system owner must be informed of the impairment in writing within 24 hours. Before proceeding with any testing, and at the conclusion of testing, all persons and facilities receiving alarm, supervisory, or trouble signals and all building occupants must be notified of the testing to prevent unnecessary response, (NFPA 72, 2007, Section 10.2).

4.2.9.1 Personnel

Service personnel must be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Qualified personnel include but are not limited to one or more of the following:

- 1) Personnel who are factory trained and certified for fire alarm system service of the specific type and brand of system
- 2) Personnel who are certified by a nationally recognized fire alarm certification organization acceptable to the AHJ (ex. NICET)
- 3) Personnel who are registered, licensed, or certified by a state or local authority
- 4) Personnel who are employed and qualified by an organization listed by a nationally recognized testing laboratory for the servicing of fire alarm systems

4.2.9.2 Test Methods

Fire alarm and voice communication system components must be visually inspected on a semiannual basis and tested on an annual basis to comply with NFPA 72. The FACP and RNPS can be visually inspected on an annual basis, (NFPA 72, 2007, Table 10.3.1).

Test methods for each component are provided below, (NFPA 72, 2007, Table 10.4.2.2):

4.2.9.2.1 Control Equipment (FACP and RNPS)

At a minimum, control equipment must be tested to verify correct receipt of alarm, supervisory, and trouble signals (inputs), operation of evacuation signals and auxiliary functions (outputs), circuit supervision including detection of open circuits and ground faults, and power supply supervision for detection of loss of AC power and disconnection of secondary batteries.

4.2.9.2.2 Manual Pull Station

Manual pull stations (fire alarm boxes) must be tested per the manufacturer's published instructions.

4.2.9.2.3 Remote Annunciators

Verify the correct operation and identification of annunciators.

4.2.9.2.4 Electromechanical Releasing Device (Door Releasing Device)

Verify correct operation by removing the fusible link and associated operating device. Lubricate any moving parts as necessary.

4.2.9.2.5 Heat Detectors (fixed-temperature and spot-type detectors)

Refer to manufacturer's published instructions for the appropriate heat source for testing. Response time must occur within 1 minute. A method other than the manufacturer's published instructions may be used for testing as long as no damage to the non-restorable fixed-temperature element occurs.

4.2.9.2.6 Smoke Detectors

Test the detector in place to ensure smoke entry into the sensing chamber initiates an alarm response. Testing with smoke or listed aerosol approved by the manufacturer is permitted as acceptable test methods. At least one of the following tests must be performed to ensure that each smoke detector is within its listed and marked sensitivity range:

- 1) Calibrated test method
- 2) Manufacturer's calibrated sensitivity test instrument
- 3) Smoke detector/control unit arrangement whereby the detector causes a signal at the control unit when its sensitivity is outside its listed sensitivity range
- 4) Other calibrated sensitivity test method approved by the AHJ

4.2.9.2.7 Duct Smoke Detectors

Test air duct detectors to ensure that the device will sample the airstream. Test in accordance with the manufacturer's published instructions.

4.2.9.2.8 Audible Alarm Notification Appliances (Speakers, Bells)

Measure sound pressure level with a sound level meter meeting ANSI S1.4a, *Specifications for Sound Level Meters*, Type 2 requirements. Measure and record levels throughout the protected area. Set the sound level meter in accordance with ANSI S3.41, *American National Standard Audible Evacuation Signal*, using the time-weighted characteristic F (FAST). Record the maximum output when the audible emergency evacuation signal is on.

4.2.9.2.9 Visual Alarm Notification Appliances (Strobes)

Test strobes in accordance with the manufacturer's published instructions. Verify appliance locations per approved layout and confirm that no floor plan changes affect the approved layout. Verify the candela rating marking agrees with the approved drawing. Confirm that each strobe flashes.

4.2.9.2.10 Digital Alarm Communicator Transmitter (UDACT)

Ensure the UDACT is connected to two separate means of transmission. Test UDACT for line seizure capability by initiating a signal while using the primary line for a telephone call. Verify receipt of the correct signal at the supervising station. Verify completion of the transmission attempt within 90 seconds from going off-hook to on-hook. Disconnect the primary line from the UDACT and verify that a trouble signal occurs at the premises as well as transmission to the supervising station within 4 minutes of detection of the fault. Disconnect the secondary line

from the UDACT and verify that a trouble signal occurs at the premises as well as transmission to the supervising station within 4 minutes of detection of the fault. Verify that the UDACT transmits a signal to the digital alarm communicator receiver (DACR).

4.2.9.2.11 Emergency Communications Equipment (Fire Fighters' Phone Jack)

Visually inspect phone jack and initiate communication path through jack.

4.2.9.2.12 Interface Equipment (Monitor Modules, Relay Modules, Dual Monitor Modules)

Test interface equipment by operating or simulating the equipment being supervised. Verify the required signal is transmitted at the control unit. Interface equipment shall be tested at the same frequency required by the equipment being supervised.

4.2.9.2.13 Beam Smoke Detector

Test beam type smoke detector by introducing smoke, other aerosol, or an optical filter into the beam path. Note: There are currently no beam smoke detectors in the design of the fire alarm and voice evacuation system. Beam smoke detector testing method has been included in the event that the fire alarm system design changes to incorporate beam type smoke detection.

4.2.9.3 Maintenance

Fire alarm system equipment must be maintained in accordance with the manufacturer's published instructions. Maintenance frequency depends on the type of equipment and the local ambient conditions.

4.2.9.4 Records

Upon successful completion of acceptance tests approved by the AHJ a set of reproducible as-built installation drawings, operation and maintenance manuals, and a written sequence of operation must be provided to the building owner (CPSU) or the owner's designated representative. The owner is responsible for maintaining these records for the life of the system for examination by any AHJ.

Maintenance, Inspection, and Testing Records must be retained until the next test and for 1 year thereafter. The records must be on a medium that will survive the retention period, (paper or electronic copy). NFPA 72, 2007, Section 10.6.2.3 lists the required information to be recorded for inspection, testing and maintenance and provides an example of an Inspection and Testing Form.

Records pertaining to signals received at the supervising station that results from maintenance, inspection, and testing must be maintained for at least 12 months. Upon request, a hard copy record must be provided to the AHJ, (paper or electronic version).

4.3 Fire Suppression Systems

The CSM is protected throughout by an automatic sprinkler system in accordance with Section 903 of the CBC, 2007. Sprinkler systems are installed, repaired, operated and maintained in accordance with Section 901.2 of the CBC, 2007. There are additional required suppression systems in the atrium, (CBC, 2007, Table 903.2.13), and the additional suppression systems require the entire CSM building to have an automatic sprinkler system, (CBC, 2007, Section 404.3). The automatic sprinkler system must comply with NFPA 13, *Standard for the Installation of Sprinkler Systems*, (CBC, 2007, Section 903.3.1.1).

The CSM is protected by a wet pipe fire sprinkler system with a fire pump and Class 1 standpipe system. All sprinklers are quick response type unless noted otherwise in the sprinkler contractor design plans.

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Sprinklers in finished ceilings are recessed chrome pendent sprinklers and sprinklers in exposed areas are chrome upright or pendent sprinklers. Piping is black steel schedule 10 and schedule 40. The system size is designed to discharge from the system test connection in not more than 60 seconds, starting at the normal air pressure on the system and at the time of fully opened inspection test connection, (NFPA 13, 2007, Section 7.2.3.2).

4.3.1 Design Criteria and Water Supply

Table 12 provides the design criteria and water supply requirements for the CSM using Hydraulic Calculations based on the Density/Area Method:

Table 12: Design Criteria and Water Supply				
Occupancy	Hazard	Protected Area (ft ²)	Design (GPM)	Hose (GPM)
A-3: Lobbies/Lecture	Light Hazard	225	0.10/1500	100/0
B: Office/Conference	Light Hazard	130	0.10/1500	100/0
B: Laboratories	Ordinary Hazard, Group 1	130	0.15/1500	100/150
S-1: Storage/Mech/Elec.	Ordinary Hazard, Group 1	130	0.15/1500	100/150
<i>Reference: NFPA 13, 2007, Table 8.6.2.2.1(a) & Table 8.6.2.2.1(b), Figure 11.2.3.1.1 and Section 12.8</i> <i>Note: Where listed quick-response sprinklers are used for a portion of the sprinkler system, the system area of operation can be reduced by $\gamma = \frac{-3x}{2} + 55$ for ceilings ≥ 10 feet and ≤ 20 feet with no unprotected ceiling pockets as long as they are classified as light hazard or ordinary hazard occupancy with a wet pipe system in place, (NFPA 13, 2007, Section 11.2.3.2.3.1 and Figure 11.2.3.2.3.1). This is the case for Remote Areas 3-1, 3-2, 6-2 and 6-3 as noted in Appendix E of this report.</i>				

4.3.1.1 General System Notes

- (1) All system piping must be hydrostatically tested at 200 psi or at 50 psi above the operational static pressure of the system, whichever is greater for two hours.
- (2) Each valve must have a permanently affixed sign indicating its function and all sprinkler system control valve handles must be located 7'-0" max A.F.F.
- (3) A stock of spare sprinklers of each style and temperature rating, with a sprinkler wrench, must be located near the riser.
- (4) Sprinklers must be quick response with chrome-recessed escutcheons U.O.N and must be in alignment and parallel to ceiling grids.
- (5) Sprinklers in unfinished areas must be TYCO Model TY-FRB quick response brass upright.
- (6) Main piping for this system must be schedule 10 pipe with grooved ends with applicable fittings.
- (7) Branch line connections to the main must be pre-drilled with shop-welded outlets.
- (8) Threaded piping 1" to 2" must be black steel BMT schedule 40 with black cast iron or ductile iron fittings.
- (9) 1-1/4" and larger branch line and main piping must be schedule 10 pipe with grooved ends and grooved fittings.
- (10) All materials used in the installation of these systems must be new and of current issue and approved by UL and/or FM.
- (11) All materials must be in conformance with NFPA 13, 2007 as well as the AHJ.
- (12) System piping will be supported with hangers in accordance with NFPA 13, 2007.
- (13) Spacing of the support and bracings of fire sprinkler piping must comply with NFPA 13, 2007.

4.3.2 Risers, Cross-Mains and Branch Lines

The CSM contains four risers, one riser in each of the four exit stair enclosures. Figure 10 provides a graphic representation of the location of sprinkler risers in the CSM.

The typical cross-mains measure 2 ½ inches diameter pipe; branch-line diameters vary depending on area of protection and distance from cross-main. Sprinkler types include:

- Recessed Pendent Sprinkler
- High Temperature Pendent Sprinkler
- Upright Sprinkler
- Extended Coverage Pendent Sprinkler
- Upright Sprinkler on Sprig Up
- Horizontal Sidewall Sprinkler

Table 13 specifies the design criteria for each riser.

Riser	Location	Size	Travel Length	PSI required at source	PSI available at source (includes 10% safety factor for adjusted flow)
Riser 1	Stairway #1, East	6 inch riser	Level 3 to roof level	44.73	50.52
Riser 2	Stairway #3, East	6 inch riser	Level 2 to roof level	47.18	48.09
Riser 3	Stairway #4, West	4 inch riser	Level 1 to Level 5	45.55	48.09
Riser 4	Stairway #5, West	4 inch riser	Level 1 to Level 3	46.80	48.08

Reference: Aero Automatic Sprinkler Company, 2011

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Table 14 calculates the system demand for each of the four rises.

Table 14: System Demand				
Calculation and Design Information	S1* Riser	S3* Riser	S4* Riser	S5* Riser
Occupancy	Light / Ordinary Hazard, Group 1			
Flow @ top most outlet	500 GPM	500 GPM	500 GPM	500 GPM
Pressure @ top most outlet	100 PSI	100 PSI	100 PSI	100 PSI
Flow for additional standpipes	250 GPM	500 GPM	500 GPM	500 GPM
Total Standpipe flow	750 GPM	1000 GPM	1000 GPM	1000 GPM
PSI Required at pump discharge	156.36 PSI	144.06 PSI	144.08 PSI	143.7 PSI
GPM Required at pump discharge	1000 GPM	1000 GPM	1000 GPM	1000 GPM
PSI Required at source	44.73 PSI	47.18 PSI	45.85 PSI	46.80 PSI
GPM Required at source	750 GPM	1000 GPM	1000 GPM	1000 GPM
PSI available at source	50.52 PSI	48.09 PSI	48.09 PSI	48.08 PSI
TOTAL PSI Safety Factor**	5.79	0.91	2.24	1.26
Reference: Aero Automatic Sprinkler Company, 2011				
* 'S1', 'S3', 'S4' and 'S5' denote 'Stairway 1', 'Stairway 3', 'Stairway 4' and 'Stairway 5,' respectively.				
** Total PSI Safety Factor does not include 10% safety factor for adjusted flow, (see Figure 4).				

Appendix E shows the sprinkler design for each floor plan and includes remote area calculations. The design criterion is reduced 39.25% for Remote Areas 3-1, 3-2, 6-2 & 6-3 as noted in Appendix E. The 39.25% reduction is based on the design criteria in Table 12 of this report and the design area reduction requirements for quick response sprinklers as shown in Figure 11 below.

Remote Areas 3-1, 3-2, 6-2 and 6-3 of Appendix E are protected by a wet pipe system, classified as Ordinary Hazard Group 1 (Laboratories), have no unprotected ceiling pockets, and have ceiling heights of 10'6", (x = 10.5 feet). Therefore, the design area reduction can be calculated:

$$Y = \frac{-3x}{2} + 55 \quad (\text{Equation 1})$$

Where, x = 10.5

$$Y = \frac{-3(10.5)}{2} + 55$$

$$Y = \frac{-31.5}{2} + 55$$

$$Y = -15.75 + 55$$

$$Y = 39.25\% \text{ reduction to design area}$$

4.4 Egress Analysis

An egress analysis evaluates the evacuation performance of buildings. The CSM is evaluated in accordance with Chapter 38 of the Life Safety Code.

Egress requirements for the CSM are based on business occupancy, ordinary hazard's contents, and a building occupant load of 3,405 persons as described below:

4.4.1 Occupancy Classification

The CSM is classified as a Group B, Business Occupancy, defined as an occupancy used for the transaction of business other than mercantile, (NFPA 101, 2006, Section 38.1.4 and Section 6.1.11.1). The CBC further defines a business occupancy as a building used for offices, professionals or service-type transactions including educational occupancies for students above the 12th grade, (CBC, 2007, Section 304). The different occupancy uses within the CSM are shown in Table 1.

Appendix B illustrates floor plans showing the different occupancy classifications.

4.4.2 Hazard of Contents

The CSM is classified as an ordinary hazard building. Ordinary hazard contents are those that are likely to burn with moderate rapidity or to give off a considerable volume of smoke, (NFPA 101, 2006, Section 38.1.5 and Section 6.2.2.3).

4.4.3 Occupancy Loads

The CSM occupant load can be calculated by dividing the floor area assigned to each occupancy use by the occupant load factor for that use as specified in Table 15.

Table 15: Occupant Load Factor	
Use	(ft ² per person)
Assembly Use Less concentrated use, without fixed seating	15 net
Business Use	100 gross
Storage Use In other than storage occupancies	500 gross
<i>Reference: NFPA 101, 2006, Section 38.1.7 and Table 7.3.1.2</i> <i>Definitions: Net Floor Area includes deductions for hallways, stairs, closets, thickness of interior walls, columns, or other features. Gross Floor Area does not deduct for hallways, stairs, closets, thickness of interior walls, columns, or other features, (NFPA 101, 2006, Section 3.3.17.2.2 and 3.3.17.2.1).</i>	

Table 16 calculates occupant load for each floor based on the occupant load factors given in Table 15.

Table 16: Occupant Load for Each Floor	
Level	Occupant Load (persons)
Level 1	930
Level 2	854
Level 3	640
Level 4	465
Level 5	264
Level 6	252
TOTAL	3,405
<i>Reference: Zimmer, 2009</i>	

4.4.4 Egress Components

The CSM contains doors, stairs, ramps, and exit passageways that comply with Chapter 7 of the Life Safety Code as referenced in Section 38.2.2, (NFPA 101, 2006). The CSM also contains horizontal exits and an area of refuge in compliance with Section 7.2.4 and 7.1, respectively.

4.4.4.1 Horizontal Exits

For purposes of the CSM, a horizontal exit is defined as a way of passage through a fire barrier to an area of refuge on approximately the same level in the same building that affords safety from fire and smoke originating from the area of incident and areas communicating therewith, (NFPA 101, 2006, Section 3.3.70.1). The CSM contains five horizontal exits throughout the building. Levels 2-6 each contain a horizontal exit in the atrium space that provide a way of passage through a fire barrier to an area of refuge in Stairway #3 on the same level that affords safety from fire and smoke originating from the area of incidence and areas communicating therewith. The horizontal exits on Levels 2-6 are acceptable by code because the total egress capacity of the other exits is not less than half that required for the entire area of the building, (NFPA 101, 2006, Section 7.2.4.1.2).

4.4.4.2 Areas of refuge

The CSM contains one area of refuge located in Stairway #3 within the Atrium portion of the building. This area of refuge is located in the path of travel for Stairway #3 and leads to a horizontal exit on Level 2 that discharges to a public way. The area of refuge is protected from the effects of fire by means of separation from other spaces, thereby permitting a delay in egress travel from any level. Since the CSM is protected throughout by an approved, supervised automatic sprinkler system, the area of refuge must meet the requirements of Section 7.1 and Section 7.2.12.2.3, (NFPA 101, 2006, Section 38.2.2.12 and Section 7.2.12).

4.4.5 Egress Capacity

Egress capacity for the CSM is based on the egress width requirements for buildings with sprinkler systems. Hazardous occupancies in the CSM must maintain an egress capacity factor of 0.4 inches per occupant. All other occupancies in the CSM must maintain an egress capacity of 0.2 inches per occupant for stairways and 0.15 inches per occupant for other egress components, (CBC, 2007, Table 1005.1).

Any corridor or passageway serving an occupant load of at least 50 occupants is required to have a clear width of at least 44 inches. Exits at street floor must be sufficient for the occupant load of the street floor plus the required capacity of stairs and ramps discharging through the street floor, (NFPA 101, 2006, Section 38.2.3).

4.4.6 Number of Exits

The CSM does not have less than two separate exits provided on every story and not less than two separate exits are accessible from every part of every story, (NFPA 101, 2006, Section 38.2.4.1).

Levels 1-3 require at least 3 exits because the occupant load is greater than 500 but less than 1000. The required number of exits does not decrease in the direction of egress travel, (NFPA 101, 2006, Section 7.4.1.2 and 7.4.1.4).

The CSM has a terrace on Levels 3-6 that complies with the minimum number of two exits, (NFPA 101, 2006, Section 38.2.4.1(1) and Section 7.4.1.1).

The CSM has two elevator lobbies, one in the atrium and another in the west wing. Both lobbies have at least one exit that is readily accessible without the use of a key, tool, special knowledge, or special effort, (NFPA 101, 2006, Section 7.4.1.6).

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Table 17 shows the occupant load for each level, terrace and elevator lobby in the CSM and compares the actual number of exits in the CSM with the number of exits required by the Life Safety Code.

Table 17: Number of Exits				
Area Description	Occupant Load	Number of Exits Required by Code	Number of Exits in the CSM	In Compliance? (Yes/No)
Level 1	930	3	5	Yes
Level 2	854	3	7	Yes
Level 3	640	3	4	Yes
Level 4	465	2	4	Yes
Level 5	264	2	2	Yes
Level 6	252	2	2	Yes
Terrace (balcony)				
Level 3	64	2	2	Yes
Level 4	48	2	2	Yes
Level 5	50	2	2	Yes
Level 6	13	2	2	Yes
Elevator #1 & #2				
Level 2 Lobby	N/A	1	2	Yes
Level 3 Lobby	N/A	1	1	Yes
Level 4 Lobby	N/A	1	1	Yes
Level 5 Lobby	N/A	1	1	Yes
Level 6 Lobby	N/A	1	1	Yes
Elevator #3				
Level 1 Lobby	N/A	1	3	Yes
Level 2 Lobby	N/A	1	2	Yes
Level 3 Lobby	N/A	1	1	Yes

Reference: NFPA 101, 2006, Section 38.2.4.1(1) and Section 7.4

Table 17 demonstrates that the CSM complies with the Life Safety Code for the number of exits required on each level, terrace and elevator lobby.

4.4.7 Arrangement of Means of Egress

Means of egress in the CSM is in compliance with Section 7.5 of the Life Safety Code. There are no dead-end corridors that exceed 50 feet in the CSM, and the common path of travel does not exceed 100 feet, (NFPA 101, 2006, Section 38.2.5).

Since the CSM is protected throughout by an automatic sprinkler system, each level is required to have a minimum separation distance between two of the exits that is not less than one-third the length of the maximum overall diagonal dimension of the area being served, (NFPA 101, 2006, Section 7.5.1.3.3 and 7.5.1.3.6).

The CSM contains one area of refuge located on Levels 2-6 to accommodate people with severe mobility impairment, (NFPA 101, 2006, Section 7.5.4.1.1). The area of refuge is considered part of an accessible means of egress because of the horizontal exit within the atrium space, (NFPA 101, 2006, Section 7.5.4.6).

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

4.4.8 Travel Distance to Exits

The CSM is protected by an approved supervised automatic sprinkler system; therefore the travel distance cannot exceed 300 feet, (NFPA 101, 2006, Section 38.2.6.1).

Appendix C illustrates floor plan Levels 1-6 and the travel distance to exits. Table 18 shows the maximum travel distance to an exit for each level based on Appendix C floor plans, and determines whether the travel distance is less than the 300 foot code requirement.

Table 18: Travel Distance to Exits			
CSM Level	Maximum Travel Distance to Exit (feet)	Required Travel Distance to Exit (feet)	In Compliance? (Yes/No)
Level 1	149	< 300	Yes
Level 2	184	< 300	Yes
Level 3	185	< 300	Yes
Level 4	185	< 300	Yes
Level 5	178	< 300	Yes
Level 6	178	< 300	Yes
Reference:	Appendix C of this report	NFPA 101, 2006, Section 38.2.6.1	NFPA 101, 2006

4.4.9 Discharge from Exits

Exit discharge from the CSM complies with the Life Safety Code, (NFPA 101, 2006, Section 38.2.7 and Section 7.7). All CSM exits terminate at an exterior exit discharge that leads directly to a public way. No exits in the CSM discharge through areas on the level of exit discharge. Exit discharge in the CSM is arranged to make clear the direction of egress to a public way.

Figure 12 illustrates exit discharge from the CSM to the nearest public way.

4.4.10 Illumination of Means of Egress

Means of egress in the CSM complies with the Life Safety Code, (NFPA 101, 2006, Section 38.2.8 and Section 7.8). Means of egress is illuminated for all stairs, aisles, corridors, ramps, passageways and walkways leading to an exit and/or public way during the time of building use. The CSM is estimated to be occupied from the time classes start at 7am until the last class ends at 10pm. For a conservative estimation, assume building use from 6am-11pm requires constant illumination of the means of egress.

The CSM must contain automatic, motion sensor-type lighting switches equipped with fail-safe operation to help illuminate the means of egress when natural lighting is not available. These artificial lights must be set for a minimum 15 minute duration and the motion sensor must be activated by any occupant movement in the area served by the lighting units.

Table 19 shows the illumination requirements for different components within the means of egress.

Table 19: Illumination Requirements		
Means of Egress	Minimum Illumination	Notes
Stair	10 foot-candle (108 lux)	Measured at the walking surfaces
Aisles, Corridors, Ramps Passageways and Walkways	1 foot-candle (10.8 lux)	Measured at the floor
Assembly Occupancies	0.2 foot-candle (2.2 lux)	Applies to exit access floors during periods of performances involving directed light
<i>Reference: NFPA 101, 2006, Section 7.8.1.3</i>		

The illumination requirements given in Table 19 must be arranged throughout the CSM so that the failure of any single lighting unit does not result in an illumination level of less than 0.2 foot-candle (2.2 lux) in any designated area.

Illumination of means of egress must be considered reliable by the AHJ, (Fire Official of CPSU). Battery-operated electric lights and other types of portable lamps or lanterns may not be used for primary illumination of the means of egress.

4.4.11 Emergency Lighting

Emergency lighting in the CSM must comply with Section 7.9 of Life Safety Code because the building is more than two stories high above the level of exit discharge, the occupancy above the level of exit discharge is greater than 50, and the total building occupancy is more than 300 total occupants, (NFPA 101, 2006, Section 38.2.9)

Emergency illumination must be provided for at least 1 ½ hours in the event of failure of normal lighting. Table 20 shows the emergency lighting requirements for the first 1 ½ hours and the permitted lighting requirements after 1 ½ hours.

Table 20: Emergency Lighting Requirements			
Stair, Aisles, Corridors, Ramps, Passageways and Walkways	Illumination Average	Minimum at Any Point	Notes
1 ½ hours	1 foot-candle (10.8 lux)	0.1 foot-candle (1.1 lux)	Measured along the path of egress at floor level
After 1 ½ hours	0.6 foot-candle (6.5 lux)	0.06 foot-candle (0.65 lux)	Measured along the path of egress at floor level
Reference: NFPA 101, 2006, Section 7.9.2.1			

The CSM is required to have an emergency lighting system of at least Type 10, Class 1.5, Level 1 in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*, (NFPA 101, 2006, Section 7.9.2.2). Type 10 requires a maximum time of 10 seconds for the Emergency Power Supply System (EPSS) to permit the load terminals of the transfer switch to be without acceptable electrical power. Class 1.5 means that a minimum time of 1 ½ hours is required for the EPSS to operate at its rated load without being refueled or recharged. A Level 1 system is required in the CSM because failure of the equipment to perform could result in loss of human life, (NFPA 110, 2005, Chapter 4).

The emergency lighting system must be either continuously operating or capable of repeated automatic operation without manual intervention. Emergency lighting is required to automatically provide illumination when a public utility fails, outside electrical power supply fails, circuit breaker or fuse opens, and/or switches controlling normal lighting are manually opened, (including accidentally opened), (NFPA 101, 2006, Section 7.9.2.3).

Any emergency generators in the CSM that provide power to emergency lighting systems must be installed, tested and maintained in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*. Any stored electrical energy systems must be installed and tested in accordance with NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*. Unit equipment and battery systems for emergency luminaires must be listed to UL 924, *Standard for Emergency Lighting and Power Equipment*, (NFPA 101, 2006, Section 7.9.2.4 and Section 7.9.2.5).

4.4.11.1 Inspection, Testing and Maintenance

Emergency lighting systems must be visually inspected for operation of the illumination sources at intervals not exceeding 30 days, (NFPA 101, 2006, Section 7.10.9.1). Functional testing of emergency lighting systems must be conducted at either, 1) 30-day intervals for not less than 30 seconds, or 2) annually for not less than 1 ½ hours if the emergency lighting system is battery powered. The functional test must demonstrate that the emergency lighting equipment is fully operational for the duration of the test and written records of visual inspection and tests must be kept by Cal Poly for inspection by the Fire Official, (NFPA 101, 2006, Section 7.9.3.1.1(1)). Alternative options are available for inspection and testing requirements as stated in NFPA 101, 2006, Section 7.9.3.1.1(2) and Section 7.9.3.1.1(3).

4.4.12 Marking of Means of Egress

The CSM must contain means of egress that is marked in accordance with Section 7.10 of the Life Safety Code, (NFPA 101, 2006, Section 38.2.10).

4.4.12.1. Internally Illuminated Signs

Exits, other than main exterior exit doors that obviously and clearly are identifiable as exits must be marked by an approved exit sign that reads, "EXIT" and is readily visible from any direction of exit access. The tactile signage for exit signs must comply with ICC/ANSI A117.1, *American National Standard for Accessible and Usable Buildings and Facilities*, (NFPA 101, 2006, Section 7.10.1). An alternative to the requirements stated above is internally illuminated signs listed in accordance with UL 924, *Standard for Emergency Lighting and Power Equipment*, (NFPA 101, 2006, Section 7.10.7.1(3)).

4.4.12.1.1 Visibility

When access to exits is not readily apparent to occupants, approved exit signs must be readily visible that direct occupants in the direction of the nearest exit. Exit access corridors must have approved exit signs every 100 feet. Exit signs must provide contrast with decorations, interior finish, or other signs and no decorations, furnishings, or equipment is permitted to impair visibility of the exit sign. No brightly illuminated sign or display (for other than exit purposes), is allowed in or near the line of vision of the exit sign, (NFPA 101, 2006, Section 7.10.1).

4.4.12.1.2 Mounting Location

Exit signs must be mounted at a vertical distance less than 6 feet 8 inches above the top edge of the egress opening intended for designation by that marking. Exit signs must be mounted at a horizontal distance less than the required width of the egress opening, as measured from the edge of the egress opening intended for designation by that marking to the nearest edge of the marking, (NFPA 101, 2006, Section 7.10.1.9).

4.4.12.1.3 Photoluminescent Signs

Photoluminescent signs are permitted as long as they are continually illuminated while the building is occupied, illumination levels are in accordance with its listing, and the charging illumination is a reliable light source as determined by the Fire Official of CPSU. The charging light must be specified in the product markings, (NFPA 101, 2006, Section 7.10.7.2).

4.4.12.1.4 Elevator Signs

Level 6 of the CSM contains Elevator No. 1 & 2 that serve as part of the accessible means of egress with the area of refuge. Signs must indicate that the elevator can be used for egress, including any restriction on use, and signs must indicate the operational status of the elevators. Elevator No. 1 & 2 are required to have a capacity of at least eight persons, (NFPA 101, 2006, Section 7.10.8.4 and Section 7.2.13.1).

4.4.12.2 Externally Illuminated Signs

Externally illuminated signs must contain letters not less than 6 inches high, with the principal strokes of letters not less than $\frac{3}{4}$ inches wide. Externally illuminated signs must be illuminated by at least 5 foot-candles (54 lux) at the illuminated surface and have a contrast ratio of at least 0.5. The word "EXIT" must be written in letters of a width not less than 2 inches, except the letter I, and the minimum spacing between letters must be greater than $\frac{3}{8}$ inches. Exit signs that are larger than the minimum established requirements must use letter widths, strokes, and spacing in proportion to their height, (NFPA 101, 2006, Section 7.10.6).

4.4.12.2.1 Directional Signs

A directional sign is required at every location where the direction of travel to reach the nearest exit is not apparent. Directional indicators must be located outside of the EXIT legend and not

less than 3/8 inches from any letter. The directional indicator must be identifiable as a directional indicator at a distance of 40 feet. The directional indicator must be located at the end of the exit sign for the direction indicated, (NFPA 101, 2006, Section 7.10.6.2.1). The directional indicator must be a chevron-type as illustrated in Figure 13 below.

5.0 Performance-Based Design

A performance-based design method complies with the CBC because it is considered an alternate design method. The AHJ is required to review the design for compliance with the intent of the CBC, (CBC, 2007, Section 108.7).

For purposes of this report, the Life Safety Code (2006 Edition) is used as a guideline for a performance-based approach. A performance-based approach to life safety design must be in accordance with Chapters 1-5 of the Life Safety Code, (NFPA 101, 2006, Section 4.2.3). Chapter 5 focuses on the performance-based approach to life safety design.

Performance Criteria

A performance-based design must prevent any occupant who is not intimate with ignition from being exposed to instantaneous or cumulative untenable conditions. The primary objectives used to achieve this goal include protecting occupants, maintaining structural integrity and maintaining system reliability for the time needed to evacuate, relocate, or defend in place, (NFPA 101, 2006, Section 5.2.2 and Section 4.2).

Retained Prescriptive Requirements

A performance-based design has certain requirements retained from the prescriptive requirements of the Life Safety Code. These requirements pertain to means of egress and are listed in Section 5.3.2 of the Life Safety Code. The relevant requirements to the CSM are covered in Section 4.4 of this report, (NFPA 101, 2006, Section 5.3).

Design Specifications

Design specifications and other conditions used in the performance-based design must be clearly stated and shown to be realistic and sustainable.

- Assumptions must be accurately translated into input data specifications, as appropriate for the calculation method or model. Assumptions that are not addressed or that are modified in the input data because of limitations in test methods must be identified and a sensitivity analysis of the consequences must be performed.
- Building characteristics that affect occupant behavior or the rate of hazard development must be identified.

- The selection of occupant characteristics must provide an accurate reflection of the expected population of building users and be approved by the AHJ.
- The basic occupant response characteristics of sensibility, reactivity, mobility and susceptibility must be evaluated.
- It should be assumed that in every normally occupied room, at least one person is located at the most remote point from the exits.
- The design must be based on the maximum number of people that every occupied room is expected to contain.

Design Fire Scenarios

The Life Safety Code specifies a minimum of eight fire design scenarios to be included in the performance-based analysis. These scenarios are described in detail in Section 5.5.3 of the Life Safety Code, 2006 edition. This report analyzes four fire scenarios that were developed in a Smoke Management Study for the atrium of the CSM and follows the guidance of the *SFPE Engineering Guide to Performance-based Fire Protection Analysis and Design of Buildings*.

Evaluation of Proposed Designs

The AHJ must approve the choice of assessment methods used in the performance-based approach. The design professional must use the assessment methods to demonstrate that the proposed design will achieve the goals and objectives, as measured by the performance criteria in light of the safety margins and uncertainty analysis, for each scenario, given the assumptions.

Input data for computer fire models must be obtained in accordance with ASTM E 1591, *Standard Guide for Obtaining Data for Deterministic Fire Models*. Data for use in analytical models that are not computer-based fire models must be obtained using appropriate measurement, recording, and storage techniques to ensure the applicability of the data to the analytical method being used.

Uncertainty in input data must be analyzed and, as determined appropriate by the AHJ, addressed through the use of conservative values. Evidence must be provided to confirm that the assessment methods are valid and appropriate for the proposed building, use, and conditions.

Approved safety factors must be included in the design methods and calculation to reflect uncertainty in the assumptions, data, and other factors associated with the performance-based design.

5.1 Methodology

5.1.1 Smoke Management Study Analysis

A Smoke Management Study was conducted prior to construction completion of the CSM. This study analyzes four design fire scenarios and their effects on atrium smoke control using a natural ventilation system. Two computer software programs, Fire Dynamics Simulator (FDS) and Simulation of Transient Evacuation and Pedestrian movements (STEPS) were used to analyze the effects of each design fire scenario. This report analyzes the design fire scenarios identified in the Smoke Management Study and compares the results of the study with both prescriptive and performance-based code requirements.

5.1.2 Demographics

The population demographics for the CSM are based on the results of a study conducted for office evacuation. Age demographics for young, middle and old persons are shown in Table 21:

Table 21: Age Demographics			
Age	Demographic Classification	Percent from "Assessment of Photoluminescent Material during Office Evacuation"	Percent used by Pathfinder Model and Smoke Management Study
20-30	Young	15%	15%
31-50	Middle	66%	63%
51-61+	Old	19%	16%
All ages	Disabled	5.6%	6%
Reference: Assessment of Photoluminescent Material during Office Evacuation, 1999, Table 5 and Smoke Management Study- Atrium Smoke Control, 2009			

Within the demographic groups provided in Table 21, approximately 6% of the occupants were disabled. Table 22 represents the percentage of occupants with limitations that could impede evacuation time.

Table 22: Limitations That Could Impede Evacuation	
Limitation	Percent
Emphysema	0.0%
Asthma	0.9%
Pregnancy	0.0%
Arthritis	1.4%
Overweight	0.0%
Injury	0.9%
Vision impairment	0.5%
Mobility impairment	1.4%
Hearing impairment	0.5%
TOTAL	5.6%
Reference: Assessment of Photoluminescent Material during Office Evacuation, 1999, Table 6	

5.1.3 Travel Speeds

The travel speeds for occupants was based on the age and mobility of the occupant. Table 23 indicates the values that were used in the Smoke Management Study for walking speeds of the occupants.

Table 23: Occupant Walking Speeds				
Occupant Type	Horizontal	Down Stairs	Up Stairs	References
Young	1.3 m/sec (4.27 ft/sec)	0.8 m/sec (2.62 ft/sec)	0.6 m/sec (1.96 ft/sec)	<i>Fruin, 1987 and Fahy, 2001</i>
Middle	1.2 m/sec (3.94 ft/sec)	0.7 m/sec (2.3 ft/sec)	0.5 m/sec (1.64 ft/sec)	<i>Fruin, 1987 and Fahy, 2001</i>
Old	1.0 m/sec 2.0 (3.28 ft/sec)	0.6 m/sec (1.96 ft/sec)	0.4 m/sec (1.31 ft/sec)	<i>Fruin, 1987</i>
Disabled	0.5 m/sec (1.64 ft/sec)	0.27 m/sec (0.89 ft/sec)	0.216 m/sec (0.71 ft/sec)	<i>Fruin, 1987 and Boyce, Shields, and Silcock, 1999.</i>
Reference: Smoke Management Study- Atrium Smoke Control, 2009				

5.2 Design Fire Development

Four design fire scenarios were developed to evaluate the effects of fire within the atrium space using a natural ventilation system. Each fire scenario was developed using the following assumptions:

- **“Qualitative Hazard Analysis.** *The peak fire growth rate or maximum heat release rate and duration of a fire within a given space is dependent upon the type, quantity and configuration of the materials within the space, as well as the effect of sprinklers. A qualitative hazard analysis was performed to determine the expected range of fire scenarios. Potential fuel sources and potential ignition sources were reviewed based upon representative materials and equipment within various areas where a performance-based approach was used. Fuel sources were chosen based upon the potential for a developing fire to cause conditions where occupants or the structure may be threatened, [(reference Figure 15 for location of design fire scenarios)].*
- **Heat Release Rate Curves.** *The fire scenarios were quantified by assuming a fast t^2 fire. This assumption is a reasonable estimate for the types of hazards that are likely in the building, [(reference Figure 14 for relation of t^2 fires to some fire tests)].*
- **Maximum Heat Release Rate.** *The maximum heat release rate was estimated by determining the expected time for sprinkler activation and by estimating the maximum fire size of a given fuel package, [(reference Appendix F for Sprinkler Control Calculations)].*
- **Determination of Smoke Production.** *Soot yields corresponding to polyurethane foam with some cellulosic material were used (effective yield of 5%). This generally results in conservative predictions of visibility,” (Smoke Management Study, 2009).*

Figure 14 shows the relation of t^2 fire growth curves to some fire tests.

5.2.1 Design Fire Scenario 1 (DF1) – Level 2, Center of Atrium

Level 2 is the ground floor of the atrium space and is open to Level 3 through two atrium spaces. DF1 evaluates the effects of a balcony spill plume on Level 2 located in the center of the atrium space. The ceiling is approximately 14 feet high and the fuel load is a mixture of cellulosic and hydrocarbon materials. The heat release rate grows at a fast t^2 fire growth rate until the upper layer gas temperature reaches sprinkler activation temperature, at which time the fire is assumed to be controlled by the sprinkler system and the heat release rate remains constant at 1,387 kW. Appendix F provides sprinkler control calculations using the Alpert correlation and DETACT model.

5.2.2 Design Fire Scenario 2 (DF2) – Level 2, High-Bay Space

The high-bay space of Level 2 is open to Levels 3-6 above by means of two atrium spaces. The ceiling is approximately 80 feet above the fire and it is assumed that sprinklers will not activate. The fire is fuel-controlled, meaning the fire will burn until the fuel source is depleted. A fuel source with a maximum heat release rate of 2,500 kW is considered reasonable for a moderate fuel load originating with chair furnishings. The majority of furnishings have a peak HRR below 2,500 kW as demonstrated in Table B.5.3(d) of NFPA 92B, 2005 edition. Two exceptions to this include:

1. Traditional loveseat with a wood frame and fire resistant polyurethane padding (2890 kW)
2. Traditional sofa with wood frame and fire resistant polyurethane padding (3120 kW)

The high-bay atrium space will not contain loveseats and sofas because it is not very wide, ($\approx$ 12 feet wide under atrium opening), and is predominantly used for circulation. The design fire will grow in accordance with a fast t^2 fire growth rate until it reaches its maximum HRR of 2,500 kW, at which point the HRR remains constant.

5.2.3 Design Fire Scenario 3 (DF3) – Level 4, Student Work Space

Level 4 contains two student work spaces and is open to Levels 2 & 3 below, and Levels 5 & 6 above by means of the two atrium spaces. The ceiling is approximately 12 feet high and the fuel load is a mixture of cellulosic and hydrocarbon materials. The heat release rate grows at a fast t^2 fire growth rate until the upper layer gas temperature reaches sprinkler activation temperature, at which time the fire is assumed to be controlled by the sprinkler system and the heat release rate remains constant at 1,185 kW. Appendix F provides sprinkler control calculations using the Alpert correlation and DETACT model.

5.2.4 Design Fire Scenario 4 (DF4) – Level 5, Center of Atrium

Level 5 is open to Levels 2-4 and Level 6 by means of two atrium spaces. The ceiling is approximately 14 feet high and the fuel load is a mixture of cellulosic and hydrocarbon materials. The heat release rate grows at a fast t^2 fire growth rate until the upper layer gas temperature reaches sprinkler activation temperature, at which time the fire is assumed to be controlled by the sprinkler system and the heat release rate remains constant at 1,387 kW. Appendix F provides sprinkler control calculations using the Alpert correlation and DETACT model.

5.2.5 Summary of Design Fire Scenarios

Table 24 provides a summary of the design fire details.

Table 24: Summary of Design Fires Fast t^2 Fire Growth Rate, $\alpha = 0.0469$ (NFPA 272, 2007, Table B.2.3.2.3.6)			
ID	Location	Calculated Fire Size ¹	FDS Fire Size ²
DF1	Level 2, Center of Atrium	1,387 kW	1,500 kW
DF2	Level 2, High-Bay Space	2,500 kW	2,500 kW
DF3	Level 4, Student Work Space	1,185 kW	1,300 kW
DF4	Level 5, Center of Atrium	1,387 kW	1,500 kW

¹ Fire size at sprinkler activation is based on the Alpert correlation and DETACT model, (Appendix F).
² HRR values used for FDS modeling in the Smoke Management Study

The fire size at sprinkler activation is based on calculations using the Alpert correlation and DETACT model, (Appendix F). In all cases the calculated fire size is less than or equal to the predicted FDS Fire Size. The FDS fire models provided in the Smoke Management Study accurately represent fire development for the design fires specified. Figure 15 shows the location of design fire scenarios within the atrium space of the CSM.

5.3 Tenability Criteria

Providing appropriate tenability criteria ensures that the building occupants are not exposed to untenable conditions. NFPA 101, Appendix A, Section A.5.2.2 provides different methods to avoid exposing occupants to untenable conditions and refers to the *SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings* to establish tenability limits.

Table 25 shows the tenability criteria used to evaluate each fire scenario at a height 6 feet above occupied floor levels.

Table 25: Tenability Criteria		
Design Criteria	Tenability Limit	Justification
Temperature Limit	140°F (60°C)	NFPA 130, <i>Standard for Fixed Guideway and Passenger Rail Systems</i>
Visibility Limit	42 feet (13 meters)	Jin, SFPE Handbook, Table 2-4.2. Assume building occupants are unfamiliar with surroundings.
Radiant Flux Limit Smoke Temperature Limit	1.7kW/m ² 350°F (180°C)	SFPE Engineering Guide, <i>Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation</i>
Carbon Monoxide	30,000 ppm/min (1,000 ppm for 30 minutes)	NFPA 101, <i>Life Safety Code</i>

Temperature, 140°F (60°C) Limit

The exposure to heat limit is 140°F (60°C) for a smoke layer 6 feet (1.8 meters) above the walking surface. Inhalation of air above 140°F (60°C) can cause thermal burns to the respiratory tract, (NFPA 130, 2007).

Visibility, 42 feet (13 meters) Limit

If the smoke layer does not descend below 6 feet (1.8 meters) as stated in the tenability criteria, then theoretically, visibility would not decrease. However, a visibility limit of 42 feet (13 meters) is appropriate for a large space where occupants are unfamiliar with their surroundings, (Jin, SFPE Handbook).

Radiant Flux, 1.7 kW/m² Limit (smoke temperature below 180°C)

Radiant flux is the result of thermal radiation from a hot smoke layer down towards the evacuating occupants. The radiant flux tenability limit is 1.7kW/m² because an incident radiant flux greater than 1.7kW/m² may cause pain on exposed skin after prolonged exposure, (SFPE Engineering Guide, *Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation*). This value is considered conservative compared to a radiant flux of 2.5 kW/m² provided by the CIBSE Guide E – Fire Engineering. A smoke temperature that is maintained below 350°F (180°C) will not exceed the radiant flux tenability limit.

Carbon Monoxide, 30,000 ppm/min Limit

Toxic gases impair an individual's ability to self-evacuate by decreasing the amount of oxygen available, causing disorientation and possibly unconsciousness. In building fires, the most common toxic gas is carbon monoxide (CO) and, to a lesser extent, hydrogen cyanide (HCN) which is more toxic. NFPA 101 specifies a CO tenability limit as an integrated dose, 30,000 ppm/min, (1,000ppm for 30 minutes).

5.4 Required Safe Egress Time

5.4.1 Overview

The Required Safe Egress Time (RSET) is the predicted time necessary to evacuate a building or component. The RSET area can be expressed as a combination of detection and notification time, pre-movement time, action time and travel time, (Nelson, et. al., SFPE Handbook).

$$RSET = t_d + t_a + t_o + t_i + t_e \quad (\text{Equation 2})$$

where,

t_d = time from fire ignition to detection (detection time)

t_a = time from detection to notification of occupants of a fire emergency (notification time)

t_o = time from notification until occupants decide to take action (pre-movement time)

t_i = time from decision to take action until evacuation commences (action time)

t_e = time from the start of evacuation until it is completed (travel time)

Figure 16 illustrates the sequence of occupant response to fire.

5.4.2 Detection and Notification Time

The detection time, t_d , and notification time, t_a , is the time from ignition to the time at which the occupants are aware of the fire and the need to evacuate. It is assumed that detection will occur when occupants become aware of smoke through either visual awareness or when smoke detectors, sprinklers, or manual alarms are activated and the building alarm is initiated. Occupants in the room or compartment of the fire and in close proximity can also be alerted to a fire by visual cues from the various fire-induced conditions, such as smoke and heat.

Given the openness of the atrium, the likely source of primary detection is the building occupants seeing smoke rise through the atrium, which would occur quickly in the event of a fire. Based upon the design fire scenarios, it is likely that the detection and notification time would be between 30-60 seconds. For

purposes of this egress analysis, a detection and notification time of 60 seconds will be used. Therefore, from Equation 2, $t_d + t_a = 60$ seconds.

5.4.3 Pre-Movement and Action Time

Pre-movement time, t_o , and action time, t_i , is the time taken to perform activities that people are engaged in prior to actual evacuation of the area. These activities may include investigating, assessing danger, warning others, collecting belongings, and seeking assistance. This behavior is a complex, cognitive thought process and is not easily characterized.

The SFPE Handbook provides a discussion regarding pre-movement times in various types of building for three different emergency notification scenarios. Table 26 shows the three notification scenarios and their estimated delay time to start evacuation.

Table 26: Estimated Delay Time to Start Evacuation		
<i>CSM Occupancy Type: Offices, commercial and Industrial buildings, schools, colleges and universities</i>		
Scenario	Warning System Description	Estimated Delay Time to Start Evacuation
W1	Live directives using a voice communication system from a control room with closed-circuit television facility, or live directives in conjunction with well-trained, uniformed staff that can be seen and heard by all occupants in the space	Less than 1 minute
W2	Nondirective voice messages (prerecorded) and/or informative warning visual display with trained staff	3 minutes
W3	Warning system using fire alarm signal and staff with no relevant training	Greater than 4 minutes
<i>Reference: Proulx, SFPE Handbook, Table 3-13.1</i>		

The CSM was designed with a prerecorded voice message that must comply with the requirements of scenario W2 for an estimated delay time to start evacuation of 3 minutes. Therefore, from Equation 2, $t_o + t_i = 180$ seconds (3 minutes).

5.4.4 Travel Time

Travel time, t_e , is the time from the start of evacuation until it is completed. The occupant travel time was calculated using the hydraulic model of emergency egress from the SFPE Handbook. Assuming the incorporation of a “phased evacuation” plan as described in Section 4.2.4 of this report, the travel time can be calculated for the atrium as the time when all occupants are evacuated out of Zone 1 (Figure 7). Research-based methods for predicting the flow of occupants in emergencies generally assume the following conditions:

- (1) All persons will start to evacuate at the same instant.
- (2) Occupant flow will not involve any interruptions caused by decisions of the individuals involved.
- (3) All or most of the persons involved are free of disabilities that would significantly impede their ability to keep up with the movement of the group.

The travel time for occupants to evacuate Zone 1 depends on the density of occupants in the space. Figure 17 shows the evacuation speed as a function of density.

Figure 17 illustrates that a density less than 0.05 persons/square feet has a walking speed of approximately 235 ft/min for corridors, ramps, aisles and doorway exit routes. The sloped lines in Figure 17 represent a density greater than 0.05 persons/square feet but less than 0.35 persons/square feet. If the population density exceeds about 0.35 persons/square feet, no movement will take place until enough of the crowd has passed from the crowded area to reduce the density. Between the density limits of 0.05 and 0.35 persons/square feet the relationship between speed and density can be considered as a linear function. The equation of this function is, (Nelson, et. al., SFPE Handbook):

$$S = k - akD \quad \text{(Equation 3)}$$

Where,

S = speed along the line of travel

D = density in persons/square feet

k = 275 (constant from SFPE Hbk. Sec. 3, Ch. 14, Table 3-14.2)

a = 2.86 (constant from SFPE Hbk. Sec. 3, Ch. 14)

Table 27 calculates the travel time to evacuate the atrium space. The density (D) is determined by dividing the occupant load by the area. The walking speed is determined by converting the density into movement speed using Figure 17 and Equation 3. The travel distance is given in Appendix C and is assumed to be the most remote location within the atrium space for each level. The time to evacuate is calculated by dividing the travel distance by the walking speed of the occupants.

Table 27: Travel Time to Evacuate Atrium Space (Zone 1)						
Atrium Space (Zone 1)	Occupant Load in Atrium Space ² (persons)	Atrium Exit Area (Sq. Ft.)	Density (D) (persons/Sq. Ft.)	Walking Speed (ft/min)	Travel Distance (ft)	Travel Time, t_e to Evacuate (sec)
Level 2	81	3675	0.02	235	100	26
Level 3	164	1835	0.09	205 ¹	112	33
Level 4	73	6731	0.01	235	152	39
Level 5	77	6641	0.01	235	152	39
Level 6	74	6731	0.01	235	152	39
<i>Reference:</i>	<i>Smoke Management Study- Atrium Smoke Control, 2009</i>	<i>Zimmer, 2009</i>	<i>Calculate: Occupant load divided by atrium area</i>	<i>Calculated: Figure 17 and Equation 3</i>	<i>Appendix C</i>	<i>Calculated: Travel distance divided by Walking Speed of occupants</i>
<p><i>Note 1: Level 3 density is between 0.05 and 0.35 persons/square feet, therefore, the linear function expressed in Equation 3 is used to calculate walking speed:</i> $S = k - akD \rightarrow S = 275 - 2.86(275)(0.09) \rightarrow S = 205 \text{ ft/min}$</p> <p><i>Note 2: Occupant loads are based on values used in the Smoke Management Study for purposes of comparing results.</i></p>						

Since the density is less than 0.05 persons/square feet for all levels except Level 3, individuals will move at their own pace, independent of the speed of others, (Nelson, et. al., SFPE Handbook). The walking speed associated with corridors, aisles and doorways is approximately 235 ft/min (Figure 17) in areas where the density is less than 0.05 persons/square feet.

For consistency with SFPE hydraulic model of emergency egress hand calculations, a Pathfinder model was constructed to simulate occupant travel times on each level of the atrium space. The occupant load for each level of the atrium space and the atrium exit area are consistent with the values listed in Table 27 above. However, instead of calculating walking speed based on density as shown in the hydraulic model of emergency egress, Pathfinder simulates travel time based on four different walking speeds for four different age demographics, Young, Middle, Old and Disabled, as specified in Table 21 and Table 23 of this report. Table 28 summarizes the occupant characteristics used in the Pathfinder simulation.

Table 28: Pathfinder Occupant Characteristics					
Atrium Space (Zone 1)	15% Young (persons age 20-30)	63% Middle (persons age 31-50)	16% Old (persons age 51-61+)	6% Disabled (persons all ages)	Total Occupant Load in Atrium Space (persons)
Level 2	12	51	13	5	81
Level 3	25	103	26	10	164
Level 4	11	46	12	4	73
Level 5	12	48	12	5	77
Level 6	11	47	12	4	74

Details of the Pathfinder model are summarized in Appendix J along with further egress analysis using Pathfinder computer modeling.

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

In addition to the SFPE hand calculations and Pathfinder computer simulation model, the Smoke Management Study uses another computer software, Simulation of Transient Evacuation and Pedestrian movements (STEPS) to simulate occupant travel time within the atrium space. The results of all three methods are shown in Table 29.

Atrium Space (Zone 1)	Hand Calculations Travel Time, t_e to Evacuate (sec)	Pathfinder Computer Evacuation Model Travel Time, t_e to Evacuate (sec)	STEPS Computer Evacuation Model Travel Time, t_e to Evacuate (sec)
Level 2	26	27	21
Level 3	33	36	37
Level 4	39	35	34
Level 5	39	39	40
Level 6	39	36	39
Reference:	Calculated in Table 27	Calculated in Appendix J	Smoke Management Study- Atrium Smoke Control, 2009

Table 29 shows that the estimated travel time using the hand calculation method is relatively consistent with both the Pathfinder and STEPS computer evacuation models. It is assumed that the hand calculations are reasonable and accurate and are used to calculate RSET.

It should be noted that a second Pathfinder model is constructed based on the occupant loads specified in the architectural plan drawings. The occupant loads in the architectural plans are slightly different from the occupant loads specified in the Smoke Management Study. It is assumed that this difference is attributed to the omission of restroom occupancy loads in the architectural plans which could account for 4 to 9 occupants per level. The difference is not significant and the conservative occupant loads specified in the Smoke Management Study were used to calculate RSET times. Appendix J provides a detailed approach to both methods of constructing Pathfinder egress models.

5.4.5 Total Evacuation Time

Table 30 provides a summary of the total evacuation times for each level of the atrium space within the CSM. CBC Section 909.4 requires a smoke control system to operate for a period of 20 minutes or 1.5 times the calculated evacuation time, whichever is less.

Level	Detection and Notification Time, $t_d + t_a$ (sec)	Pre-movement and Action Time, $t_o + t_i$ (sec)	Travel Time, t_e (sec)	RSET Total Time (sec)	1.5 times RSET (sec)
Level 2	60	180	26	266	399
Level 3	60	180	33	273	410
Level 4	60	180	39	279	419
Level 5	60	180	39	279	419
Level 6	60	180	39	279	419
Reference:	Section 5.4.2	Section 5.4.3	Section 5.4.4	Calculated RSET using Equation 2: $t_d + t_a + t_o + t_i + t_e$	CBC Section 909.4.6

5.5 Available Safe Egress Time

The Available Safe Egress Time (ASET) represents the time from ignition until the atrium space becomes untenable. The ASET was analyzed in the Smoke Management Study using the four design fire scenarios described in Section 5.2 of this report. The atrium was modeled to include natural ventilation conditions consistent with the geometry of the building as currently designed. Table 31 shows the location and size of ventilation openings.

Table 31: Ventilation Openings	
Ventilation Opening Description	Area
North double-door	133.5 ft ²
South double-door	133.5 ft ²
North roof vent	100 ft ²
South roof vent	100 ft ²
<i>Reference: Smoke Management Study- Atrium Smoke Control, 2009</i>	

Each design fire scenario is modeled in the Smoke Management Study using Fire Dynamics Simulator (FDS). Table 32 summarizes the ASET of each design fire scenario.

Table 32: ASET Summary			
Design Fire Scenario	Building Elevation	Tenability Criteria	
		Duration of Time that Temperature is Maintained Below 140°F (60°C)	Duration of Time that Visibility is Maintained Below 42 feet (13 meters)
DF1: 1500 kW Level 2 Center of Atrium	Level 2	1200 seconds	1200 seconds
	Level 3	1200 seconds	240 seconds
	Level 4	1200 seconds	720 seconds
	Level 5	1200 seconds	720 seconds
	Level 6	1200 seconds	720 seconds
DF2: 2500 kW Level 2 High-Bay Space	Level 2	1200 seconds	1200 seconds
	Level 3	1200 seconds	1200 seconds
	Level 4	1200 seconds	400 seconds
	Level 5	1200 seconds	360 seconds
	Level 6	1200 seconds	260 seconds
DF3: 1250 kW Level 4 Student Work Space	Level 2	1200 seconds	1200 seconds
	Level 3	1200 seconds	1200 seconds
	Level 4	1200 seconds (outside fire plume)	1200 seconds (outside fire plume)
	Level 5	1200 seconds	320 seconds
	Level 6	1200 seconds	400 seconds
DF4: 1500 kW Level 5 Center of Atrium	Level 2	1200 seconds	1200 seconds
	Level 3	1200 seconds	1200 seconds
	Level 4	1200 seconds	1200 seconds
	Level 5	1200 seconds (outside fire plume)	1200 seconds (outside fire plume)
	Level 6	240 seconds	180 seconds

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

In summary, the ASET for each level of the atrium is as follows:

- Level 2 has an ASET of 1200 seconds in all design fire scenarios.
- Level 3 has an ASET of 240 seconds, limited by DF1.
- Level 4 has an ASET of 400 seconds, limited by DF2.
- Level 5 has an ASET of 320 seconds, limited by DF3.
- Level 6 has an ASET of 180 seconds, limited by DF4.

Reference Attachment 3: Smoke Management Study for detailed images of the FDS analysis.

5.6 Results

Table 33 provides a summary of the evacuation times for each floor and the duration for which tenability is maintained.

Table 33: RSET vs. ASET			
Level	RSET (seconds)	ASET (seconds)	PASS/FAIL Tenability Criteria
Level 2	399	1200	PASS
Level 3	410	240	FAIL
Level 4	419	400	FAIL
Level 5	419	320	FAIL
Level 6	419	180	FAIL

Figure 18 provides a graphical representation of the data in Table 33.

Level 2 has an ASET time greater than the RSET time and passes the tenability criteria described in Section 5.3 of this report. Levels 3, 4, 5 & 6 have an RSET time that is greater than the ASET time and fail to meet the tenability criteria.

6.0 Conclusion

This report evaluates the Smoke Management Study and concludes that a natural ventilation smoke management system is not adequate for the atrium space. The performance-based approach demonstrates that tenability criteria are not met for Levels 3, 4, 5 & 6 of the atrium space. Therefore, a natural ventilation system does not provide a level of safety commensurate with that required by the California Building Code.

7.0 Recommendations

The following recommendations are based on the results of this fire and life safety analysis:

- 1) Recommend designing a voice evacuation system in accordance with a W1 system, defined in the SFPE Handbook as, “live directives using a voice communication system from a control room with closed-circuit television facility, or live directives in conjunction with well-trained, uniformed staff that can be seen and heard by all occupants in the space.” This would reduce pre-movement times by 120 seconds and reduce RSET times by 180 seconds bringing Levels 3, 4, 5 & 6 in compliance with the CBC.
- 2) Recommend a Fire Safety Management Plan that incorporates “phased evacuation” for the CSM. This would allow occupants within close proximity of the fire to evacuate the building first. Appendix G provides an example of a Fire Safety Management Plan for the CSM.
- 3) Recommend re-designing the natural ventilation system or designing a mechanical ventilation system in accordance with NFPA 92B for smoke control within the atrium space of the CSM. The smoke control system should provide at least 1.5 times the required RSET evacuation time for safe occupant evacuation. It should be noted that the RSET times listed in Table 30 are subject to change based on incorporation of Recommendation #1. Appendix H provides a design for a smoke control system in the atrium space using the exhaust method.
- 4) Recommend performing an egress analysis based on occupant loads specified in the architectural plans. Appendix J provides two methodologies that analyze occupant evacuation times based on different occupant loads and floor plan layouts. In Appendix J, Methodology 2 is based on occupant loads specified in the architectural floor plans and follows the floor plan layout that would be expected in each room/space within the atrium. The evacuation time for this model is limited by Level 3 at 59 seconds. This results in a calculated RSET of 465 seconds which is greater than the RSET of 419 seconds used in this report. For purposes of this report, an RSET of 465 seconds will still satisfy the ASET requirement of 760 seconds estimated in Appendix H.
- 5) Recommend challenging the assumption in the Smoke Management Study, that “since all of the design fires are in relatively close proximity to occupied spaces where occupants would clearly be able to see smoke and flames, it is reasonable to consider W1 conditions [of 60 seconds] for pre-movement time,” (Section 6.3 of the Smoke Management Study). It is not reasonable to assume all occupants would be able to clearly see smoke and flames because there are administrative offices and work spaces that subdivide the atrium space on Levels 2-6. Therefore, the naturally ventilated smoke control system should consider a pre-movement time of 180 seconds instead of 60 seconds. The increase in pre-movement time is based on analysis in the SFPE Handbook for university buildings that contain a voice evacuation system as defined by W2 (Table 26).

References

1. Aero Automatic. 2011. *Shop Drawings Submittal for Cal Poly Center for Science*.
2. Alpert, R. L. "Ceiling Jet Flows." The SFPE Handbook of Fire Protection Engineering, 3rd Edition, Section 2, Chapter 2. SFPE and NFPA. 2002.
3. ARUP, 2009. *Smoke Management Study- Atrium Smoke Control*. Cal Poly San Luis Obispo Laboratory Building. Zimmer Gunsul Frasca Architects, LLC.
4. ASFP, 2013. Glossary of Terms. Association for Specialist Fire Protection. Kingsley House, United Kingdom.
5. AS1670.1, 2004. *Fire Detection, Warning, Control and Intercom Systems*. Queensland Fire and Rescue Service, Australia.
6. Boyce, Shields, and Silcock, Towards the Characterization of Building Occupancy for Fire Safety Engineering: Capabilities of Disabled People Moving Horizontally and on an Incline, Fire Technology, 35, 1, 1999.
7. BS5839.1, 2002. *Fire Detection and Alarm Systems: Testing and Maintenance*.
http://www.nutecsecurity.co.uk/Industry/Legislation/BS5839_FireDetectionAndAlarmSystems.pdf
8. Cal Poly, 2010. "Groundbreaking Saturday, May 1, 2010." Center for Science and Mathematics.
http://cosam.calpoly.edu/pdf/csm/csm_groundbreaking_program.pdf
9. California Department of Forestry and Fire protection, 2013. "Building Materials Listings – Search Listing Services". Retrieved from:
http://osfm.fire.ca.gov/licensinglistings/licenselisting_bml_searchcotest.php
10. CBC, 2007. *2007 California Building Code: California Code of Regulations Title 24, Part 2, Volume 2 of 2*. California Building Standards Commission.
11. CIBSE Guide E – Fire Engineering. The Chartered Institution of Building Services Engineers. London. 1997.
12. College of Science and Mathematics, 2012. "Center for Science and Mathematics." California Polytechnic State University, San Luis Obispo, CA.
http://cosam.calpoly.edu/center_sci_math.html
13. CFC, 2007. *2007 California Fire Code: California Code of Regulations Title 24, Part 9*. California Building Standards Commission.
14. CPSU, 2013. http://maps.calpoly.edu/images/maps_images/PolyMapCtr.pdf

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

15. Deep Blue Integration. 2012. *Fire Alarm and Voice Evacuation System, Design Review 1*. Center for Science and Mathematics California Polytechnic State University. San Luis Obispo, CA.
16. Duke University Hospital, 2012. *Fire/Life Safety Management Plan*.
17. Fahy, Rita F. and Proulx, Guylene, *Toward Creating a Database on Delay Times to Start Evacuation and Walking Speeds for Use in Evacuation Modeling*, Human Behavior in Fire Proceedings of the 2nd International Symposium, MIT, March 2001. Drill in Mid-Rise.
18. McGrattan, K., Forney, G. *Fire Dynamics Simulator (Version 4) User's Guide*. National Institute of Standards and Technology. U.S. Department of Commerce.
19. McGrattan, K., McDermott, R., Hostikka, S., Floyd, J. *Fire Dynamics Simulator (Version 5) User's Guide*. NIST Special Publication 1019-5. National Institute of Standards and Technology. U.S. Department of Commerce.
20. Flickr: <http://www.flickr.com/photos/calpolyscience/sets/72157628917516905/show/>
21. Fruin, John J., *Pedestrian Planning and Design*, Revised Edition, Elevator World, Inc., Mobile, Alabama, 1987, - Public Spaces.
22. Jin, T. "Visibility and Human Behavior in Fire Smoke." *The SFPE Handbook of Fire Protection Engineering*, 3rd Edition. Section 2, Chapter 4. SFPE and NFPA. 2002.
23. McGrattan, K. "Fire Dynamics Simulator (Version 5) User's Guide". National Institute of Standards and Technology. U.S. Department of Commerce.
24. Milke, J. et. al. "Tenability Analyses in Performance-Based Design." September 2005. Society of Fire Protection Engineers. Retrieved from: <http://magazine.sfpe.org/occupants-and-egress/tenability-analyses-performance-based-design>
25. Mowrer, F. 2012. "FPE 551-Fire Safety Regulation and Management." Module 1.
26. Mowrer, F. 2012. "FPE 504- Fire Modeling." Module 9: Fire Detection/ Suppression.
27. Nelson, Harold and Mowrer, Frederick. "Emergency Movement." *The SFPE Handbook of Fire Protection Engineering*, 3rd Edition, Section 3, Chapter 14. SFPE and NFPA. 2002.
28. NFPA 13, 2007. *Standard for the Installation of Sprinkler Systems* and therefore. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
29. NFPA 20, 2007. *Standard for the Installation of Stationary Pumps for Fire Protection*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
30. NFPA 70, 2005. *National Electrical Code*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.

31. NFPA 72, 2007. *National Fire Alarm Code*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
32. NFPA 92B, 2005. *Standard for Smoke Management Systems in Malls, Atria, and Large Spaces*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
33. NFPA 101, 2006. *Life Safety Code*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
34. NFPA 110, 2005. *Standard for Emergency and Standby Power Systems*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
35. NFPA 130, 2007. *Standard for Fixed Guideway and Passenger Rail Systems*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
36. NFPA, 2008. *Fire Protection Handbook*, 20th Edition, Volume 1. National Fire Protection Association, Quincy, MA.
37. Notifier, 2012. Data sheets.
<https://www.notifier.com/salesandsupport/documentation/Pages/default.aspx>
38. Nuclear Regulatory Commission, *Version 1805.0*, Chapter 11.
39. Poh, W. 2010. "Tenability in Building Fires: Limits and Design Criteria." *Industry Matters Magazine*, Australia.
40. Poh, W., 2011. "Tenability Criteria for Design of Smoke Hazard Management Systems". Forum: Umow Lai Pty Ltd., Australia.
41. Proulx, G. and Tiller, D. 1999. "Assessment of Photoluminescent Material during Office Evacuation." Internal Report No. 774.
42. Proulx, Guylene. "Movement of People: The Evacuation Timing." *The SFPE Handbook of Fire Protection Engineering*, 3rd Edition, Section 3, Chapter 13. SFPE and NFPA. 2002.
43. Society of Fire Protection Engineers. 2000. *Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation*. Engineering Guide.
44. Society of Fire Protection Engineers. 2007. *SFPE Engineering Guide to Performance-based Fire Protection Analysis and Design of Buildings*.
45. System Sensor, 2012. Retrieved from: <http://www.systemsensor.com/products/hvac-intelligent>

46. Texas Tech University Health Sciences Center. 2011. *Fire Safety Management Plan*. Rev. 2.
47. University of Queensland. *Fire Safety Management Plan (FSMP)*. Property & Facilities Division and Occupational Health and Safety Unit.
48. Xtralis. OSID Smoke Detector Product Guide, Revision A. Document No.: 15204. July 2011.
49. Zimmer, 2009. "Center for Science." Construction Documents – Plan Check Response 2. Zimmer Gunsul Frasca Architects LLP. October 23, 2009.

Bibliography

1. ANSI S1.4a, *Specifications for Sound Level Meters*
2. ANSI S3.41, *American National Standard Audible Evacuation Signal*
3. ASME A17.1, 2007. *Safety Code for Elevators and Escalators*. An American National Standard. The American Society of Mechanical Engineers. New York, NY.
4. ASTM Standard E 84, 2007. "Standard Test Method of Surface Burning Characteristics of Building Materials," ASTM International, West Conshohocken, PA, 2003, DOI: 10.1520/C0033-03, www.astm.org
5. FM 4880, *Approval Standard for Class 1 Insulated Wall or Wall and Roof/Ceiling Panels; Plastic Interior Finish Materials; Plastic Exterior Building Panels; Wall/Ceiling Coating Systems; Interior of Exterior Finish Systems*
6. ICC/ANSI A117.1, *American National Standard for Accessible and Usable Buildings and Facilities*.
7. Klotz, J. 1994. "Method of Predicting Smoke Movement in Atria with Application to Smoke Management." National Institute of Standards and Technology, Gaithersburg, MD.
8. Klotz, J. "Smoke Control." The SFPE Handbook of Fire Protection Engineering, 3rd Edition, Section 4, Chapter 12. SFPE and NFPA. 2002.
9. NFPA 10, 2007. *Standard for Portable Fire Extinguishers*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
10. NFPA 45, 2004. *Standard on Fire Protection for Laboratories Using Chemicals*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
11. NFPA 54, 2006. *National Fuel Gas Code*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.

12. NFPA 58, 2004. *Liquefied Petroleum Gas Code*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
13. NFPA 111, 2005. *Standard on Stored Electrical Energy Emergency and Standby Power Systems*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
14. NFPA 253, 2006. *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*
15. NFPA 255, 2006. *Standard Method of Test of Surface Burning Characteristics of Building Materials*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
16. NFPA 286, 2006. *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth*. National Fire Protection Association, an International Codes and Standards Organization. Quincy, MA.
17. Purser, D. "Toxicity Assessment of Combustion Products." The SFPE Handbook of Fire Protection Engineering, 3rd Edition, Section 2, Chapter 6. SFPE and NFPA. 2002.
18. UL 723, *Standard for Test of Surface Burning Characteristics of Building Materials*
19. UL 924, *Standard for Emergency Lighting and Power Equipment*.
20. UL 1040, *Standard for Fire Test of Insulated Wall Construction*
21. UL 1715, *Standard for Fire Test of Interior Finish Material*
22. UL 2079, *Standard for Tests of Fire Resistance of Building Joint Systems*

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

[illegible]

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure A.2: Level 2 Fire-Resistance Ratings

Reference: Zimmer, 2009

APPENDIX A: FIRE-RESISTANCE RATINGS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure A.3: Level 3 Fire-Resistance Ratings

Reference: Zimmer, 2009

APPENDIX A: FIRE-RESISTANCE RATINGS

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure A.4: Level 4 Fire-Resistance Ratings

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure A.5: Level 5 Fire-Resistance Ratings

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure A.6: Level 6 Fire-Resistance Ratings

Reference: Zimmer, 2009

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure B.1: Level 1 Occupancy Classifications

APPENDIX B: OCCUPANCY CLASSIFICATIONS

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure B.2: Level 2 Occupancy Classifications

APPENDIX B: OCCUPANCY CLASSIFICATIONS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure B.3: Level 3 Occupancy Classifications

APPENDIX B: OCCUPANCY CLASSIFICATIONS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure B.4: Level 4 Occupancy Classifications

Reference: Zimmer, 2009

APPENDIX B: OCCUPANCY CLASSIFICATIONS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure B.5: Level 5 Occupancy Classifications

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure B.6: Level 6 Occupancy Classifications

Reference: Zimmer, 2009

APPENDIX C: TRAVEL DISTANCE TO EXITS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Appendix C: Travel Distance to Exits

Figure C.1: Level 1 Travel Distance to Exits

APPENDIX C: TRAVEL DISTANCE TO EXITS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure C.2: Level 2 Travel Distance to Exits

APPENDIX C: TRAVEL DISTANCE TO EXITS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure C.3: Level 3 Travel Distance to Exits

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure C.4: Level 4 Travel Distance to Exits

APPENDIX C: TRAVEL DISTANCE TO EXITS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure C.5: Level 5 Travel Distance to Exits

APPENDIX C: TRAVEL DISTANCE TO EXITS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure C.6: Level 6 Travel Distance to Exits

APPENDIX D: FIRE DETECTION DEVICES

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Appendix D: Fire Detection Devices

Figure D.1: Level 1 Fire Detection Devices

Legend:

- Smoke Detector
- Manual Pull Station

Notes:

This drawing shows fire detection devices designed as of February 2012. The only fire detection device required by code is the smoke detector located near the elevator door. Smoke detectors are required within 21ft. of the centerline of each elevator door for fire fighters' service recall, (NFPA 72, 2007, Section 6.16.3)

Smoke detector is not required above the FACP because the building is fully sprinklered, (NFPA 72, 2007, Section 4.4.5 Exception No. 2)

Manual fire alarm boxes and heat detection are not required because the CSM is equipped throughout with an automatic sprinkler system and the alarm notification appliances will activate upon sprinkler water flow, (CBC, 2007, Section 907.2)

Duct smoke detectors are not included, (design is currently in progress).

Reference: Zimmer, 2009 and Deep Blue Integration, 2012, (NFPA 101, 2006, Section 9.6.2)

APPENDIX D: FIRE DETECTION DEVICES

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure D.2: Level 2 Fire Detection Devices

APPENDIX D: FIRE DETECTION DEVICES

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure D.3: Level 3 Fire Detection Devices

APPENDIX D: FIRE DETECTION DEVICES

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure D.4: Level 4 Fire Detection Devices

APPENDIX D: FIRE DETECTION DEVICES

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure D.5: Level 5 Fire Detection Devices

Legend:

- Smoke Detector
- Manual Pull Station

Notes:

This drawing shows fire detection devices designed as of February 2012. Code requirements are described below:

Smoke detectors are required within 21ft. of the centerline of each elevator door for fire fighters' service recall, (NFPA 72, 2007, Section 6.16.3)

Smoke detector is not required above the FACP because the building is fully sprinklered, (NFPA 72, 2007, Section 4.4.5 Exception No. 2)

Manual fire alarm boxes and heat detection are not required because the CSM is equipped throughout with an automatic sprinkler system and the alarm notification appliances will activate upon sprinkler water flow, (CBC, 2007, Section 907.2)

Duct smoke detectors are not included, (design is currently in progress).

Reference: Zimmer, 2009 and Deep Blue Integration, 2012, (NFPA 101, 2006, Section 9.6.2)

APPENDIX D: FIRE DETECTION DEVICES

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure D.6: Level 6 Fire Detection Devices

APPENDIX D: FIRE DETECTION DEVICES

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure D.7: Roof Level Fire Detection Devices

APPENDIX E: SPRINKLER DESIGN LAYOUT

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Appendix E: Sprinkler Design Layout

Figure E.1: Level 1 Sprinkler Design Layout

Reference: Aero Automatic Sprinkler Company, 2011

APPENDIX E: SPRINKLER DESIGN LAYOUT
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure E.2: Level 2 Sprinkler Design Layout

Reference: Aero Automatic Sprinkler Company, 2011

APPENDIX E: SPRINKLER DESIGN LAYOUT
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure E.3: Level 3 Sprinkler Design Layout

APPENDIX E: SPRINKLER DESIGN LAYOUT
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure E.4: Level 4 Sprinkler Design Layout

APPENDIX E: SPRINKLER DESIGN LAYOUT
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure E.5: Level 5 Sprinkler Design Layout

Reference: Aero Automatic Sprinkler Company, 2011

APPENDIX E: SPRINKLER DESIGN LAYOUT
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Figure E.6: Level 6 Sprinkler Design Layout

Appendix F: Sprinkler Control Calculations

The Alpert correlations for fire plume and ceiling jet temperatures and velocities are used to calculate sprinkler activation time for each design fire scenario. The Alpert correlations use the theoretical heat release rate (Q), based on the fuel mass loss rate and the complete heat of combustion of the fuel. It should be noted that other axisymmetric fire plume correlations use the convective heat release rate instead of the total theoretical heat release rate. This accounts for most of the difference in the temperature coefficients among different correlations. Table F.1 shows the equations used to calculate fire plume and ceiling jet temperatures and velocities, (Mowrer, 2012 as derived by Alpert, SFPE Handbook).

Table F.1: Alpert Correlations for Fire Plume and Ceiling Jet Temperatures and Velocities		
	Fire Plume (R/H < 0.2)	Ceiling Jet (R/H > 0.2)
Gas temperature rise, ΔT_g ,	$\Delta T_{g,pl} = 16.9 \frac{Q^{2/3}}{H^{5/3}}$	$\frac{\Delta T_{g,cj}}{\Delta T_{g,pl}} = \frac{0.32}{(R/H)^{2/3}}$
Gas velocity, u_g ,	$u_{g,pl} = 0.95 \frac{Q^{1/3}}{H}$	$\frac{u_{g,cj}}{u_{g,pl}} = \frac{0.20}{(R/H)^{5/6}}$

The Euler method can be used to express fire detector response time:

$$T_e^{t+\Delta t} = T_e^t + \left. \frac{dT_e}{dt} \right|_t \cdot \Delta t = T_e^t + \left(\frac{\sqrt{u_g^t}}{RTI} (T_g^t - T_e^t) \right) \cdot \Delta t \quad (\text{Equation F-1})$$

NFPA Handbook, Chapter 4, Section 2 defines the following fire growth rates:

Table F.2: Fire Growth Rates		
Fire Growth Rate	Time to Reach 1,000 kW (sec)	Associated Fire Growth Rate α
Slow	600	0.00293
Medium	300	0.01172
Fast	150	0.0469
Ultra-fast	75	0.1876

The heat release rate for each design fire scenario is assumed to grow at a t^2 growth rate in accordance with the following equation, (NFPA Handbook, Chapter 4, Section 2):

$$Q = \alpha t^2 \quad (\text{Equation F-2})$$

Where,

Q = rate of heat release (kW)

α = a constant describing the speed of growth (kW/s²)

t = time (s)

APPENDIX F: SPRINKLER CONTROL CALCULATIONS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Design Fire Scenario 1 and Design Fire Scenario 4:

Table F.3: Input Assumptions: DF1 and DF4 $Q = \alpha t^2$		
Notation	Value	Notes
α	0.0469	Fast fire growth rate from NFPA Hbk.
RTI	50 (m – s) ^{1/2}	Given in reference, (Zimmer, 2009)
T_o	20 °C	68 °F
T_{act}	73.89 °C	165 °F
Ceiling Height (H)	4.27 m	14 feet
Radius (r)	3.05 m	10 feet sprinkler spacing
r/H	0.71	> 0.2 so sprinklers in the ceiling jet
Results: DF1 and DF4		
t_{act}	172 seconds	
HRR (Q) at t_{act}	1387 kW	

Figure F.1: Sprinkler Activation for DF1 & DF4

APPENDIX F: SPRINKLER CONTROL CALCULATIONS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Design Fire Scenario 2:

Table F.4: Input Assumptions: DF2 $Q = \alpha t^2$		
Notation	Value	Notes
α	0.0469	Fast fire growth rate from NFPA Hbk.
Maximum HRR (Q)	2500 kW	Assume fuel-controlled fire resulting from light to moderate fuel load representative of boxes, several full trash bags, miscellaneous light furniture, or cleaning materials and similar items
Results: DF2		
t_{act}	231 seconds

APPENDIX F: SPRINKLER CONTROL CALCULATIONS
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Design Fire Scenario 3:

Table F.5: Input Assumptions: DF3		
Notation	Value	Notes
α	0.0469	Fast fire growth rate from NFPA Hbk.
RTI	50 (m – s) ^{1/2}	Given in reference, (Zimmer, 2009)
T_o	20 °C	68 °F
T_{act}	73.89 °C	165 °F
Ceiling Height (H)	3.66 m	12 feet
Radius (r)	3.05 m	10 feet sprinkler spacing
r/H	0.83	> 0.2 so sprinklers in the ceiling jet
Results: DF3		
t_{act}	159 sec.	
HRR (Q) at t_{act}	1185 kW	

Figure F.3: Sprinkler Activation for DF3

Appendix G: Fire Safety Management Plan

Fire Safety Management Plan for California Polytechnic State University, San Luis Obispo, CA Building 152, Center for Science and Mathematics (CSM)

Mission

The purpose of this plan is to promote, implement and administer a comprehensive fire prevention and life safety program for the Center for Science and Mathematics (CSM) located at California Polytechnic State University in San Luis Obispo, California. The plan provides for and monitors a safe environment for employees, students, professors and visitors designed and maintained to comply with the Life Safety Code (NFPA 101, 2006) and California Fire Code (CFC, 2007).

Authority Organization

The Administration & Finance Department includes Environmental Health and Safety, which functions as the oversight body for Fire Safety at Cal Poly State University (CPSU).

Goals and Objectives

The goal of this plan is to protect occupants not intimate with the initial fire development and to improve survivability of the occupants intimate with the initial fire development, (NFPA 101, 2006, Section 4.1.1).

To achieve this goal, the Life Safety Code has objectives to protect occupants, structural integrity and system effectiveness, (NFPA 101, 2006, Section 4.2).

These objectives can be achieved using prescriptive-based provisions (NFPA 101, 2006, Section 4.4.2), or performance-based provisions, (NFPA 101, 2006, Section 4.4.3).

Prescriptive-based codes- Prescriptive or specification-based codes spell out in detail what materials can be used, the building geometry (heights and areas), and how the various building components should be assembled. The traditional codes that have evolved through history tend to be prescriptive or specification oriented. A prescriptive-based life safety design for the CSM building must comply with Chapters 1 through 4, Chapters 6 through 11, Chapter 43, and the applicable occupancy chapter. The CSM building is classified as Group B, Business Occupancy and therefore must comply with Chapter 38: *New Business Occupancies*. Where specific requirements contained in Chapter 38 and 43 differ from general requirements contained in Chapters 1 through 4, and Chapters 6 through 10, the requirements of Chapter 38 and 43 shall govern, (NFPA 101, 2006, Section 4.4.2).

Performance-based codes- Performance-oriented building and fire codes detail the goals and objectives to be met and establish criteria for determining if the objective has been reached. Performance-oriented building and fire codes are a relatively new and evolving concept, which is only in recent years enjoying more widespread acceptance. A performance-based life safety design shall be in accordance with Chapters 1 through 5, (NFPA 101, 2006, Section 4.4.3).

APPENDIX G: FIRE SAFETY MANAGEMENT PLAN

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Code Requirements

Fire Safety Management Code Requirements for the CSM are determined by following the suggested procedure in Annex A of the Life Safety Code.

Occupancy Classification

The CSM is classified as Business Occupancy: An occupancy used for the transaction of business other than mercantile, (NFPA 101, 2006, Section 6.1.11.1). The CSM is also classified as Multiple Occupancy: A building or structure, in which two or more classes of occupancy exist, (NFPA 101, 2006, Section 6.1.14.2.1). More specifically, the CSM is classified as Separated Occupancy: A multiple occupancy where the occupancies are separated by fire resistance-rated assemblies, (NFPA 101, 2006, Section 6.1.14.2.3).

The CSM is classified by the CBC as Groups B, A-3, S-1, S-2 and H-3:

- Group B: Facilities for office, professional or service-type transactions, including storage of records and accounts. Business occupancies include: offices, conference rooms, laboratories, (CBC, 2007, Section 304).
- Group A-3: Assembly uses intended for worship, recreation or amusement and other assembly uses not classified elsewhere in Group A including: Lecture halls (CBC, 2007, Section 303)
- Group S: Facilities used for storage and not classified as hazardous occupancy, (CBC, 2007, Section 311):
 - S-1: Moderate hazard storage: Electrical, Telephone/Data, Mechanical equipment
 - S-2: Low hazard storage: Storage
- Group H-3: Facilities containing materials that readily support combustion or that pose a physical hazard, including: Class I, II or IIIA flammable or combustible liquids that are used or stored in normally closed containers or systems pressurized at 15 pounds per square inch gauge or less, (CBC, 2007, Section 307.5).

Reference Appendix B of this report for Occupancy Classification Floor Plans.

New or Existing

The CSM is classified as a new building, (NFPA 101, 2006, Chapter 3).

Occupant Load

The CSM occupant load, in number of persons for whom means of egress and other provisions are required, shall be determined on the basis of the occupant load factors provided in Table 15 and Table 16 of this report.

The CSM occupant load has been calculated based on the characteristic of the use of the space and shall not be less than the number of persons determined by dividing the floor area assigned to that use by the occupant load factor for that use as specified in the Life Safety Code, (NFPA 101, 2006, Table 7.3.1.2).

Hazards of Contents

The CSM is classified as an overall Business Occupancy, regardless of the multiple occupancies listed above. The contents of business occupancies shall be classified as ordinary hazard in accordance with Section 6.2, (NFPA 101, 2006, Section 38.1.5). Ordinary hazard contents shall be classified as those that are likely to burn with moderate rapidity or to give off a considerable volume of smoke, (NFPA 101, 2006, Section 6.2.2.3).

APPENDIX G: FIRE SAFETY MANAGEMENT PLAN

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Applicable Occupancy Chapter

The CSM applicable occupancy chapter of the Life Safety Code is Chapter 38: *New Business Occupancies*.

Fire Drill Plan

This fire drill plan is in accordance with the Life Safety Code, (NFPA 101, 2006, Section 38.7.2 and Section 4.7) and the California Fire Code, (CFC, 2007, Section 405).

To familiarize occupants with the drill procedure and to establish conduct of the drill as a matter of routine, emergency evacuation and relocation drills shall be conducted at least annually. Drills shall be designed in cooperation with the local authorities. When conducting drills, emphasis shall be placed on orderly evacuation rather than on speed. Drills shall be held at expected and unexpected times and under varying conditions to simulate the unusual conditions that can occur in an actual emergency. Drill participants shall relocate to a predetermined location (Lot H11 as illustrated Figure G.1) and remain at such location until dismissal is given. Records shall be maintained of required emergency evacuation drills and include the following information:

1. Identity of the person conducting the drill
2. Date and time of the drill
3. Notification method used
4. Staff members on duty and participating
5. Number of occupants evacuated
6. Special conditions simulated
7. Problems encountered
8. Weather conditions when occupants were evacuated
9. Time required to accomplish complete evacuation

Figure G.1 shows the location of Lot H11 with relationship to the CSM.

APPENDIX G: FIRE SAFETY MANAGEMENT PLAN

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Emergency Evacuation Plan

Cal Poly's Environmental Health and Safety Department regulates a procedure for Fire Drill & Building Evacuation. This procedure ensures the orderly and complete evacuation of all campus buildings in the event of an emergency and/or the activation of alarm system.

The following Emergency Evacuation Plan is specific to the CSM and uses the guidance of Cal Poly's Fire Drill & Building Evacuation Procedure in combination with Annex A, Section A.4.8.2.1(3) of the Life Safety Code and Chapter 4 of the California Fire Code (CFC).

Purpose

This procedure has been prepared to ensure orderly evacuation and occupant relocation in the event of an emergency and/or the activation of the alarm system in the CSM.

Primary objectives include the following:

1. All occupants leave the building safely or relocate to an area of refuge;
2. All occupants are accounted for after an emergency evacuation, and
3. Personnel are selected in advance of an emergency to ensure plan objectives are met.

Policy

Evacuation drills must be conducted on an annual basis. Emergency evacuation may become necessary under the following situations:

- Fire
- Explosion
- Bomb threats
- Release of hazardous chemicals
- Building air contamination
- Weather related emergencies
- Earthquake

Evacuation Process

1. At the sound of the Emergency Alarm, evacuate immediately and proceed to Lot H11 or remain in an area of refuge within the building. An area of refuge for occupants on Levels 2-6 is in Stairway #3, within the atrium in the middle of the building.
2. The voice evacuation system provides specific instructions for evacuation of the atrium space, (Zone 1) within the CSM. In the event of a fire detected in Zone 1, occupants are responsible to follow instructions provided by the voice evacuation system, (for an illustration of recommended zones within the CSM see Figure 7 of this report).
3. Building occupants are responsible for ensuring that their visitors follow this procedure.
4. Faculty members are responsible for dismissing their classes and directing students to leave the building by the nearest building exit or area of refuge upon hearing the building alarm or upon being notified of an emergency.
5. Designated personnel, who are critical for shut down operations while an evacuation is underway, are responsible for determining when to abandon the operation and evacuate themselves safely.
6. Contract workers are expected to leave the building when the alarm sounds.

APPENDIX G: FIRE SAFETY MANAGEMENT PLAN

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Evacuation Instructions

Whenever you hear the Emergency Alarm (Fire Alarm) or are informed of a general building emergency:

1. Remain calm.
2. Listen for announcements giving directions for evacuation.
3. Leave the building or relocate to an area of refuge immediately, in an orderly fashion, following directions given during announcement. A partial evacuation announcement may occur to better manage the evacuation process.
4. Exit the building utilizing stairways, not elevators.
5. Dismiss classes and instruct students to exit the building or relocate to an area of refuge immediately.
6. Follow quickest evacuation route as noted on the exit diagram posted near exit doors.
7. Do not go back to your office or classroom for any reason.
8. Proceed to emergency assembly point, Lot H11, near Administration Offices (Reference Figure G.1).
9. Report to a Building Coordinator if you have any knowledge of missing persons or specific building conditions which might be helpful to responders.
10. Return to the building only after emergency personnel have given the all-clear signal. Silencing the alarm does not mean the emergency is over.

Emergency Evacuation Personnel

1. Building Coordinators are employees who have been selected and trained to ensure building evacuation is carried out as planned. Building Coordinators are selected among building occupants on a voluntary basis. Building Coordinators are responsible for the following:
 - Maintain a current list of all occupants in their immediate work area.
 - Ensure that all employees in immediate work area are familiar with the emergency evacuation plan for their work area and for the building.
 - Assist and encourage work area occupants to leave the building or relocate to an area of refuge in cases where there may be an alternative form emergency notification, other than the sound of building fire alarms.
 - Inform occupants of their duty to immediately report to Lot H11.
 - Assist occupants with limited mobility, down stairs if able to negotiate stairways.
 - Never put yourself in danger. Leave the building or relocate to an area of refuge as soon as possible and go directly to your assigned assembly area.
 - Check off co-workers who safely reported to assembly area from occupant list.
 - Collect information on missing personnel known, or suspected to still be in the building, and report to responding University Police representatives.
 - Complete Building Assessment Form, if applicable.
2. University Police and SLO City Fire are responsible for the following:
 - Collect information on building occupants known or suspected to still be in the building.
 - Meet off-campus emergency responders (fire, medical, etc.) and assist with directions to the building/area as needed.
 - Report information on occupants needing assistance to evacuate and other personnel suspected to still be in the building to fire and rescue response personnel.
 - Assist with securing the building/area and preventing re-entry.

APPENDIX G: FIRE SAFETY MANAGEMENT PLAN

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Employee Training and Response Procedures

This employee training and response procedure follows the guidance of the California Fire Code, Section 404 and 408.2.

Employees of California Polytechnic State University who will be using the CSM Building shall be trained in the fire emergency procedures described in this Fire Safety Management Plan. Employees shall receive training in the contents of fire safety and evacuation plans and their duties as part of new employee orientation and at least annually thereafter. Records shall be kept and made available to the fire code official upon request.

- Fire prevention training: Employees shall be apprised of the fire hazards of the materials and processes to which they are exposed. Each employee shall be instructed in the proper procedures for preventing fires in the conduct of their assigned duties.
- Evacuation training: Employees shall be familiarized with the fire alarm and evacuation signals, their assigned duties in the event of an alarm or emergency, evacuation routes, areas of refuge, exterior assembly areas and procedures for evacuation.
- Fire Safety training: Employees assigned fire-fighting duties shall be trained to know the locations and proper use of portable fire extinguishers or other manual fire-fighting equipment and the protective clothing or equipment required for its safe and proper use.

In specific rooms classified as Assembly Occupancy, located on Level 1, (Reference Appendix B), a detailed seating plan, occupant load and occupant load limit shall be available. An audible announcement shall be made not more than 10 minutes prior to the start of each program to notify the occupants of the location of the exits to be used in the event of a fire or other emergency.

Testing and Maintenance

Cal Poly Maintenance Department and SLO City Fire implement maintenance, testing and inspection procedures to support the operational reliability of fire and life safety systems and reduce the occurrence of false alarms. The following are maintained, tested and inspected in accordance with current NFPA standards on a regular schedule:

- Automatic fire extinguishing systems
- Fire detection and alarm systems
- Portable fire extinguishers
- Building systems, including:
 - Fire/smoke doors
 - Fire/smoke dampers
 - Exit lighting
 - Emergency lighting
 - Standpipe systems

Corresponding Policies

- Campus Hot Work Program
- Requirements for Bulletin Boards in Corridors
- Protect Your Lungs from Wildfire Smoke
- Campus Building Evacuation Procedure
- Campus Annual Fire Safety Report (for calendar years 2009, 2010 & 2011)

The policies above can be retrieved online at: <http://www.afd.calpoly.edu/ehs/firesafety.asp>

Appendix H: Smoke Control System

Introduction

Smoke control systems are designed to keep building occupants safe from the effects of smoke in the event of a fire. Buildings that contain large volume spaces, like atriums often require smoke control systems that rely on the exhaust method to maintain tenable requirements for building occupants. An exhaust method removes smoke from the building at a rate that is greater than or equal to the rate at which smoke is being generated from the fire, or at a rate that maintains a tenable environment for occupants during building evacuation.

This report analyzes the atrium space within the CSM with the goal of designing a smoke control system that maintains a tenable environment for building occupants for a period of 1.5 times the calculated egress time.

The scope of work involves sizing an atrium exhaust system using two methods:

1. Prescriptive design approach per algebraic calculations in NFPA 92B, and
2. Performance-based design approach per fire/smoke modeling.

Code Requirements

The California Building Code (CBC), Section 404.4 requires atriums greater than two stories to be protected with a smoke control system in accordance with Section 909. Section 909 provides design requirements for smoke control systems and refers to NFPA 92B, *Standard for Smoke Management Systems in Malls, Atria, and Large Spaces*, for the design of smoke control systems in atriums.

Section 909 Smoke Control Systems. Section 909 of the CBC on Smoke Control Systems requires a passive or mechanical smoke control system to provide tenable conditions for evacuating occupants in a building with an atrium that connects more than two stories.

Section 909.4 Analysis. Section 909.4 of the CBC requires a rational analysis to support the type of smoke control system to be employed, its method of operation, the system supporting it and the method of construction to be utilized. Sub-section 909.4.6 requires the smoke control system to be operable for at least 20 minutes after detection of a fire, or 1.5 times the calculated egress time, whichever is less.

Section 909.8 Exhaust method. Section 909.8 of the CBC allows smoke control systems that have been approved by the fire code official to use mechanical smoke control for atriums by means of the exhaust method. Sub-section 909.8.1 requires the smoke layer to be maintained above 6 feet of any walking surface that is required for building egress. The exhaust method must be designed in accordance with NFPA 92B.

Section 1.3 Purpose. The purpose of NFPA 92B is to provide guidance on how to implement smoke management systems to maintain a tenable environment when evacuating large volume building spaces.

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

A.2.4.1.3. Annex A of NFPA 92B explains how a computer model can be constructed to calculate the smoke layer position over time, with and without smoke exhaust. This approach is considered performance-based design and relies on a computer model to justify that the smoke control system proposed provides a level of fire life safety that satisfies the intent of the CBC.

In addition to the performance-based design provisions permitted under Section 104.11 of the CBC, specific requirements for the analysis in selecting the design fire are included in Section 909.9.

Section 909.9 Design fire. Section 909.9 of the CBC requires a design fire based on a rational analysis performed by a registered design professional and approved by the fire code official. Sub-section 909.9.1 of the CBC requires an engineering analysis to include whether the fire is likely to be steady or unsteady.

Design Fire Development

Section 909.9 of the CBC requires a rational analysis for selected fuel and heat release rates of the design fire. Of the design fires analyzed in this report, DF2 produces the most smoke and requires the highest exhaust rate. For this reason, the mechanical exhaust system is designed using DF2 input parameters: Fast t^2 fire growth rate, ceiling height of 80 feet and a peak HRR of 2,500 kW.

Tenability Criteria

Providing appropriate tenability criteria ensures that the building occupants are not exposed to untenable conditions. Section 5.3 of this report explains the tenability criteria summarized below.

Temperature Limit	140°F (60°C)
Visibility Limit	42 feet (13 meters)
Radiant Flux Limit	1.7kW/m ²
Smoke Temperature Limit	350°F (180°C)
Carbon Monoxide Limit	30,000 ppm/min (1,000 ppm for 30 minutes)

Exhaust Calculations and Modeling

CBC 2007, Section 909.8 requires smoke control systems using the Exhaust Method to be designed in accordance with NFPA 92B. NFPA 92B provides a primary set of equations for determining the required exhaust rate of axisymmetric plumes (NFPA 92B, 2005, Section 6.2.1).

Required Exhaust Rate

NFPA 92B, 2005, equations 6.2.1.1a(1) and 6.2.1.1b(1) can be used to calculate the rate at which smoke is produced from the fire plume. Once the rate of smoke production is known, the required exhaust rate needs to be equal to or greater than the rate at which smoke is produced by the fire in order to maintain tenable conditions 1.8 meters (6 feet) above the highest walking surface. The highest walking surface is Level 6, approximately 19.5 meters (64 feet) above the floor of the atrium. Of the design fires considered in the Smoke Management Study, DF2 produces the most smoke and requires the highest exhaust rate. For this reason, the mechanical exhaust system is designed using DF2 input parameters. The smoke layer must be kept above 21.3 meters (70 feet) to maintain tenable conditions 6 feet above the Level 6 walking surface. Figure H.1 provides a diagram of the atrium space.

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Before calculating smoke production rate, determine limiting elevation of flame height, z_l :

Given:

$Q = 2,500$ kW (heat release rate)

$Q_c = 1,750$ kW (convection portion of heat release rate = $0.7Q$)

Equation 6.2.1.1a(1)

$$z_l = 0.166Q_c^{2/5}$$

Solution:

$z_l = 3.29$ m (limiting elevation of flame height)

Since $z > z_l$, ($21.3\text{m} > 3.29\text{m}$) calculate the smoke production rate, m :

Given:

$Q_c = 1,750$ kW (convection portion of heat release rate = $0.7Q$)

$z = 21.3$ m (distance above fire to smoke layer interface)

Equation 6.2.1.1b(1)

$$m = (0.071Q_c^{1/3}z^{5/3}) + 0.0018Q_c$$

Solution:

$m = 143.2$ kg/s (mass flow rate in fire plume is equal to required mass flow rate of smoke exhaust)

Required mechanical exhaust rate is equal to the smoke production rate, $m = 143.2$ kg/s

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Exhaust Vents Required to Limit Plug-holing

Plug-holing occurs when the exhaust rate is too high and air from below the smoke layer is pulled through the smoke layer into the smoke exhaust. First, calculate smoke layer temperature, T_s :

Given:

$T_o = 20^\circ\text{C}$ (ambient temperature)
 $K_s = 0.5$ (fraction of convective heat release in smoke layer, Section 6.2.5.2)
 $Q_c = 1,750 \text{ kW}$ (convection portion of heat release rate = $0.7Q$)
 $m = 143.2 \text{ kg/s}$ (mass flow rate in fire plume at height=21.3m)
 $C_p = 1.0 \text{ kJ/kg}^\circ\text{C}$ (specific heat of plume gases)

Equation 6.2.5b

$$T_s = T_o + \frac{K_s Q_c}{m C_p}$$

Solution:

$T_s = 26.11^\circ\text{C}$ (average plume smoke layer temperature)

Calculate the maximum volumetric flow rate, V_{max} , that can be exhausted by a single exhaust vent without plug-holing:

Given:

$\gamma = 1.0$ (for exhaust vents centered no closer than twice the diameter from the nearest wall, Section 6.2.3)
 $d = 3\text{m}$ (depth of smoke layer below exhaust inlet)
 $T_s = 299.26\text{K}$ (absolute temperature of the smoke layer, $=26.11^\circ\text{C}$)
 $T_o = 293.15\text{K}$ (absolute ambient temperature, $=20^\circ\text{C}$)

Equation 6.3.3b

$$V_{max} = 4.16 \gamma d^{5/2} \left(\frac{T_s - T_o}{T_o} \right)^{1/2}$$

Solution:

$V_{max} = 9.34 \text{ m}^3/\text{s}$ (maximum volumetric flow rate for exhaust vent to prevent plug-holing)

Calculate the density of smoke, ρ :

Given:

$P_{atm} = 101,325 \text{ Pa}$ (atmospheric pressure)
 $R = 287 \text{ J/kgK}$ (gas constant)
 $T = 299.26\text{K}$ (absolute temperature of smoke)

Equation 6.5b

$$\rho = \frac{P_{atm}}{RT}$$

Solution:

$\rho = 1.18 \text{ kg/m}^3$ (density of smoke at temperature 299.26K)

Calculate the required volumetric flow rate of smoke exhaust, V :

Given:

$m = 143.2 \text{ kg/s}$ (mass flow rate of smoke exhaust is equal to required mass flow rate in fire plume)
 $\rho = 1.18 \text{ kg/m}^3$ (density of smoke at temperature 299.26K)

Equation 6.4b

$$V = \frac{m}{\rho}$$

Solution:

$V = 121.4 \text{ m}^3/\text{s}$ (volumetric flow rate of exhaust vents)

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Calculate the number of exhaust vents:

In order to exhaust the required 143.2 kg/s of smoke from the atrium, the exhaust vents require a volumetric flow rate of 121.4 m³/s. However, the maximum volumetric flow rate through one vent without plug-holing at the smoke layer temperature is limited by 9.34 m³/s.

- $121.4 \text{ m}^3/\text{s} \div 9.34 \text{ m}^3/\text{s} = 13$ exhaust vents. This means that at least 13 exhaust vents are required to prevent plug-holing and maintain the smoke layer above 70 feet to maintain tenable conditions. For a more conservative design, assume 14 exhaust vents, (see Figure H.2 for exhaust vent diagram).

Calculate the minimum separation distance required to prevent plug-holing for multiple exhaust inlets:

Given:

$V_e = V_{\max} = 9.34 \text{ m}^3/\text{s}$ (volumetric flow rate without plug-holing)

Equation 6.3.9b

$$S_{\min} = 0.9V_e^{1/2}$$

Solution:

$S_{\min} = 2.75 \text{ m}$ (minimum separation distance between exhaust vents)

Calculate the diameter of the exhaust vents, D_i :

- The ratio d/D_i must be greater than 2, (NFPA 92B, 2005, Section 6.3.7).
- Rearrange the above ratio so that $d/2 > D_i$.
- The depth of the smoke layer below exhaust inlet is given as $d = 3.29$ meters.
- Substitute d into the above ratio to get $1.65 > D_i$.
- Conservatively use an exhaust vent diameter of 2.0 meters.
- For rectangular exhaust inlets, $D_i = 1.4$ when the length and width of the inlet is 1 meter and 2 meters, respectively, (NFPA 92B, 2005, Equation 6.3.8).

Figure H.2: Exhaust Vent Diagram

Atrium Roof Area = 486m² (5251ft²)

Separation distance between vents = 3.0 meters (> than 2.75 meter minimum distance required)

Separation distance between walls and vents = 3.0 meters (> than 2.75 meter min. distance required)

A total atrium roof area of 486m² (5,251ft²) is assumed for the design of this atrium space. This is a conservative assumption based on architectural plans, (Zimmer, 2009).

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Makeup Air Requirements

Makeup air requirements include determining the area of supply vents required so that the supply air velocity does not exceed 1.02 meters/second, (NFPA 92B, 2005, Section 4.6). Makeup air must be less than the mass flow rate of the mechanical smoke exhaust system, (NFPA 92B, 2005, Section 4.6.2). The makeup air is recommended to be designed at 85% to 95% of the exhaust system. The theory behind this recommendation is that the remaining air (5%-15%) will enter the atrium space through leakage paths preventing positive pressurization of the atrium, (NFPA 92B, Section A.4.6.2).

The smoke exhaust system is designed for a smoke flow rate of 143.2kg/s. Therefore, a makeup air system designed at 90% of the exhaust system requires 128.9 kg/s of makeup air.

Calculate the required volumetric flow rate of makeup air supply vent, V:

Given:

$m = 128.9 \text{ kg/s}$ (90% of exhaust system)

$\rho = 1.20 \text{ kg/m}^3$ (density of air at ambient temperature 293.15K)

Equation 6.4b

$$V = \frac{m}{\rho}$$

Solution:

$V = 107.4 \text{ m}^3/\text{s}$ (volumetric flow rate of makeup air supply vents)

Each makeup air vent has the dimensions $3\text{m} \times 4\text{m} = 12\text{m}^2$. The atrium requires at least 9 makeup air vents to maintain a velocity below 1.02 meters/second for each supply vent. For example: $107.4\text{m}^3/\text{s} \div (9 \text{ vents at } 12\text{m}^2) = 0.99 \text{ meters/second}$.

Door Opening Forces

Smoke control systems can produce pressure differences across doors that make it difficult for occupants to evacuate the building. The force for opening interior egress doors must not exceed 30 pounds, (CBC Section 1008.1.3). Calculate the maximum pressure difference required to maintain a door opening force less than 30 pounds.

Given:

$F_{dc} = 22 \text{ N}$ (force to overcome closing device)

$K_d = 1.0$ (coefficient)

$W = 0.9144\text{m}$ (door width, (3 feet))

$A = 1.95 \text{ m}^2$ (door area, assume door height of 2.1 meters (7 feet))

$F = 133 \text{ N}$ (maximum door opening force)

$d = 0.08 \text{ feet}$ (distance from doorknob to the edge of the knob side of the door, (0.25 feet))

Equation 9-1 (CBC , Section 909.6.2)

$$F = F_{dc} + \frac{k_d W A \Delta P}{2(W - d)}$$

Solution, solve for ΔP :

$\Delta P = 58.4 \text{ Pa}$ (maximum pressure difference across the door)

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

FDS Fire Modeling

FDS Fire Modeling is used to simulate Design Fire Scenario #2 using the NFPA 92B calculations shown in this appendix. A summary from the NFPA 92B calculations that are used as input parameters to the FDS fire model are shown in Table H.1.

Table H.1: FDS Input Parameters	
Duration of Model	20 minutes (1200 seconds)
Atrium Enclosure Dimensions (Volume)	18m x 27m x 24.3m = 11,810m ³
Heat Release Rate per Unit Area (HRRPUA)	538 kW/m ² (results in a 2,500 kW fire)
Fire Area	4.65 m ²
Peak Heat Release Rate (HRR)	2,500 kW
Time until fire reaches peak HRR of 2,500 kW	231 seconds
Exhaust Vents	14 exhaust vents
Exhaust Vent dimensions	1.0 x 2.0 = Area of 2.0m ² per vent
Exhaust Vent Maximum Volumetric Flow Rate to Avoid Plug-holing	9.34m ³ /s
Separation Distance between Exhaust Vents to Avoid Plug-holing	> 2.75m
Supply Vents	9 supply vents
Supply Vent Dimensions	3.0m x 4.0m = 12.0m ² per vent
Supply Vent Air Velocity	0.99 m/s

Figure H.3 shows the FDS model with 14 exhaust vents on the ceiling in blue, and 9 supply vents in green. The fire is located in the center of the atrium and has a burn area of 4.65m².

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

The calculated required safe egress time (RSET) must be 1.5 times the total evacuation time. From Table 30 of this report, the maximum RSET time is 419 seconds for Levels 4, 5 & 6. For purposes of this report, a conservative RSET time of 419 seconds will be used for all Levels of the atrium.

Temperature Results

Figure H.4 shows the smoke layer temperature of the atrium at the RSET, 419 seconds and the ASET, 760 seconds. Part A shows the atrium smoke layer temperature is approximately 26°C after 419 seconds. This accurately represents the NFPA 92B temperature calculations, $T_s = 26.11^\circ\text{C}$. Part B shows the atrium smoke layer temperature 6 feet above the Level 6 floor begins to approach the tenability limit of 60°C after 760 seconds. Part C shows the atrium smoke layer temperature 6 feet above the Level 5 floor begins to approach the tenability limit of 60°C after 970 seconds.

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Visibility Results

Figure H.5 demonstrates that the visibility within the atrium space at the RSET, 419 seconds and the ASET, 760 seconds is approximately 28 meters and 24 meters, respectively. This is more than the tenability criteria of 13 meters specified.

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Radiant Flux Results

Figure H.6 shows that the smoke layer temperature just below the ceiling of Level 6 at the RSET, 419 seconds, and the ASET, 1200 seconds is 40°C and 70°C, respectively. In order to maintain a radiant heat flux below 1.7 kW/m^2 , the smoke layer temperature cannot exceed 180°C. The smoke layer temperature is well below the tenability criteria for radiant flux.

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Carbon Monoxide Results

Figure H.7 shows that the CO levels in the smoke layer of the atrium at the RSET, 419 seconds and the ASET, 1200 seconds are approximately 0.000034 mol gas/mol air (34 ppm) and 0.000122 mol gas/mol air (122ppm), respectively. This is well below the 30,000 ppm/min CO tenability limit.

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Velocity

Figure H.8 demonstrates that the air velocity through exhaust vents at the RSET, 419 seconds and the ASET, 1200 seconds are 2.0 m/s and 4.0 m/s, respectively. Part A and Part B both demonstrate that the supply air vents are not distorting the formation of the fire plume.

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Door Opening Forces

Figure H.9 illustrates that five different pressure slices across the atrium at 419 seconds all show the exact same pressure. It is assumed that the change in pressure across a door boundary would be close to zero. Using Equation 9-1 (CBC Section 909.6.2) results in a door closing force of approximately 22N (5 lbs). This is less than the required 133N (30 lbs) required by code, (CBC Section 1008.1.3).

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Results

A smoke control system using a mechanical exhaust system as specified in this Appendix is capable of removing smoke from the atrium at a rate that maintains tenable conditions 6 feet above the highest occupied walking surface for a duration of 760 seconds. This performance-based approach provides a level of safety commensurate with that required by the California Building Code.

Figure H.10 demonstrates that the ASET is greater than the RSET on Levels 2, 3, 4, 5 & 6 and passes tenability criteria as described in Section 5.3 of this report.

Tables H.2, H.3, and H.4 summarize the results of the smoke control system, exhaust vent requirements, and supply vent requirements analyzed in this Appendix.

Table H.2: Results Summary						
Velocity		Design Fire	Safe Egress Time		Door Opening Forces	
NFPA 92B	FDS	Atrium	Required	Available	Required	Actual
0.33m/s	0.32 m/s	2,500 kW	419 seconds	760 seconds	Max. 30 lbs (133 N)	5 lbs (22 N)

Table H.3: Results Summary Exhaust Vent Requirements			
Max. Volumetric flow rate per vent to avoid plug-holing	Number of vents	Area of each Vent	Edge Separation of Vents
9.34 m ³ /sec	14	2m ²	3 meters

Table H.4: Results Summary Supply Vent Requirements			
Max. Volumetric flow rate to avoid fire plume deformation	Number of vents	Area of each Vent	Edge Separation of Vents
0.99 m ³ /sec	9	12m ²	N/A

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

FDS Input File

```
Sprinkler_Activation.fds
Cal Poly Center for Science and Mathematics
Atrium Fire Model
&HEAD CHID='Sprinkler Activation'/
&TIME T_END=1200.00/
&DUMP RENDER_FILE='Sprinkler_Activation'/

&MESH ID='1', IJK=100,100,20, XB=0.00,27.00,0.00,18.00,0.00,24.30/
&REAC ID='TEST FIRE 1',
    C=1.00,
    H=4.00,
    O=0.00,
    N=0.00,
    HEAT_OF_COMBUSTION=1.76000000E004,
    CO_YIELD=0.0280,
    SOOT_YIELD=0.0100,
    MASS_EXTINCTION_COEFFICIENT=8.7000000E003,
    VISIBILITY_FACTOR=3.00/

&MATL ID='YELLOW PINE',
    FYI='Quintiere, Fire Behavior - NIST NRC Validation',
    SPECIFIC_HEAT=2.85,
    CONDUCTIVITY=0.1400,
    DENSITY=640.00/

&SURF ID='burner', HRRPUA=538., RAMP_Q='fire', COLOR='RED' /
&RAMP ID='fire', T=0.0, F=0.00/
&RAMP ID='fire', T=10.0, F=0.0018756/
&RAMP ID='fire', T=20.0, F=0.0075024/
&RAMP ID='fire', T=30.0, F=0.0168804/
&RAMP ID='fire', T=40.0, F=0.0300096/
&RAMP ID='fire', T=50.0, F=0.04689/
&RAMP ID='fire', T=60.0, F=0.0675216/
&RAMP ID='fire', T=70.0, F=0.0919044/
&RAMP ID='fire', T=80.0, F=0.1200384/
&RAMP ID='fire', T=90.0, F=0.1519236/
&RAMP ID='fire', T=100.0, F=0.18756/
&RAMP ID='fire', T=110.0, F=0.2269476/
&RAMP ID='fire', T=120.0, F=0.2700864/
&RAMP ID='fire', T=130.0, F=0.3169764/
&RAMP ID='fire', T=140.0, F=0.3676176/
&RAMP ID='fire', T=150.0, F=0.42201/
&RAMP ID='fire', T=160.0, F=0.4801536/
&RAMP ID='fire', T=170.0, F=0.5420484/
&RAMP ID='fire', T=180.0, F=0.6076944/
&RAMP ID='fire', T=190.0, F=0.6770916/
&RAMP ID='fire', T=200.0, F=0.75024/
&RAMP ID='fire', T=210.0, F=0.8271396/
&RAMP ID='fire', T=220.0, F=0.9077904/
&RAMP ID='fire', T=230.0, F=0.9921924/
&RAMP ID='fire', T=231.0, F=1.000838916/
&RAMP ID='fire', T=600.0, F=1.000838916/
&RAMP ID='fire', T=601.0, F=0.00/

&SURF ID='Yellow Pine',
    RGB=146,202,166,
    MATL_ID(1,1)='YELLOW PINE',
    MATL_MASS_FRACTION(1,1)=1.00,
    THICKNESS(1)=0.5000/

&PART ID='water drops',
    WATER=.TRUE.,
    AGE=4.00/
```

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

&SURF ID='Exhaust',
COLOR='BLUE'
VOLUME_FLUX=9.34,
POROUS=.TRUE./

&SURF ID='Supply',
VEL=-0.99,
COLOR='GREEN'
POROUS=.TRUE./ 90% of total exhaust vents divided by 9 supply vents

&HOLE XB=4.0,10.0,6.0,14.0,4.30,4.90/ Hole 1, Level 2 ceiling
&HOLE XB=17.0,23.0,6.0,14.0,4.30,4.90/ Hole 2, Level 2 ceiling
&HOLE XB=4.0,10.0,6.0,14.0,9.20,9.80/ Hole 1, Level 3 ceiling
&HOLE XB=17.0,23.0,6.0,14.0,9.20,9.80/ Hole 2, Level 3 ceiling
&HOLE XB=4.0,10.0,6.0,14.0,14.0,14.60/ Hole 1, Level 4 ceiling
&HOLE XB=17.0,23.0,6.0,14.0,14.0,14.60/ Hole 2, Level 4 ceiling
&HOLE XB=4.0,10.0,6.0,14.0,18.90,19.50/ Hole 1, Level 5 ceiling
&HOLE XB=17.0,23.0,6.0,14.0,18.90,19.50/ Hole 2, Level 5 ceiling

&OBST XB=5.8375,8.1625,8.8375,11.1625,0.00,1.00, SURF_IDS='burner','INERT','INERT'/

&OBST XB=0.00,27.0,0.00,18.0,-0.4,0.00, SURF_ID='Yellow Pine'/ Level 2 Floor
&OBST XB=0.00,27.0,0.00,18.0,4.30,4.90, SURF_ID='Yellow Pine'/ Level 3 Floor
&OBST XB=0.00,27.0,0.00,18.0,9.2,9.80, SURF_ID='Yellow Pine'/ Level 4 Floor
&OBST XB=0.00,27.0,0.00,18.0,14.0,14.60, SURF_ID='Yellow Pine'/ Level 5 Floor
&OBST XB=0.00,27.0,0.00,18.0,18.9,19.50, SURF_ID='Yellow Pine'/ Level 6 Floor
&OBST XB=0.00,27.0,0.00,18.0,23.7,24.30, SURF_ID='Yellow Pine'/ Level 6 Ceiling

&OBST XB=0.00,27.0,0.00,0.50,0.00,24.30, COLOR='INVISIBLE', SURF_ID='Yellow Pine'/ Front Wall
&OBST XB=26.5,27.0,0.00,18.0,0.00,24.30, COLOR='INVISIBLE', SURF_ID='Yellow Pine'/ Right Wall
&OBST XB=0.00,27.0,17.5,18.0,0.00,24.30, COLOR='INVISIBLE', SURF_ID='Yellow Pine'/ Back Wall
&OBST XB=0.00,0.50,0.00,18.0,0.00,24.30, COLOR='INVISIBLE', SURF_ID='Yellow Pine'/ Left Wall

&VENT SURF_ID='Supply', XB=0.50,0.50,3.00,7.00,0.0,3.0/ Supply Vent 1 Level 2
&VENT SURF_ID='Supply', XB=0.50,0.50,11.00,15.00,0.0,3.0/ Supply Vent 2 Level 2
&VENT SURF_ID='Supply', XB=26.50,26.50,7.00,11.00,0.0,3.0/ Supply Vent 3 Level 2
&VENT SURF_ID='Supply', XB=0.50,0.50,7.00,11.00,4.90,7.90/ Supply Vent 4 Level 3
&VENT SURF_ID='Supply', XB=26.50,26.50,7.00,11.00,4.90,7.90/ Supply Vent 5 Level 3
&VENT SURF_ID='Supply', XB=0.50,0.50,7.00,11.00,9.80,12.80/ Supply Vent 6 Level 4
&VENT SURF_ID='Supply', XB=26.50,26.50,7.00,11.00,9.80,12.80/ Supply Vent 7 Level 4
&VENT SURF_ID='Supply', XB=0.50,0.50,7.00,11.00,14.60,17.60/ Supply Vent 8 Level 5
&VENT SURF_ID='Supply', XB=26.50,26.50,7.00,11.00,14.60,17.60/ Supply Vent 9 Level 5

&VENT SURF_ID='Exhaust', XB=7.0,8.0,3.0,5.0,23.7,23.7/ Exhaust Vent 1
&VENT SURF_ID='Exhaust', XB=11.0,12.0,3.0,5.0,23.7,23.7/ Exhaust Vent 2
&VENT SURF_ID='Exhaust', XB=15.0,16.0,3.0,5.0,23.7,23.7/ Exhaust Vent 3
&VENT SURF_ID='Exhaust', XB=19.0,20.0,3.0,5.0,23.7,23.70/ Exhaust Vent 4
&VENT SURF_ID='Exhaust', XB=3.0,4.0,8.0,10.0,23.7,23.7/ Exhaust Vent 5
&VENT SURF_ID='Exhaust', XB=7.0,8.0,8.0,10.0,23.7,23.7/ Exhaust Vent 6
&VENT SURF_ID='Exhaust', XB=11.0,12.0,8.0,10.0,23.7,23.7/ Exhaust Vent 7
&VENT SURF_ID='Exhaust', XB=15.0,16.0,8.0,10.0,23.7,23.7/ Exhaust Vent 8
&VENT SURF_ID='Exhaust', XB=19.0,20.0,8.0,10.0,23.7,23.7/ Exhaust Vent 9
&VENT SURF_ID='Exhaust', XB=23.0,24.0,8.0,10.0,23.7,23.7/ Exhaust Vent 10
&VENT SURF_ID='Exhaust', XB=7.0,8.0,13.0,15.0,23.7,23.7/ Exhaust Vent 11
&VENT SURF_ID='Exhaust', XB=11.0,12.0,13.0,15.0,23.7,23.7/ Exhaust Vent 12
&VENT SURF_ID='Exhaust', XB=15.0,16.0,13.0,15.0,23.7,23.7/ Exhaust Vent 13
&VENT SURF_ID='Exhaust', XB=19.0,20.0,13.0,15.0,23.7,23.70/ Exhaust Vent 14

&PROP ID='K-5.6', QUANTITY='SPRINKLER LINK TEMPERATURE', RTI=50., C_FACTOR=0.7, ACTIVATION_TEMPERATURE=68.,
OFFSET=0.10,PART_ID='water drops', FLOW_RATE=175.0, DROPLET_VELOCITY=10., SPRAY_ANGLE=30.,80. /

&DEVC ID='Spr_0', XYZ=4.0,2.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_1', XYZ=7.0,2.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_2', XYZ=10.0,2.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_3', XYZ=13.5,2.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

&DEVC ID='Spr_5', XYZ=17.0,2.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_6', XYZ=20.0,2.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_7', XYZ=23.0,2.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_8', XYZ=4.0,5.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_9', XYZ=7.0,5.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_10', XYZ=10.0,5.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_11', XYZ=13.5,5.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_12', XYZ=17.0,5.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_13', XYZ=20.0,5.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_14', XYZ=23.0,5.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_15', XYZ=4.0,9.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_16', XYZ=10.0,9.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_17', XYZ=13.5,9.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_18', XYZ=17.0,9.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_19', XYZ=23.0,9.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_20', XYZ=4.0,13.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_21', XYZ=7.0,13.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_22', XYZ=10.0,13.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_23', XYZ=13.5,13.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_24', XYZ=17.0,13.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_25', XYZ=20.0,13.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_26', XYZ=23.0,13.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_27', XYZ=4.0,16.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_28', XYZ=7.0,16.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_29', XYZ=10.0,16.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_30', XYZ=13.5,16.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_31', XYZ=17.0,16.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_32', XYZ=20.0,16.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling
&DEVC ID='Spr_33', XYZ=23.0,16.0,4.25, PROP_ID='K-5.6' / Level 2 ceiling

&DEVC ID='Spr_0', XYZ=4.0,2.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_1', XYZ=7.0,2.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_2', XYZ=10.0,2.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_3', XYZ=13.5,2.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_5', XYZ=17.0,2.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_6', XYZ=20.0,2.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_7', XYZ=23.0,2.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_8', XYZ=4.0,5.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_9', XYZ=7.0,5.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_10', XYZ=10.0,5.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_11', XYZ=13.5,5.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_12', XYZ=17.0,5.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_13', XYZ=20.0,5.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_14', XYZ=23.0,5.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_15', XYZ=4.0,9.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_16', XYZ=10.0,9.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_17', XYZ=13.5,9.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_18', XYZ=17.0,9.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_19', XYZ=23.0,9.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_20', XYZ=4.0,13.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_21', XYZ=7.0,13.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_22', XYZ=10.0,13.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_23', XYZ=13.5,13.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_24', XYZ=17.0,13.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_25', XYZ=20.0,13.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_26', XYZ=23.0,13.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_27', XYZ=4.0,16.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_28', XYZ=7.0,16.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_29', XYZ=10.0,16.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_30', XYZ=13.5,16.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_31', XYZ=17.0,16.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_32', XYZ=20.0,16.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling
&DEVC ID='Spr_33', XYZ=23.0,16.0,9.15, PROP_ID='K-5.6' / Level 3 ceiling

&DEVC ID='Spr_0', XYZ=4.0,2.0,13.95, PROP_ID='K-5.6' / Level 4 ceiling
&DEVC ID='Spr_1', XYZ=7.0,2.0,13.95, PROP_ID='K-5.6' / Level 4 ceiling

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

```
&DEVC ID='Spr_0', XYZ=4.0,2.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_1', XYZ=7.0,2.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_2', XYZ=10.0,2.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_3', XYZ=13.5,2.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_5', XYZ=17.0,2.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_6', XYZ=20.0,2.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_7', XYZ=23.0,2.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_8', XYZ=4.0,5.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_9', XYZ=7.0,5.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_10', XYZ=10.0,5.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_11', XYZ=13.5,5.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_12', XYZ=17.0,5.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_13', XYZ=20.0,5.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_14', XYZ=23.0,5.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_15', XYZ=4.0,9.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_16', XYZ=10.0,9.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_17', XYZ=13.5,9.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_18', XYZ=17.0,9.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_19', XYZ=23.0,9.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_20', XYZ=4.0,13.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_21', XYZ=7.0,13.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_22', XYZ=10.0,13.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_23', XYZ=13.5,13.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_24', XYZ=17.0,13.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_25', XYZ=20.0,13.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_26', XYZ=23.0,13.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_27', XYZ=4.0,16.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_28', XYZ=7.0,16.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_29', XYZ=10.0,16.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_30', XYZ=13.5,16.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_31', XYZ=17.0,16.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_32', XYZ=20.0,16.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
&DEVC ID='Spr_33', XYZ=23.0,16.0,18.85, PROP_ID='K-5.6' / Level 5 ceiling
```

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

&DEVC ID='Spr_0', XYZ=4.0,2.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_1', XYZ=7.0,2.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_2', XYZ=10.0,2.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_3', XYZ=13.5,2.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_5', XYZ=17.0,2.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_6', XYZ=20.0,2.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_7', XYZ=23.0,2.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_8', XYZ=4.0,5.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_9', XYZ=7.0,5.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_10', XYZ=10.0,5.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_11', XYZ=13.5,5.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_12', XYZ=17.0,5.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_13', XYZ=20.0,5.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_14', XYZ=23.0,5.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_15', XYZ=4.0,9.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_16', XYZ=7.0,9.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_17', XYZ=10.0,9.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_18', XYZ=13.5,9.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_19', XYZ=17.0,9.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_20', XYZ=20.0,9.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_21', XYZ=23.0,9.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_22', XYZ=4.0,13.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_23', XYZ=7.0,13.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_24', XYZ=10.0,13.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_25', XYZ=13.5,13.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_26', XYZ=17.0,13.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_27', XYZ=20.0,13.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_28', XYZ=23.0,13.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_29', XYZ=4.0,16.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_30', XYZ=7.0,16.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_31', XYZ=10.0,16.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_32', XYZ=13.5,16.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_33', XYZ=17.0,16.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_34', XYZ=20.0,16.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling
&DEVC ID='Spr_35', XYZ=23.0,16.0,23.65, PROP_ID='K-5.6' / Level 6 ceiling

&BNDF QUANTITY='WALL TEMPERATURE'/

&ISOF QUANTITY='TEMPERATURE', VALUE=80.00/

&SLCF QUANTITY='TEMPERATURE', PBZ=2.00/ 2m above level 2
&SLCF QUANTITY='TEMPERATURE', PBZ=6.90/ 2m above level 3
&SLCF QUANTITY='TEMPERATURE', PBZ=11.80/ 2m above level 4
&SLCF QUANTITY='TEMPERATURE', PBZ=16.60/ 2m above level 5
&SLCF QUANTITY='TEMPERATURE', PBZ=21.50/ 2m above level 6
&SLCF QUANTITY='TEMPERATURE', PBX=7.0/
&SLCF QUANTITY='TEMPERATURE', PBZ=9.0/
&SLCF QUANTITY='visibility', PBZ=2.00/ 2m above level 2
&SLCF QUANTITY='visibility', PBZ=6.90/ 2m above level 3
&SLCF QUANTITY='visibility', PBZ=11.80/ 2m above level 4
&SLCF QUANTITY='visibility', PBZ=16.60/ 2m above level 5
&SLCF QUANTITY='visibility', PBZ=21.50/ 2m above level 6
&SLCF QUANTITY='visibility', PBX=7.0/
&SLCF QUANTITY='visibility', PBZ=9.0/
&SLCF QUANTITY='carbon monoxide', PBZ=2.00/
&SLCF QUANTITY='carbon monoxide', PBZ=6.90/
&SLCF QUANTITY='carbon monoxide', PBZ=11.80/
&SLCF QUANTITY='carbon monoxide', PBZ=16.60/
&SLCF QUANTITY='carbon monoxide', PBZ=21.50/
&SLCF QUANTITY='carbon monoxide', PBZ=9.00/
&SLCF QUANTITY='extinction coefficient', PBZ=2.00/
&SLCF QUANTITY='extinction coefficient', PBZ=9.00/
&SLCF QUANTITY='VELOCITY', VECTOR=.TRUE., PBX=7.0/
&SLCF QUANTITY='VELOCITY', VECTOR=.TRUE., PBZ=9.0/
&SLCF QUANTITY='VELOCITY', VECTOR=.TRUE., PBZ=2.00/
&SLCF QUANTITY='VELOCITY', VECTOR=.TRUE., PBZ=21.50/

APPENDIX H: SMOKE CONTROL SYSTEM

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

&SLCF QUANTITY='PRESSURE', PBZ=3.0/
&SLCF QUANTITY='PRESSURE', PBZ=6.0/
&SLCF QUANTITY='PRESSURE', PBZ=9.0/
&SLCF QUANTITY='PRESSURE', PBZ=12.0/
&SLCF QUANTITY='PRESSURE', PBZ=15.0/
&SLCF QUANTITY='soot', PBZ=2.00/
&SLCF QUANTITY='soot', PBZ=21.50/
&SLCF QUANTITY='soot', PBZ=9.0/
&SLCF QUANTITY='soot density', PBZ=2.00/
&SLCF QUANTITY='soot density', PBZ=21.50/
&SLCF QUANTITY='soot density', PBZ=9.0/
&SLCF QUANTITY='soot volume fraction', PBZ=2.00/
&SLCF QUANTITY='soot volume fraction', PBZ=21.50/
&SLCF QUANTITY='soot volume fraction', PBZ=9.00/

&TAIL /

APPENDIX I: FLAMMABLE AND COMBUSTIBLE LIQUIDS

FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Appendix I: Flammable and Combustible Liquids

Table I.1: Maximum Allowable Quantity of Flammable and Combustible Liquids in Wholesale and Retail Sales Occupancies Per Control Area					
Type of Liquid	Class	Organic Store	Vault Store	General Chemicals	Maximum Allowable Quantity per Control Area (gallons) With Sprinklers
Class 1A					
Acetonitrile	1A	4	8	0	
Diethylether	1A	20	90	1	
Petroleum Ether	1A	20	60	0	
Subtotal (liters)		44	158	1	
Subtotal (gallons) (liter x 0.264)		12	42	0	60
Class 1B, 1C, II and IIIA					
Acetone	1B	40	100	2	
Butanol	1C	5	8	0	
Cyclohexane	1B	4	25	1	
Ethanol	1B	8	40	1	
Ethyl Acetate	1B	20	44	4	
Hexane	1B	20	44	0	
Isopropanol	1B	10	24	2	
Methanol	1B	20	28	0	
Tetrahydrofuran	1B	8	16	0	
Toluene	1B	20	20	0	
Xylenes	1C	4	28	0	
Heptane	1B	4	20	0	
Subtotal (liters)		163	397	10	
Subtotal (gallons) (liter x 0.264)		43	105	3	7,500
Class IIIB					
Other flammables:	IIIB	4	5	5	
Subtotal (liters)		4	5	5	
Subtotal (gallons) (liter x 0.264)		1	1	1	Unlimited
<i>Reference: CBC, 2007, Table 414.2.5(2) and Zimmer, 2009</i>					

Appendix J: Pathfinder Computer Evacuation Models- Atrium Space

Introduction

Pathfinder is a type of computer software used to model occupant evacuation times in buildings. Pathfinder is used in this report for three primary reasons:

- 1) To compare results with hand calculated evacuation times from the SFPE Handbook, (Section 5.4 of this report).
- 2) To compare results with STEPS model evacuation times performed in the Smoke Management Study, (Attachment 3).
- 3) To further analyze occupant evacuation times in the atrium space when all occupants evacuate simultaneously and compare results to individual level evacuation times.

In order to accurately compare the Pathfinder computer evacuation model with the SFPE hand calculations, the input parameters for both scenarios must be similar. The hand calculations are calculated based on each individual level in the atrium space, (Section 5.4 of this report). Therefore, a Pathfinder model was constructed for each individual level in the atrium space to simulate occupant travel times for each level. The evacuation times from the Pathfinder model can then be compared with the STEPS model performed by the Smoke Management Study, (Attachment 3).

To further analyze occupant evacuation times within the atrium space, a second Pathfinder model simulates all occupants on Level 2 through Level 6 evacuating simultaneously. The results of both evacuation models are compared in the results section of this Appendix.

It should be noted that the Pathfinder models evaluated in this Appendix are based on the assumption that phased evacuation is utilized; therefore, the Pathfinder evacuation times are representative of Zone 1, Atrium space as recommended in Figure 7 of this report.

Population Demographics

The population demographics are based on the results of a study conducted for office evacuation and are approximated based on the percent used by the Smoke Management Study. Table J.1 summarizes occupant walking speed and population demographics:

Table J.1: Occupant Walking Speed Based on Age Demographic			
Age	Demographic Classification	Percent used by Pathfinder Model and Smoke Management Study	Walking Speed (m/s)
20-30	Young	15%	1.3
31-50	Middle	63%	1.2
51-61+	Old	16%	1.0
All ages	Disabled	6%	0.5
Reference: Assessment of Photoluminescent Material during Office Evacuation, 1999, Table 5 and Smoke Management Study- Atrium Smoke Control, 2009			

**APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52**

Methodology 1: Individual Level Evacuation Models

Each Level of the atrium space was designed in Pathfinder to have the exact same square footage as provided in the architectural plans. The occupant load for each level was specified based on occupant loads provided in the Smoke Management Study (Attachment 3), this is the same occupant load analyzed by hand calculations (Section 5.4 of this report).

Occupant load and atrium square footage is modeled in Pathfinder as shown in Table J.2:

Table J.2: Pathfinder Occupant Load and Area		
Atrium Level	Occupant Load for Each Level in the Atrium (persons)	Atrium Area specified in Pathfinder (sq. ft.)
Level 2	81	3,675
Level 3	164	1,835
Level 4	73	6,731
Level 5	77	6,641
Level 6	74	6,731
<i>Reference:</i>	<i>Smoke Management Study, 2009</i>	<i>Zimmer, 2009</i>

Based on the occupant loads provided in Table J.2, and the occupant characteristics shown in Table J.1, the amount of occupants categorized to be Young, Middle, Old, or Disabled are calculated in Table J.3.

Table J.3: Population Demographic Distribution for Each Level					
Atrium Space (Zone 1)	15% Young (persons age 20-30)	63% Middle (persons age 31-50)	16% Old (persons age 51-61+)	6% Disabled (persons all ages)	Total Occupant Load in Atrium Space (persons)
Level 2	12	51	13	5	81
Level 3	25	103	26	10	164
Level 4	11	46	12	4	73
Level 5	12	48	12	5	77
Level 6	11	47	12	4	74

Young, Middle and Old occupants are programmed to exit towards the nearest exit using the steering mode in Pathfinder. Disabled occupants are programmed to exit to the area of refuge (Stairway #3) for Levels 3, 4, 5 & 6.

APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Level 2:

For level 2, a standard rectangular geometry represents the atrium space with two double doors specified at 144 inches each on the North and South sides of the atrium. This layout is consistent with the architectural floor plan for Level 2. Notice that the 96 inch doors located on the East and West wings of the atrium space are not considered exits in the Pathfinder model because egress will flow into the atrium from the East and West wings of the building, (hence the door swings inward towards the atrium space). Stairway #2 is not considered an exit because it is an open stairway and is assumed to be affected by fire, therefore is not considered an accessible means of egress. Figure J.1 compares the architectural floor plans with the Pathfinder Model for Level 2 and shows that all 81 occupants evacuate Level 2 at approximately 27 seconds.

APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Level 4:

For level 4, a standard rectangular geometry represents the atrium space with two double doors specified at 96 inches that exit into the East Wing and West Wing of the building. This layout is consistent with the architectural floor plan for Level 4. Level 4 egresses the same as Level 3 for the East and West exit doors, Stairway #2 and area of refuge (Stairway #3). Figure J.3 compares the architectural floor plans with the Pathfinder model for Level 4 and shows that all 73 occupants evacuate Level 4 at approximately 35 seconds.

APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Level 5:

For level 5, a standard rectangular geometry represents the atrium space with one double door specified at 96 inches that exits into the East Wing of the building. This layout is consistent with the architectural floor plan for Level 5. Level 5 egresses the same as Level 3 & 4 for the East exit doors, Stairway #2 and area of refuge (Stairway #3). Figure J.4 compares the architectural floor plans with the Pathfinder model for Level 5 and shows that all 77 occupants evacuate Level 5 at approximately 39 seconds.

APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Level 6:

For level 6, a standard rectangular geometry represents the atrium space with one double door specified at 96 inches that exits into the East Wing of the building. This layout is consistent with the architectural floor plan for Level 6. Level 6 egresses the same as Levels 3, 4 & 5 for the East exit doors, Stairway #2 and area of refuge (Stairway #3). Figure J.5 compares the architectural floor plans with the Pathfinder model for Level 6 and shows that all 74 occupants evacuate Level 6 at approximately 36 seconds.

APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Methodology 2: Entire Atrium Evacuation Model

A second Pathfinder model was constructed to analyze occupant evacuation times when all occupants on Level 2 through Level 6 evacuate simultaneously. This model is intended to represent a more realistic approach to building evacuation within the controlled area of the atrium space.

Each Level of the atrium space is designed in Pathfinder based on the floor plan layout provided in the architectural plans. The occupant load for each level is based on the occupant load of each individual room specified in the architectural plans. The occupant loads specified in the architectural plans are different from the occupant loads specified in the Smoke Management Study, therefore, Methodology 2 may not be accurately compared to the evacuation times calculated by hand calculations and the Smoke Management Study. However, Methodology 2 more accurately represents evacuation times using a phased evacuation model for Zone 1: Atrium Space assuming architecture plans are accurate.

Occupant characteristics are based on distribution of population demographics as shown in Table J.1 of this Appendix. Young, Middle and Old occupants are programmed to exit towards the nearest exit using the steering mode in Pathfinder. Disabled occupants are programmed to exit to the area of refuge (Stairway #3) for Levels 3, 4, 5 & 6. Stairway #2 is not considered an exit because it is an open stairway and is assumed to be affected by fire, therefore is not considered an accessible means of egress.

Figure J.6 shows a screenshot of the Pathfinder model.

**APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52**

Level 2:

For level 2, a background layer of the atrium architectural plan was imported into Pathfinder to scale the model appropriately. Each room/space that is identified with an occupant load on the architectural plans is modeled in Pathfinder with the corresponding occupant load.

Figure J.7 shows the Level 2 model in Pathfinder along with the corresponding evacuation time. Notice that the architectural plans specify an occupant load of 77 persons (compared with the Smoke Management Study occupant load of 81 persons). This difference may be due to the fact that the architectural plans do not specify an occupant load for the women's and men's restrooms. Assuming business occupancy for the restrooms, an additional 2 or 3 occupants would be added per restroom depending on square footage of the restrooms. It is possible that the Smoke Management Study includes an additional 4 occupants (2 per restroom) for this sake.

The last occupant evacuates through the North double doors on Level 2 at approximately 19 seconds.

APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Level 3:

For level 3, the floor plan from Level 2 was duplicated at a floor height of 14 feet to maintain portions appropriate to the background layer imported from the architectural plans. Each room/space was modified to accurately represent the floor plan and occupant loads specified in level 3 architectural plans.

Figure J.8 shows the Level 3 model in Pathfinder along with the corresponding evacuation time. Notice that the architectural plans specify an occupant load of 155 persons (compared with the Smoke Management Study occupant load of 164 persons). This difference may be due to the fact that the architectural plans do not specify an occupant load for the women's and men's restrooms. Assuming business occupancy for the restrooms, an additional 2 or 3 occupants would be added per restroom depending on square footage of the restrooms. It is possible that the Smoke Management Study includes additional occupants for this sake, however, an additional 9 occupant seems unrealistic for restroom occupancy.

The last occupant evacuates through the area of refuge doors on Level 3 at approximately 70 seconds. All occupants are now evacuated into the area of refuge and are considered safe from the effects of fire.

**APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52**

Level 3 continued analysis: Alternate design considers the addition of two 36 inch doors to Level 3.

Figure J.9 shows that the evacuation simulation for Level 3 has several queued occupants within the student work spaces. This is due to the fact that only one 36 inch door is provided for each of the student work spaces with an occupant load of 66 and 68 persons, respectively.

The code requires at least two exits for an occupant load greater than 50 persons. It is possible that the AHJ accepted a higher occupant load because a 1-hour fire wall was constructed to separate the student work spaces from the atrium space. However, a second Pathfinder simulation is shown in Figure J.10 illustrating that evacuation time decreases to 52 seconds if two 36 inch doors are provided for each of the student work spaces.

When an additional 36 inch door is added to each of the student work spaces then the last occupant evacuates through the area of refuge doors on Level 3 at approximately 52 seconds. All occupants are now evacuated into the area of refuge and are considered safe from the effects of fire.

**APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52**

Level 3 continued analysis: Alternate design reduces occupant load due to 1-hour fire rated wall

A third approach to the design of Level 3 excludes the student work spaces from evacuating because a 1-hour fire rated wall separates the atrium space from all other areas on level 3. Figure J.11 illustrates that in this scenario, the occupant load decreases from 155 occupants to 21 occupants and the evacuation time decreases to 33 seconds.

When the 1-hour fire rated walls are considered adequate to retain occupants within the student work spaces then the last occupant evacuates through the area of refuge doors on Level 3 at approximately 33 seconds. The only remaining occupants are on Levels 5 & 6.

APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Level 4:

For level 4, the floor plan from Level 3 was duplicated at a floor height of 14 feet to maintain portions appropriate to the background layer imported from the architectural plans. Each room/space was modified to accurately represent the floor plan and occupant loads specified in Level 4 architectural plans.

Figure J.12 shows the Level 4 model in Pathfinder along with the corresponding evacuation time. Notice that the architectural plans specify an occupant load of 64 persons (compared with the Smoke Management Study occupant load of 73 persons). This difference may be due to the fact that the architectural plans do not specify an occupant load for the women's and men's restrooms. Assuming business occupancy for the restrooms, an additional 2 or 3 occupants would be added per restroom depending on square footage of the restrooms. It is possible that the Smoke Management Study includes additional occupants for this sake; however, an additional 9 occupant seems unrealistic for restroom occupancy.

The last occupant evacuates through the East Wing doors on Level 4 at approximately 30 seconds while the remaining occupants on Level 4 are safely evacuated into the area of refuge.

**APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52**

Levels 5 & 6:

For levels 5 & 6, the floor plan from Level 4 was duplicated at a floor height of 14 feet so that Level 5 maintains portions appropriate to the background layer imported from the architectural plans. Level 6 floor plan is representative of Level 5, therefore, Level 5 was duplicated at a height of 14 feet to simulate similar proportions for Level 6. Each room/space was modified to accurately represent the floor plans and occupant loads specified in Level 5 and Level 6 architectural plans.

Figure J.13 shows the Level 5 & 6 model in Pathfinder along with the corresponding evacuation times. Notice that the architectural plans specify an occupant load of 68 persons for Level 5 and 68 persons for Level 6 (compared with the Smoke Management Study occupant load of 77 persons for Level 5 and 74 persons for Level 6). This difference may be due to the fact that the architectural plans do not specify an occupant load for the women's and men's restrooms. Assuming business occupancy for the restrooms, an additional 2 or 3 occupants would be added per restroom depending on square footage of the restrooms. It possible that the Smoke Management Study includes additional occupants for this sake, however, an additional 9 occupants for level 5 seems unrealistic for restroom occupancy, while an additional 6 occupants for level 6 may be reasonable depending on square footage of the restrooms.

The last occupant on Levels 5 & 6 evacuate through the area of refuge doors on Levels 5 & 6 at approximately 44 seconds. In both cases, the evacuation time is limited by the walking speed of a disabled occupant.

**APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52**

Results

Methodology 1 results are summarized in Table J.4 by comparing evacuation times calculated from the SFPE hand calculations, Pathfinder model and STEPS model. The results of Methodology 1 demonstrate that all three performance based design approaches to calculating evacuation times are consistent with one another. The evacuation times used to calculate RSET time in this report are based on the SFPE hand calculation method, (Section 5.4 of this report).

Table J.4: Methodology 1 Results				
Atrium Space (Zone 1)	Occupant Load in Atrium Space (persons)	Hand Calculations Travel Time, t_e to Evacuate (sec)	Pathfinder Model Methodology 1: Travel Time, t_e to Evacuate (sec)	STEPS Model Travel Time, t_e to Evacuate (sec)
Level 2	81	26	27	21
Level 3	164	33	36	37
Level 4	73	39	35	34
Level 5	77	39	39	40
Level 6	74	39	36	39
Reference:	Smoke Management Study, 2009	Calculated in Table 27 of this report	Calculated in this Appendix	Smoke Management Study, 2009

Methodology 2 results are summarized in Table J.5 using the occupant loads specified in the architectural plans. Each level evacuates simultaneously and each room/space within the level has a specified occupant load based on the architectural plans.

Table J.5: Methodology 2 Results		
Atrium Space Controlled Area (Zone 1)	Occupant Load in Atrium Space (persons)	Pathfinder Model Methodology 2: Travel Time, t_e to Evacuate (sec)
Level 2	77	19
Level 3	155	70
*Level 3 alternate design (Additional 36 inch door)	155	52
*Level 3 alternate design (1-hour fire rated wall)	21	33
Level 4	64	30
Level 5	68	44
Level 6	68	44
Reference:	Zimmer, 2009	Calculated in this Appendix
*Alternate designs are for research purposes only		

The results of Methodology 2 show a more accurate representation of the evacuation process within the atrium space as described below:

- Level 2 evacuates faster than represented in Methodology 1 because fewer occupants are exiting through the same number of exits.
- Level 3 evacuates much slower than represented in Methodology 1 because occupants are limited by one 36 inch door exiting from each of the student work spaces. Further analysis on

APPENDIX J: PATHFINDER COMPUTER EVACUATION MODELS- ATRIUM SPACE
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Level 3 demonstrates that an additional 36 inch door exiting from each of the student work spaces would decrease evacuation time to 52 seconds which is still slow compared with Methodology 1 analysis. Another approach to Level 3, is to refrain from evacuating the student work spaces since a 1-hour fire barrier wall separates the atrium space from all other spaces within the controlled area. In this scenario, Level 3 evacuation time decreases to 33 seconds which is consistent with Methodology 1 analysis. However, such implications would need to be specified in the Fire Safety Management Plan and would require a W1 voice communication system, (reference Methodology 2, Level 3 analysis in this Appendix).

- Level 4 evacuates faster than represented in Methodology 1 because fewer occupants are exiting through the same number of exits.
- Levels 5 & 6 evacuate slower than represented in Methodology 1 because evacuation time is limited by the walking speed of a disabled occupant.

In summary, Methodology 2 calculates total evacuation times for the controlled area of the atrium space. It can be conservatively concluded that all occupants are safely evacuated from the Atrium area or are evacuated into the area of refuge at a time of 70 seconds. Using the RSET calculation method from Section 5.4 of this report, Table J.6 shows the total evacuation times using the Methodology 2 Pathfinder model.

Table J.6: Total Evacuation Times Using Methodology 2 Pathfinder Model					
Equation 2: $RSET = t_d + t_a + t_o + t_i + t_e$					
Level	Detection & Notification Time, $t_d + t_a$ (sec)	Pre-movement & Action Time, $t_o + t_i$ (sec)	Pathfinder Methodology 2 Travel Time, t_e (sec)	RSET Total Time (sec)	1.5 times RSET (sec)
Level 2	60	180	19	259	389
Level 3	60	180	70	310	465
Level 4	60	180	30	270	405
Level 5	60	180	44	284	426
Level 6	60	180	44	284	426
<i>Reference:</i>	<i>Section 5.4.2</i>	<i>Section 5.4.3</i>	<i>Section 5.4.4</i>	<i>Calculated RSET using Equation 2</i>	<i>CBC Section 909.4.6</i>

Level 3 has a limiting RSET of 465 seconds which is greater than the RSET of 419 seconds calculated by hand calculations, Methodology 1 Pathfinder model, and STEPS model. For purposes of this report, an ASET of 760 seconds using a mechanical exhaust system as specified in Appendix H is still greater than the calculated RSET time for all egress scenarios and meets the requirements set for in the CBC.

ATTACHMENT 1: DATA SHEETS**FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52****Attachment 1: Data Sheets**

See attached data sheets containing the following fire alarm system devices:

Pages	Device	Description	CSFM Listing #	Manufacturer/Model
6	FACP	Fire Alarm Control Panel	7165-0028:0243/0224	Notifier by Honeywell, CAB-4 Series Cabinets
2	FDU-80	Remote Annunciator	7120-0028:209	Notifier by Honeywell, FDU-80
2	PULL	Manual Pull Station	7150-0028:0199	Notifier by Honeywell, NBG-12LX
2	RNPS	Remote Power Supply	7315-0028:248	Notifier by Honeywell, ACPS-610(E)
2	FRM-1	Addressable Modules	7300-0028:0219	Notifier by Honeywell, FCM-1(A) & FRM-1(A) Series
2	SD	Smoke Detector	7272-0028:0206	Notifier by Honeywell, FAPT-851(A)
4	FDM-1	Monitor Module	7300-0028:0219	Notifier by Honeywell, FMM-1(A), FMM-101(A), FZM-1(A) & FDM-1(A)
2	SPK/SR	Indoor Speaker/Strobe	7320-1653:201	Notifier by Honeywell, SpectrAlert Advance
4	SPK/SR	Outdoor Speaker/Strobe	7320-1653:201	SpectrAlert Advance (System Sensor)
2	HEAT	Heat Detector	7270-0028:196	Notifier by Honeywell, FST-851 Series
4	DSD	Duct Smoke Detector	3242-1653:209/210	System Sensor, Innovairflex
2	FTM-1	Fire Fighter Phone Jack	7300-1653:0182, 7165-0028:0224, 7165-0028:0243	Notifier by Honeywell, FTM-1(A)
2	BELL	Fire Alarm Bell	7135-1653:0217	System Sensor, SSM/SSV Series
2	BEAM	Beam Smoke Detector	No Listing	Xtralis, OSID

Attachment 1 contains 38 pages total.

CAB-4 Series Cabinets

ONYX® Series Backboxes with Locking Doors

Peripheral Devices

General

All cabinets for NOTIFIER fire alarm control panels are fabricated from 16-gauge steel. The cabinet assembly consists of two basic parts: a backbox and a locking door. Cabinets are available in either black or red, with or without windows. The window model provides a tasteful combination to accent the decor of the finest lobby setting.

- The **key-locked door** is provided with a pin-type hinge, two keys and the necessary hardware to mount the door to the backbox.
- The **backbox** has been engineered to provide ease-of-entry for the installer. **Knockouts** are positioned at numerous points to aid the installer in bringing a conduit into the enclosure with a minimum of hardship.
- **Right- or left-hand hinges**, selectable in the field. Door opens 180°.
- Cabinets are arranged in **four standard sizes**, A (one tier) through D (four tiers), plus a **mini cabinet** (AA, one tier without a battery compartment). See *Ordering Information*.
- A **trim ring option** is available for semi-flush mounting.
- **Chassis bridge** available for assembling multiple CHS-4 chassis external to the backbox.
- Certified for seismic applications when used with the appropriate **seismic mounting kit**.

Ordering Information

A complete cabinet assembly consists of: a door, a backbox, an optional battery plate, and an optional semi-flush trim ring. For each cabinet required, order one "DR" door and one "SBB" backbox. The BP2-4 battery plate is required for each cabinet assembly that mounts batteries and/or a power supply in the lower position of the cabinet. The optional trim ring is an attractive "picture frame"-style black metal ring.

MINI "AA" SIZE, ONE TIER

DR-AA4: Door assembly, window, one tier (no battery compartment), BLACK.

DR-AA4R: Door assembly, window, one tier (no battery compartment), RED.

DR-AA4B: Door assembly, solid door, one tier (no battery compartment), BLACK.

DR-AA4BR: Door assembly, solid door, one tier (no battery compartment), RED.

SBB-AA4: Backbox assembly, one tier (no battery compartment), BLACK.

SBB-AA4R: Backbox assembly, one tier (no battery compartment), RED.

TR-AA4: Accessory semi-flush-mount trim ring, one tier (no battery compartment).

NOTE: Black trim rings are used with red or black cabinets.

ONE TIER, "A" SIZE

DR-A4: Door assembly, window, one tier, BLACK.

DR-A4R: Door assembly, window, one tier, RED.

DR-A4B: Door assembly, solid door, one tier, BLACK.

NFS2-3030 and DVC in "C" sized CAB-4 cabinet

DR-A4BR: Door assembly, solid door, one tier, RED.

SBB-A4: Backbox assembly, one tier, BLACK.

SBB-A4R: Backbox assembly, one tier, RED.

TR-A4: Accessory semi-flush-mount trim ring, one tier (opening 24.062" [61.118 cm] W x 20.062" [50.958 cm] H), BLACK.

NOTE: Black trim rings are used with red or black cabinets.

BP2-4: Battery plate. Used to cover battery and power supply when lower position is used in backbox.

TWO TIERS, "B" SIZE

DR-B4: Door assembly, window, two tiers, BLACK.

DR-B4R: Door assembly, window, two tiers, RED.

ADDR-B4: Two-tier-sized door designed for use with a CA-2 chassis mounted in the top rows. BLACK.

ADDR-B4R: Two-tier-sized door designed for use with a CA-2 chassis mounted in the top rows. RED.

DR-B4B: Door assembly, solid door, two tiers, BLACK.

DR-B4BR: Door assembly, solid door, two tiers, RED.

SBB-B4: Backbox assembly, two tiers, BLACK.

SBB-B4R: Backbox assembly, two tiers, RED.

TR-B4: Accessory semi-flush-mount trim ring, two tiers (opening 24.062" [61.118 cm] W x 28.562" [72.548 cm] H), BLACK.

NOTE: Black trim rings are used with red or black cabinets.

BP2-4: Battery plate. Used to cover battery and power supply when lower position is used in backbox.

THREE TIERS, "C" SIZE

DR-C4: Door assembly, window, three tiers, BLACK.

DR-C4R: Door assembly, window, three tiers, RED.

ADDR-C4: Three-tier-sized door designed for use with a CA-2 chassis mounted in the top rows. BLACK.

ADDR-C4R: Three-tier-sized door designed for use with a CA-2 chassis mounted in the top rows. RED.

DR-C4B: Door assembly, solid door, three tiers, BLACK.

DR-C4BR: Door assembly, solid door, three tiers, RED.

SBB-C4: Backbox assembly, three tiers, BLACK.

SBB-C4R: Backbox assembly, three tiers, RED.

TR-C4: Accessory semi-flush-mount trim ring, three tiers (opening 24.062" [61.118 cm] W x 37.187" [94.455 cm] H), BLACK.

NOTE: Black trim rings are used with red or black cabinets.

BP2-4: Battery plate. Used to cover battery and power supply when lower position is used in backbox.

FOUR TIERS, "D" SIZE

DR-D4: Door assembly, window, four tiers, BLACK.

DR-D4R: Door assembly, window, four tiers, RED.

ADDR-D4: Four-tier-sized door designed for use with a CA-2 chassis mounted in the top rows. BLACK.

ADDR-D4R: Four-tier-sized door designed for use with a CA-2 chassis mounted in the top rows. RED.

DR-D4B: Door assembly, solid door, four tiers, BLACK.

DR-D4BR: Door assembly, solid door, four tiers, RED.

SBB-D4: Backbox assembly, four tiers, BLACK.

SBB-D4R: Backbox assembly, four tiers, RED.

TR-D4: Accessory semi-flush-mount trim ring, four tiers (opening 24.062" [61.118 cm] W x 45.812" [116.363 cm] H), BLACK.

NOTE: Black trim rings are used with red or black cabinets.

BP2-4: Battery plate. Used to cover battery and power supply when lower position is used in backbox.

ACCESSORIES

ADP-4B: Annunciator dress panel.

CB-1: Chassis bridge. Provides a bridge between CHS Series chassis.

DP-1B: Blank dress panel, covers one CAB-4 tier, BLACK.

SEISKIT-CAB: Seismic mounting kit. Required for seismic-certified applications with NFS2-3030, NFS2-640, and NFS-320SYS. Includes battery bracket for two 26 AH batteries.

VP-2B: Ventilator panel.

WC-2: Wire channel. Provides a pair of wire trays to neatly route wiring between CHS chassis.

Agency Listings and Approvals

These listings and approvals below apply to the CAB-4 Series Cabinets. In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL** Listed: S635
- **ULC** Listed: S635
- **MEA:** 317-01-E, 345-02-E
- **CSFM:** 7165-0028:0243 (NFS2-640), 7165-0028:0224 (NFS2-3030)
- **FM** approved
- **FDNY:** COA# 6067, COA# 6065

CAB-4 Series cabinets with SEISKIT-CAB comply with seismic requirements of **IBC 2000, IBC 2003, IBC 2006, IBC2009, and CBC 2007.**

Cabinet Dimensions and Features

ONYX® and NOTIFIER® are registered trademarks of Honeywell International Inc.
©2011 by Honeywell International Inc. All rights reserved. Unauthorized use of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

Made in the U.S. A.

FDU-80

80 Character Liquid Crystal Display

Annunciators

General

The FDU-80 is a compact, cost-effective, 80-character, backlit LCD remote Fire Annunciator for use with the NOTIFIER Fire-Warden-100-2, NFS2-640, and NFS-320 Fire Alarm Control Panels (FACPs). The FDU-80 mimics the display of the control panel and displays complete system point status information.

Up to 32 FDU-80s may be connected onto the EIA-485 terminal port of each FACP. The FDU-80 requires no programming, which saves time during system commissioning.

Features

- 80-character Liquid Crystal Display.
- Mimics all display information from the host panel.
- Control switches for System Acknowledge, Signal Silence, Drill and Reset with enable key.
- System status LEDs for Power, Alarm, Trouble, Supervisory and Alarm Silenced.
- No programming necessary — FDU-80 connects to the terminal port on the FACP.
- Displays device type identifiers, individual point alarm, trouble or supervisory, zone and custom alpha labels.
- Time-and-date display field.
- Aesthetically pleasing design.
- May be powered from the host FACP or by remote power supply (requires 24 VDC).
- Up to 32 FDU-80 annunciators per FACP.
- Plug-in terminal blocks for ease of installation and service.
- Can be remotely located up to 6,000 feet (1828.8 m) from the FACP.
- Local piezo sounder with alarm and trouble resound.
- Semi-flush mounts to 2.188" (5.556 cm) minimum deep, three-gang electrical box (NOTIFIER PN **10103**) or three-gangable electrical switchbox.
- Surface-mounts to NOTIFIER PN **SBB-3** surface backbox.

Operation

The FDU-80 annunciator provides the FACP with point annunciation with full display text on an 80-character LCD display. The FDU-80 also provides an array of LEDs to indicate system status, and includes control switches for remote control of critical system functions.

The FDU-80 provides the FACP with up to 32 remote serially connected annunciators. All field-wiring terminations on the FDU-80 use removable, compression-type terminal blocks for ease of wiring and circuit testing.

Communication between the FACP and the annunciators is accomplished over an EIA-485 serial interface, which greatly reduces wire and installation cost over traditional systems.

Installation

The FDU-80 can be semi-flush mounted to a 2.188" (5.556 cm) minimum deep, three-gang electrical box or three-gangable electrical switchboxes. Alternately, an SBB-3 surface backbox is available for surface-mount applications.

6820fd8.jpg

Ordering Information

FDU-80: 80 character, backlit, LCD Fire Annunciator with control switches for remote control of system functions, and key-switch lock.

FDU-80C: ULC-listed version; see DN-60573 for details.

10103: Three-gang electrical box, minimum 2.188" (5.556 cm) deep, for semi-flush mount applications.

SBB-3: Three-gang surface backbox for surface-mount applications.

Agency Listings And Approvals

These listings and approvals apply to the modules specified in this document. In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL Listed:** S635
- **MEA Listed:** 245-00-E
- **FDNY:** COA#6038
- **CSFM:** 7120-0028:209
- **FM Approved**

NOTE: For ULC-listed version, see DN-60573.

NOTIFIER® is a registered trademark of Honeywell International Inc.
©2010 by Honeywell International Inc. All rights reserved. Unauthorized use
of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

Made in the U.S. A.

NBG-12LX

Addressable Manual Pull Station

Intelligent/Addressable Devices

General

The Notifier NBG-12LX is a state-of-the-art, dual-action (i.e., requires two motions to activate the station) pull station that includes an addressable interface for any Notifier intelligent control panel except FireWarden series panels, and the NSP-25 panel. Because the NBG-12LX is addressable, the control panel can display the exact location of the activated manual station. This leads fire personnel quickly to the location of the alarm.

Features

- Maintenance personnel can open station for inspection and address setting without causing an alarm condition.
- Built-in bicolor LED, which is visible through the handle of the station, flashes in normal operation and latches steady red when in alarm.
- Handle latches in down position and the word “ACTIVATED” appears to clearly indicate the station has been operated.
- Captive screw terminals wire-ready for easy connection to SLC loop (accepts up to 12 AWG/3.25 mm² wire).
- Can be surface mounted (with SB-10 or SB-I/O) or semi-flush mounted. Semi-flush mount to a standard single-gang, double-gang, or 4" (10.16 cm) square electrical box.
- Smooth dual-action design.
- Meets ADAAG controls and operating mechanisms guidelines (Section 4.1.3[13]); meets ADA requirement for 5 lb. maximum activation force.
- Highly visible.
- Attractive shape and textured finish.
- Key reset.
- Includes Braille text on station handle.
- Optional trim ring (BG12TR).
- Meets UL 38, Standard for Manually Actuated Signaling Boxes.
- Up to 99 NBG-12LX stations per loop on CLIP protocol loops.
- Up to 159 NBG-12LX stations per loop on FlashScan® protocol loops.
- Dual-color LED blinks green to indicate normal on FlashScan® systems.

Construction

Shell, door, and handle are molded of durable polycarbonate material with a textured finish.

Specifications

- **Shipping Weight:** 9.6 oz. (272.15 g)
- **Normal operating voltage:** 24 VDC.
- **Maximum SLC loop voltage:** 28.0 VDC.
- **Maximum SLC loop current:** 375 µA.
- **Temperature Range:** 32°F to 120°F (0°C to 49°C)
- **Relative Humidity:** 10% to 93% (noncondensing)
- **For use indoors in a dry location**

The NBG-12LX
Addressable Manual Pull Station

Installation

The NBG-12LX will mount semi-flush into a single-gang, double-gang, or standard 4" (10.16 cm) square electrical outlet box, or will surface mount to the model SB-10 or SB-I/O surface backbox. If the NBG-12LX is being semi-flush mounted, then the optional trim ring (BG12TR) may be used. The BG12TR is usually needed for semi-flush mounting with 4" (10.16 cm) or double-gang boxes (not with single-gang boxes).

Operation

Pushing in, then pulling down on the handle causes it to latch in the down/activated position. Once latched, the word “ACTIVATED” (in bright yellow) appears at the top of the handle, while a portion of the handle protrudes from the bottom of the station. To reset the station, simply unlock the station with the key and pull the door open. This action resets the handle; closing the door automatically resets the switch.

Each manual station, on command from the control panel, sends data to the panel representing the state of the manual switch. Two rotary decimal switches allow address settings (1 – 159 on FlashScan® systems, 1 – 99 on CLIP systems).

Architectural/Engineering Specifications

Manual Fire Alarm Stations shall be non-coded, with a key-operated reset lock in order that they may be tested, and so designed that after actual Emergency Operation, they cannot be restored to normal except by use of a key. An operated station shall automatically condition itself so as to be visually detected as activated. Manual stations shall be constructed of red-colored polycarbonate material with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in white letters, 1.00 inches (2.54 cm) or larger. Stations shall be suitable for surface mounting on matching backbox SB-10 or SB-I/O; or semi-flush mounting on a standard single-gang, double-gang, or 4"

(10.16 cm) square electrical box, and shall be installed within the limits defined by the Americans with Disabilities Act (ADA) or per national/local requirements. Manual Stations shall be Underwriters Laboratories listed.

Manual stations shall connect with two wires to one of the control panel SLC loops. The manual station shall, on command from the control panel, send data to the panel representing the state of the manual switch. Manual stations shall provide address setting by use of rotary decimal switches.

The loop poll LED shall be clearly visible through the front of the station. The LED shall flash while in the normal condition, and stay steadily illuminated when in alarm.

Product Line Information

NBG-12LX: Dual-action addressable pull station. Includes key locking feature.

SB-10: Surface backbox; metal.

SB-I/O: Surface backbox; plastic.

BG12TR: Optional trim ring.

17021: Keys, set of two.

NY-Plate: New York City trim plate

Agency Listings and Approvals

In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL / CUL Listed:** S692 (listed for Canadian and non-Canadian applications)
- **MEA:** 67-02-E
- **CSFM:** 7150-0028:0199
- **FDNY:** COA #6038 (NFS2-640), COA #6058 (NFS2-3030)
- **BSMI:** CI313066760047
- **U.S. Coast Guard:** 161.002/23/3 (AFP-200); 161.002/27/3 (AM-2020/AFP-1010; 161.002/42/1 (NFS-640)
- **Lloyd's Register:** 02/6007 (NFS-640); 94/60004 (E2) (AFP-200); 03/60011 (E1); 07/60007 (NFS2-3030)
- **FM Approved**

Patented: U.S. Patent No. D428,351; 6,380,846; 6,314,772; 6,632,108.

Notifier® and FlashScan® are a registered trademarks of Honeywell International Inc.

©2010 by Honeywell International Inc. All rights reserved. Unauthorized use of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

Made in the U.S. A.

ACPS-610(E)

Addressable Charger/Power Supply

Power Supplies

General

The ACPS-610(E) is an auxiliary power supply with a battery charging option and a host of special features. Selectable charging options allow the ACPS-610(E) to provide 6 amps of shared power to four outputs while charging batteries from 12 to 200 AH, or 10 amps of shared power when the unit is configured for use with an external battery charger. Four individually addressable outputs can be independently configured for auxiliary power or Notification Appliance Circuits (NAC). NAC outputs support notification appliance synchronization for devices manufactured by System Sensor®, Wheelock, and Gentex. An option to disable battery charging allows the system designer to use the four built-in circuits to distribute 10 amps of power for general purposes, excluding NAC applications.

The ACPS-610(E) is compatible with NOTIFIER intelligent fire alarm control panels using CLIP and FlashScan® protocol.

Features

- Listed to UL Standard 864, 9th Edition.
- Provides 6.0 A of NAC power or 10 A of general purpose power.
- Four Class B (Style Y) or four Class A (Style Z) outputs, individually addressable by the FACP.
- When built-in outputs are configured for NAC operation, each circuit supports strobe synchronization with the following manufacturers' audio/visual devices: System Sensor (SpectrAlert® and SpectrAlert Advance Series) or Wheelock or Gentex.
- Each circuit can be software-selected for use as: a Notification Appliance Circuit, general purpose 24 VDC power, four-wire detector power, or door holder.
- Steady, March Time (120 PPM), Two Stage, Temporal, or UZC Zone-Coded and Non-Coded devices - software-selectable by circuit.
- Universal Zone Coder (UZC-256) option supports for programmable coded outputs. Up to 256 different codes.
- Auxiliary Outputs: 24V @ 0.5A and 5V @ 0.15A
- Charges 12 to 200 AH batteries with full supervision. The charger on the ACPS may be disabled via software. When disabled, a separate, external charger is required, for example a CHG-120.
- May be used to provide battery backup for multiple ACPS supplies.
- AC loss detection, brownout detection, and AC loss delay reporting.
- Power-limited outputs.
- Isolated Signaling Line Circuit (SLC) interface.
- Selectable ground fault detection.
- Canadian two stage operation.

60244cov.jpg

Specifications

- Primary (AC) power:
 - ACPS-610: 120 VAC, 50/60 Hz input, 5.0 A maximum
 - ACPS-610E: 220/240 VAC, 50/60 Hz input, 2.5 A maximum
- Output voltage: 24 VDC electrically regulated and power limited (under primary AC mains). Under secondary power, 20.4 to 26.4 VDC.
- Output circuits - TB3, TB4, TB5, TB6 on Main Board: 1.5 A maximum for any NAC output circuit. 2.5 A maximum for any Power output with battery charger disabled.
- Secondary power (battery) charging circuit - lead-acid battery charger which will charge 12 to 200 AH batteries. Maximum charger current - 5.0 A.
- Secondary power auxiliary outputs - TB2 on CPS-24 Board:
 - 24V @ 0.5A, power limited
 - 5V @ 0.15A, power limited
- Wiring: utilizes wire sizes 12 to 18 AWG (3.1 to 0.78 mm²).
- SLC specifications: Average SLC current is 1.287 mA. SLC data is transmitted between 24.0 VDC, 5 VDC, and 0 VDC at approximately 3.33 Kbaud.
- Battery fuse (F2): 15A, Fast-acting
- Weight: 4.5 lb

ACPS Programming

The ACPS-610(E) is programmable via the simple-to-use PK-PPS programming utility, which requires a Windows® PC with a USB port and cable. A copy of the PK-PPS programming utility is included with each ACPS-610(E). Programming may be performed during an on-line session with the ACPS-610(E), or previously saved programs may be downloaded to individual ACPS-610(E) units. The ACPS-610(E) requires the use of a minimum of 5 SLC address points, and will use up to 14 SLC address points to fulfill requirements for Canadian supervision and two stage operation.

**Example of Programming
for the ACPS-610 Using 6 Addresses**

**Example for ACPS-610
Using Canadian Reporting with Two Stage.**

Listings and Approvals

These listings and approvals apply to the modules specified in this document. In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL Listed:** S635
- **ULC Listed:** S635
- **FM Approved**
- **CSFM:** 7315-0028:248
- **MEA #30-08-E**

Product Line Information

ACPS-610: Addressable charger power supply, with selectable built-in synchronization, and four built-in control modules. Includes installation instructions and PK-PPS programming utility CD. Requires Windows PC with USB port and USB cable. Several mounting options available (see below).

ACPS-610E: Same as ACPS-610, but configured for 220/240 VAC operation.

CAB-PS1: The CAB-PS1 can house one ACPS-610(E) and two 12 AH batteries. Dimensions: 15.218" (38.654 cm) high x 14.5" (36.83 cm) wide x 3.562" (9.048 cm) deep with door.

DR-PS1: When installing an ACPS-610(E) into an older version of the CAB-PS1 used for an ACPS-2406(E), the new wider door must be ordered for use with the older version cabinet.

BB-25: The BB-25 can house one ACPS-610(E) and two 12 volt, 26 AH batteries.

CAB-4 Series: The ACPS-610(E) can mount in any of the CAB-4 Series cabinets. This can be in the bottom of the cabinet or a tier via a CHS-PS and CHS-BH. See CAB-4 Series data sheet (DN-6857).

EQ Cabinet Series: The ACPS-610(E) can mount in any of the EQ Cabinet Series cabinets. See EQ Cabinet Series data sheet (DN-60229).

CHS-PS/CHS-6: Power supply mounting plate. Optional kit used to mount the ACPS-610(E) in a location other than the bottom of the CAB-4 cabinet or in an EQ Series cabinet (e.g., 2nd, 3rd, or 4th tier).

CHS-BH: Battery mounting chassis used to mount batteries in a location other than the bottom of the CAB-4 cabinet (e.g., 2nd, 3rd, or 4th tier).

Batteries: ACPS-610(E) battery charging circuit range is 12 - 200 AH. See BAT Series data sheet (DN-6933).

Notifier®, FlashScan®, System Sensor®, and SpectraAlert® are registered trademarks of Honeywell International Inc.
©2009 by Honeywell International Inc. All rights reserved. Unauthorized use of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

FCM-1(A) & FRM-1(A) Series

Control and Relay Modules

Intelligent / Addressable Devices

General

FCM-1(A) Control Module: The FCM-1(A) Addressable Control Module provides Notifier intelligent fire alarm control panels a circuit for Notification Appliances (horns, strobes, speakers, etc.). Addressability allows the FCM-1(A) to be activated, either manually or through panel programming, on a select (zone or area of coverage) basis.

FRM-1(A) Relay Module: The FRM-1(A) Addressable Relay Module provides the system with a dry-contact output for activating a variety of auxiliary devices, such as fans, dampers, control equipment, etc. Addressability allows the dry contact to be activated, either manually or through panel programming, on a select basis.

FlashScan® (U.S. Patent 5,539,389) is a communication protocol developed by NOTIFIER Engineering that greatly enhances the speed of communication between analog intelligent devices. Intelligent devices communicate in a grouped fashion. If one of the devices within the group has new information, the panel CPU stops the group poll and concentrates on single points. The net effect is response speed greater than five times that of other designs.

FCM-1(A)

Features

- Built-in type identification automatically identifies these devices to the control panel.
- Internal circuitry and relay powered directly by two-wire SLC loop. The FCM-1(A) module requires power (for horns, strobes, etc.), or audio (for speakers).
- Integral LED “blinks” green each time a communication is received from the control panel and turns on in steady red when activated.
- LED blink may be deselected globally (affects all devices).
- High noise immunity (EMF/RFI).
- The FCM-1(A) may be used to switch 24-volt NAC power, audio (up to 70.7 Vrms).
- Wide viewing angle of LED.
- SEMS screws with clamping plates for wiring ease.
- Direct-dial entry of address 01– 159 for FlashScan loops, 01 – 99 for CLIP mode loops.
- Speaker, and audible/visual applications may be wired for Class B or A (Style Y or Z).

Applications

The FCM-1(A) is used to switch 24 VDC audible/visual power, high-level audio (speakers). The FRM-1(A) may be programmed to operate dry contacts for applications such as door holders or Air Handling Unit shutdown, and to reset four-wire smoke detector power.

NOTE: Refer to the SLC Manual (PN 51253) for details regarding releasing applications with the FCM-1(A). Refer to the FCM-1-REL datasheet (DN-60390) for new FlashScan® releasing applications.

Construction

- The face plate is made of off-white heat-resistant plastic.
- Controls include two rotary switches for direct-dial entry of address (01-159).

- The FCM-1(A) is configured for a single Class B (Style Y) or Class A (Style Z) Notification Appliance Circuit.
- The FRM-1(A) provides two Form-C dry contacts that switch together.

Operation

Each FCM-1(A) or FRM-1(A) uses one of 159 possible module addresses on a SLC loop (99 on CLIP loops). It responds to regular polls from the control panel and reports its type and status, including the open/normal/short status of its Notification Appliance Circuit (NAC). The LED blinks with each poll received. On command, it activates its internal relay. The FCM-1(A) supervises Class B (Style Y) or Class A (Style Z) notification or control circuits.

Upon code command from the panel, the FCM-1(A) will disconnect the supervision and connect the external power supply in the proper polarity across the load device. The disconnection of the supervision provides a positive indication to the panel that the control relay actually turned ON. The external power supply is always relay isolated from the communication loop so that a trouble condition on the external power supply will never interfere with the rest of the system.

Rotary switches set a unique address for each module. The address may be set before or after mounting. The built-in TYPE CODE (not settable) will identify the module to the control panel, so as to differentiate between a module and a sensor address.

Specifications for FCM-1(A)

Normal operating voltage: 15 to 32 VDC.

Maximum current draw: 6.5 mA (LED on).

Average operating current: 350 μ A direct poll, 375 μ A group poll with LED flashing, 485 μ A Max. (LED flashing, NAC shorted.)

Maximum NAC Line Loss: 4 VDC.

External supply voltage (between Terminals T10 and T11): Maximum (NAC): Regulated 24 VDC; Maximum (Speakers): 70.7 V RMS, 50W.

Drain on external supply: 1.7 mA maximum using 24 VDC supply; 2.2 mA Maximum using 80 VRMS supply.

Max NAC Current Ratings: For class B wiring system, the current rating is 3A; For class A wiring system, the current rating is 2A.

Temperature range: 32°F to 120°F (0°C to 49°C).

Humidity range: 10% to 93% non-condensing.

Dimensions: 4.5" (114.3 mm) high x 4" (101.6 mm) wide x 1.25" (31.75 mm) deep. Mounts to a 4" (101.6 mm) square x 2.125" (53.975 mm) deep box.

Accessories: SMB500 Electrical Box; CB500 Barrier

Specifications for FRM-1(A)

Normal operating voltage: 15 to 32 VDC.

Maximum current draw: 6.5 mA (LED on).

Average operating current: 230 µA direct poll; 255 µA group poll.

EOL resistance: not used.

Temperature range: 32°F to 120°F (0°C to 49°C).

Humidity range: 10% to 93% non-condensing.

Dimensions: 4.5" (114.3 mm) high x 4" (101.6 mm) wide x 1.25" (31.75 mm) deep. Mounts to a 4" (101.6 mm) square x 2.125" (53.975 mm) deep box.

Accessories: SMB500 Electrical Box; CB500 Barrier

Agency Listings and Approvals

In some cases, certain modules may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL:** S635
- **ULC:** S3705 (A version only)
- **FM Approved**
- **CSFM:** 7300-0028:0219
- **MEA:** 14-00-E
- **FDNY:** COA #6067, #6065

Contact Ratings for FRM-1(A)

Current Rating	Maximum Voltage	Load Description	Application
3 A	30 VDC	Resistive	Non-Coded
2 A	30 VDC	Resistive	Coded
.9 A	110 VDC	Resistive	Non-Coded
.9 A	125 VDC	Resistive	Non-Coded
.5 A	30 VDC	Inductive (L/R=5ms)	Coded
1 A	30 VDC	Inductive (L/R=2ms)	Coded
.3 A	125 VAC	Inductive (PF=0.35)	Non-Coded
1.5 A	25 VAC	Inductive (PF=0.35)	Non-Coded
.7 A	70.7 VAC	Inductive (PF=0.35)	Non-Coded
2 A	25 VAC	Inductive (PF=0.35)	Non-Coded

NOTE: Maximum (Speakers): 70.7 V RMS, 50 W

Product Line Information

NOTE: "A" suffix indicates ULC Listed model.

FCM-1(A): Intelligent Addressable Control Module.

FRM-1(A): Intelligent Addressable Relay Module.

A2143-20: Capacitor, required for Class A (Style Z) operation of speakers.

SMB500: Optional Surface-Mount Backbox.

CB500: Control Module Barrier — required by UL for separating power-limited and non-power limited wiring in the same junction box as FCM-1(A).

NOTE: For installation instructions, see the following documents:

- *FCM-1(A) Installation document I56-1169.*
- *FRM-1(A) Installation document I56-3502.*
- *Notifier SLC Wiring Manual, document 51253.*

Notifier® and **FlashScan®** are registered trademarks of Honeywell International Inc.

©2011 by Honeywell International Inc. All rights reserved. Unauthorized use of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

Made in the U.S. A.

FAPT-851(A)

**Acclimate® Plus™ Multi-Sensor
Low-Profile Intelligent Detector**

Intelligent/Addressable Devices

General

The Notifier FAPT-851(A) Acclimate® Plus™ detector is an intelligent, addressable, multi-sensing, low-profile detector designed for use with Notifier Onyx and CLIP series Fire Alarm Control Panels.

The Acclimate Plus detector uses a combination of photoelectric and thermal sensing technologies to increase immunity to false alarms. Unlike traditional intelligent detectors, the Acclimate Plus detector has a microprocessor in the detector head that processes alarm data. As a result, the Acclimate Plus detector adjusts its sensitivity automatically, without operator intervention or control panel programming.

Areas where the Acclimate Plus detector is especially useful include office complexes, schools, college campuses, manufacturing and industrial facilities, and anywhere else the use of a particular area may change. The Acclimate Plus detector automatically adjusts its sensitivity to the environment.

FlashScan (U.S. Patent 5,539,389) is a communication protocol developed to greatly enhance the speed of communication between analog intelligent devices and compatible systems. Intelligent devices communicate in a grouped fashion. If one of the devices within the group has new information, the panel's CPU stops the group poll and concentrates on single points. The net effect is response speed greater than five times that of earlier designs.

Features

- Automatically adjusts sensitivity levels without operator intervention or programming. Sensitivity increases with heat.
- Microprocessor-based, combination photo and thermal technology.
- FlashScan® and CLIP system compatible (NFS-320, NFS-640, NFS2-640, NFS-3030 and NFS2-3030)
- Addressable-analog communication.
- Sleek, low-profile design.
- Two-wire SLC connection.
- Direct-Dial entry of address: (1 – 159 on FlashScan systems; 1 – 99 on CLIP systems).
- Addresses can be viewed and changed without electronic programmers.
- Dual bi-color LED design provides 360° viewing angle.
- LEDs lock red when in alarm. In FlashScan, LEDs flash green in standby for normal condition.
- Built-in tamper-resistant feature.
- Constructed of off-white fire-resistant plastic, designed to commercial standards, and offers an attractive appearance.
- SEMS screws for wiring of the separate base.
- Several base options, including relay, isolator, and sounder.
- Built-in functional test switch activated by external magnet.
- Listed to UL 268.
- Capable of heat-only alarm mode, enabled by a special command from the panel. Smoke alarms are ignored.
- Low-temperature signal at 45°F +/- 10°F (7.22°C +/- 5.54°C).

FAPT-851(A) in B710LP base (base ordered separately)

Specifications

Sensitivity: *auto-adjusting levels:* 1 to 2%/ft. and 2 to 4%/ft. with classic CLIP systems; 1 to 2, 2 to 3, and 3 to 4%/ft. with systems; *fixed-sensitivity levels:* 1, 2, and 4%/ft. with classic CLIP systems; 0.5, 1, 2, 3, and 4%/ft. with FlashScan systems.

Size: 2.0" (5.3 cm) high x 4.1" (10.4 cm) diameter installed in B501 base, 6.1" (15.5 cm) diameter installed in B710LP base.

Shipping weight: 5.2 oz. (147 g).

Operating temperature: 0°C to 38°C (32°F to 100°F).

Operating altitude: up to 10,000 feet.

UL-Listed velocity range: 0 – 4000 ft./min. (1219.2 m/min.), suitable for installation in ducts.

Relative humidity: 10% – 93% noncondensing.

Thermal sensing rating: fixed-temperature setpoint 135°F (57°C).

ELECTRICAL SPECIFICATIONS:

Voltage range: 15 – 32 volts DC peak.

Standby current (max. avg.): 300 µA.

Loop resistance: 50 ohms maximum; varies according to control panel used. Refer to panel installation manuals.

LED current (max.): 6.5 mA @ 24 VDC ("ON").

Installation

The FAPT-851(A) plug-in detector uses a separate base to simplify installation, service, and maintenance. A special tool allows maintenance personnel to plug-in and remove detectors without using a ladder. Suitable mounting base boxes include:

- 4.0" (10.16 cm) square box.
- 3.5" (8.89 cm) or 4.0" (10.16 cm) octagonal box.
- Single-gang box (except relay or isolator base).

NOTE: The FAPT-851(A) detector has the unique ability to adjust sensitivity according to the environment, based on heat and smoke levels. Avoid installing these detectors in locations that are susceptible to rapid and high temperature changes. An example of an incorrect application would be near or in line with the output of a self-contained heater.

Agency Listings and Approvals

These listings and approvals apply to the modules specified in this. In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. *Consult factory for latest listing status.*

- **UL Listed:** S1115
- **ULC Listed:** S1115
- **MEA Listed:** 225-02-E
- **FM Approved**
- **CSFM:** 7272-0028:0206
- **U.S. Coast Guard:** 161.002/42/1 (NFS-640)
- **Lloyd's Register:** 02/60007 (NFS-640)
- **Maryland State Fire Marshal:** Permit # 2122

Ordering Information

NOTE: "A" suffix indicates ULC Listed model.

FAPT-851: Low-profile intelligent multi-sensor detector. Must be mounted to one of the bases listed below.

FAPT-851A: Same as FAPT-851 but with ULC Listing.

INTELLIGENT BASES

B501(A): Flangeless mounting base.

B200S(A): Intelligent sounder base capable of producing sound output in high or low volume with ANSI Temporal 3, ANSI Temporal 4, continuous tone, marching tone, and custom tone.

B200SR(A): Intelligent sounder base capable of producing sound output with ANSI Temporal 3 or continuous tone. Replaces the B501BH series bases in retrofit applications.

B710LP: Flanged mounting base. (6.1", 15.5 cm diameter)

B710LPA: Flanged mounting base, ULC Listed.

B224RB: Relay base Screw terminals: up to 14 AWG (2.0 mm²). Relay type: Form-C. Rating: 2.0 A @ 30 VDC resistive; 0.3 A @ 110 VDC inductive; 1.0 A @ 30 VDC inductive. Dimensions: 6.2" (15.748 cm) x 1.2" (3.048 cm)..

B224RBA: Relay base, ULC Listed.

B224BI: Isolator base. Dimensions: 6.2" (15.748 cm) x 1.2" (3.048 cm). Maximum: 25 devices between isolator bases.

B224BIA: Isolator base, ULC Listed.

ACCESSORIES:

F110: Retrofit replacement flange for older high profile bases. Converts bases for use with FlashScan® detectors.

RA100Z(A): Remote LED annunciator. 3 – 32 VDC. Fits U.S. single-gang electrical box. Supported by B710LP(A) and B501(A) bases only.

SMB600: Surface mounting kit for use with B710LP(A).

BCK-200B: Black detector covers, box of 10.

M02-04-00: Test magnet.

M02-09-00: Test magnet with telescope stick.

XR2B: Detector removal tool. Allows installation and/or removal of FlashScan® Series detector heads from base in high ceiling installations.

T55-127-010: Detector removal tool without pole.

XP-4: Extension pole for XR2B. Comes in three 5-ft. sections.

Notifier®, ONYX®, FlashScan®, and Acclimate® are registered trademarks and Acclimate Plus™ is a trademark of Honeywell International Inc. ©2010 by Honeywell International Inc. All rights reserved. Unauthorized use of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

Made in the U.S. A.

FMM-1(A), FMM-101(A), FZM-1(A) & FDM-1(A)

Monitor Modules with FlashScan®

Intelligent/Addressable Devices

General

Four different monitor modules are available for Notifier's intelligent control panels for a variety of applications. Monitor modules supervise a circuit of dry-contact input devices, such as conventional heat detectors and pull stations, or monitor and power a circuit of two-wire smoke detectors (FZM-1(A)).

FMM-1(A) is a standard-sized module (typically mounts to a 4" [10.16 cm] square box) that supervises either a Style D (Class A) or Style B (Class B) circuit of dry-contact input devices.

FMM-101(A) is a miniature monitor module a mere 1.3" (3.302 cm) H x 2.75" (6.985 cm) W x 0.5" (1.270 cm) D that supervises a Style B (Class B) circuit of dry-contact input devices. Its compact design allows the FMM-101(A) to be mounted in a single-gang box behind the device it monitors.

FZM-1(A) is a standard-sized module that monitors and supervises compatible two-wire, 24 volt, smoke detectors on a Style D (Class A) or Style B (Class B) circuit.

FDM-1(A) is a standard-sized dual monitor module that monitors and supervises two independent two-wire Style B (Class B) dry-contact initiating device circuits (IDCs) at two separate, consecutive addresses in intelligent, two-wire systems.

FlashScan® (U.S. Patent 5,539,389) is a communication protocol developed by NOTIFIER that greatly increases the speed of communication between analog intelligent devices. Intelligent devices communicate in a grouped fashion. If one of the devices within the group has new information, the panel CPU stops the group poll and concentrates on single points. The net effect is response speed greater than five times that of other designs.

FMM-1(A) Monitor Module

- Built-in type identification automatically identifies this device as a monitor module to the control panel.
- Powered directly by two-wire SLC loop. No additional power required.
- High noise (EMF/RFI) immunity.
- SEMS screws with clamping plates for ease of wiring.
- Direct-dial entry of address: 01 – 159 on FlashScan loops; 01 – 99 on CLIP loops.
- LED flashes green during normal operation (this is a programmable option) and latches on steady red to indicate alarm.

The FMM-1(A) Monitor Module is intended for use in intelligent, two-wire systems, where the individual address of each module is selected using the built-in rotary switches. It provides either a two-wire or four-wire fault-tolerant Initiating Device Circuit (IDC) for normally-open-contact fire alarm and supervisory devices. The module has a panel-controlled LED indicator. The FMM-1(A) can be used to replace MMX-1(A) modules in existing systems.

FMM-1(A) APPLICATIONS

Use to monitor a zone of four-wire smoke detectors, manual fire alarm pull stations, waterflow devices, or other normally-open dry-contact alarm activation devices. May also be used to monitor normally-open supervisory devices with special supervisory indication at the control panel. Monitored circuit may be wired as an NFPA Style B (Class B) or Style D (Class

FMM-1(A) (Type H)

A) Initiating Device Circuit. A 47K ohm End-of-Line Resistor (provided) terminates the Style B circuit. No resistor is required for supervision of the Style D circuit.

FMM-1(A) OPERATION

Each FMM-1(A) uses one of the available module addresses on an SLC loop. It responds to regular polls from the control panel and reports its type and the status (open/normal/short) of its Initiating Device Circuit (IDC). A flashing LED indicates that the module is in communication with the control panel. The LED latches steady on alarm (subject to current limitations on the loop).

FMM-1(A) SPECIFICATIONS

Nominal operating voltage: 15 to 32 VDC.

Maximum current draw: 5.0 mA (LED on).

Average operating current: 350 µA (LED flashing), 1 communication every 5 seconds, 47k EOL.

Maximum IDC wiring resistance: 40 ohms.

EOL resistance: 47K ohms.

Temperature range: 32°F to 120°F (0°C to 49°C).

Humidity range: 10% to 93% noncondensing.

Dimensions: 4.5" (11.43 cm) high x 4" (10.16 cm) wide x 1.25" (3.175 cm) deep. Mounts to a 4" (10.16 cm) square x 2.125" (5.398 cm) deep box.

FMM-101(A) Mini Monitor Module

- Built-in type identification automatically identifies this device as a monitor module to the panel.
- Powered directly by two-wire SLC loop. No additional power required.
- High noise (EMF/RFI) immunity.
- Tinned, stripped leads for ease of wiring.
- Direct-dial entry of address: 01 – 159 on FlashScan loops; 01 – 99 on CLIP loops.

The FMM-101(A) Mini Monitor Module can be installed in a single-gang junction directly behind the monitored unit. Its small size and light weight allow it to be installed without rigid mounting. The FMM-101(A) is intended for use in intelligent, two-wire systems where the individual address of each module is selected using rotary switches. It provides a two-wire initiating device circuit for normally-open-contact fire alarm and security devices. The FMM-101(A) can be used to replace MMX-101(A) modules in existing systems.

FMM-101(A) APPLICATIONS

Use to monitor a single device or a zone of four-wire smoke detectors, manual fire alarm pull stations, waterflow devices, or other normally-open dry-contact devices. May also be used to monitor normally-open supervisory devices with special supervisory indication at the control panel. Monitored circuit/device is wired as an NFPA Style B (Class B) Initiating Device Circuit. A 47K ohm End-of-Line Resistor (provided) terminates the circuit.

FMM-101(A) OPERATION

Each FMM-101(A) uses one of the available module addresses on an SLC loop. It responds to regular polls from the control panel and reports its type and the status (open/normal/short) of its Initiating Device Circuit (IDC).

FMM-101(A) SPECIFICATIONS

Nominal operating voltage: 15 to 32 VDC.

Average operating current: 350 μ A, 1 communication every 5 seconds, 47k EOL; 600 μ A Max. (Communicating, IDC Shorted).

Maximum IDC wiring resistance: 40 ohms.

Maximum IDC Voltage: 11 Volts.

Maximum IDC Current: 400 μ A.

EOL resistance: 47K ohms.

Temperature range: 32°F to 120°F (0°C to 49°C).

Humidity range: 10% to 93% noncondensing.

Dimensions: 1.3" (3.302 cm) high x 2.75" (6.985 cm) wide x 0.65" (1.651 cm) deep.

Wire length: 6" (15.24 cm) minimum.

FZM-1(A) Interface Module

- Supports compatible two-wire smoke detectors.
- Supervises IDC wiring and connection of external power source.
- High noise (EMF/RFI) immunity.
- SEMS screws with clamping plates for ease of wiring.
- Direct-dial entry of address: 01 – 159 on FlashScan loops, 01 – 99 on CLIP loops.
- LED flashes during normal operation; this is a programmable option.
- LED latches steady to indicate alarm on command from control panel.

The FZM-1(A) Interface Module is intended for use in intelligent, addressable systems, where the individual address of each module is selected using built-in rotary switches. This module allows intelligent panels to interface and monitor two-wire conventional smoke detectors. It transmits the status (normal, open, or alarm) of one full zone of conventional detectors back to the control panel. All two-wire detectors being monitored must be UL compatible with the module. The FZM-1(A) can be used to replace MMX-2(A) modules in existing systems.

FZM-1(A) APPLICATIONS

Use the FZM-1(A) to monitor a zone of two-wire smoke detectors. The monitored circuit may be wired as an NFPA Style B (Class B) or Style D (Class A) Initiating Device Circuit. A 3.9 K ohm End-of-Line Resistor (provided) terminates the end of the Style B or D (class B or A) circuit (maximum IDC loop resistance is 25 ohms). Install ELR across terminals 8 and 9 for Style D application.

FZM-1(A) OPERATION

Each FZM-1(A) uses one of the available module addresses on an SLC loop. It responds to regular polls from the control panel and reports its type and the status (open/normal/short) of its Initiating Device Circuit (IDC). A flashing LED indicates that the module is in communication with the control panel. The LED latches steady on alarm (subject to current limitations on the loop).

FZM-1(A) SPECIFICATIONS

Nominal operating voltage: 15 to 32 VDC.

Maximum current draw: 5.1 mA (LED on).

Maximum IDC wiring resistance: 25 ohms.

Average operating current: 300 μ A, 1 communication and 1 LED flash every 5 seconds, 3.9k eol.

EOL resistance: 3.9K ohms.

External supply voltage (between Terminals T3 and T4): DC voltage: 24 volts power limited. Ripple voltage: 0.1 Vrms maximum. Current: 90 mA per module maximum.

Temperature range: 32°F to 120°F (0°C to 49°C).

Humidity range: 10% to 93% noncondensing.

Dimensions: 4.5" (11.43 cm) high x 4" (10.16 cm) wide x 1.25" (3.175 cm) deep. Mounts to a 4" (10.16 cm) square x 2.125" (5.398 cm) deep box.

FDM1(A) Dual Monitor Module

The FDM-1(A) Dual Monitor Module is intended for use in intelligent, two-wire systems. It provides two independent two-wire initiating device circuits (IDCs) at two separate, consecutive addresses. It is capable of monitoring normally open contact fire alarm and supervisory devices; or either normally open or normally closed security devices. The module has a single panel-controlled LED.

NOTE: The FDM-1(A) provides two Style B (Class B) IDC circuits ONLY. Style D (Class A) IDC circuits are NOT supported in any application.

FDM-1(A) SPECIFICATIONS

Normal operating voltage range: 15 to 32 VDC.

Maximum current draw: 6.4 mA (LED on).

Average operating current: 750 μ A (LED flashing).

Maximum IDC wiring resistance: 1,500 ohms.

Maximum IDC Voltage: 11 Volts.

Maximum IDC Current: 240 μ A

EOL resistance: 47K ohms.

Maximum SLC Wiring resistance: 40 Ohms.

Temperature range: 32° to 120°F (0° to 49°C).

Humidity range: 10% to 93% (non-condensing).

Dimensions: 4.5" (11.43 cm) high x 4" (10.16 cm) wide x 2.125" (5.398 cm) deep.

FDM-1(A) AUTOMATIC ADDRESSING

The FDM-1(A) automatically assigns itself to two addressable points, starting with the original address. For example, if the FDM-1(A) is set to address "26", then it will automatically assign itself to addresses "26" and "27".

NOTE: "Ones" addresses on the FDM-1(A) are 0, 2, 4, 6, or 8 only. Terminals 6 and 7 use the first address, and terminals 8 and 9 use the second address.

CAUTION:

Avoid duplicating addresses on the system.

Installation

FMM-1(A), FZM-1(A), and FDM-1(A) modules mount directly to a standard 4" (10.16 cm) square, 2.125" (5.398 cm) deep, electrical box. They may also be mounted to the SMB500 surface-mount box. Mounting hardware and installation instructions are provided with each module. All wiring must conform to applicable local codes, ordinances, and regulations. These modules are intended for power-limited wiring only.

The FMM-101(A) module is intended to be wired and mounted without rigid connections inside a standard electrical box. All wiring must conform to applicable local codes, ordinances, and regulations.

Agency Listings and Approvals

In some cases, certain modules may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL:** S635
- **ULC:** S635
- **FM Approved**
- **CSFM:** 7300-0028:0219
- **MEA:** 457-99-E
- **U.S. Coast Guard:**

– 161.002/23/3 (AFP-200: FMM-1/-101, FZM-1)

– 161.002/42/1 (NFS-640: FMM-1/-101)

- **Lloyd's Register:**

– 03/60011/E1 (FMM-1/-101, FZM-1)

– 94/60004/E2 (AFP-200: except FDM-1)

– 02/60007 (NFS-640: FDM-1)

- **FDNY:** COA #6038 (NFS2-640, NFS-320), COA# 6058 (NFS2-3030)

Product Line Information

NOTE: "A" suffix indicates ULC-listed model.

FMM-1(A): Monitor module.

FMM-101(A): Monitor module, miniature.

FZM-1(A): Monitor module, two-wire detectors.

FDM-1(A): Monitor module, dual, two independent Class B circuits.

SMB500: Optional surface-mount backbox.

NOTE: See installation instructions and refer to the SLC Wiring Manual, PN 51253.

FlashScan® and NOTIFIER® are registered trademarks and FireWatch™ is a trademark of Honeywell International Inc.
©2010 by Honeywell International Inc. All rights reserved. Unauthorized use of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

Made in the U.S. A.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

SpectrAlert® Advance

Indoor Selectable Output Speaker Strobes and Dual Voltage Evacuation Speakers

Audio/Visual Devices

General

The SpectrAlert Advance Series of speakers and speaker strobes is designed to reduce ground faults. The plug-in design allows the installer to pre-wire mounting plates and dress the wires before plugging in the speakers. The plastic cover prevents nicked wires by covering exposed speaker components.

This design also allows faster installations with instant feedback to ensure that wiring is properly connected; rotary switches to select voltage and power settings; and 11 field selectable candela settings for wall and ceiling speaker strobes.

The low total harmonic distortion of the SP speaker offers high fidelity sound output while the SPV speaker offers high volume sound output for use in high ambient noise applications.

SpectrAlert Advance makes installation easy

- Attach a universal mounting plate to a 4" x 4" x 2-1/8" back box. Flush mount applications are achievable without the need for an extension ring.
- Connect the notification appliance circuit or speaker wiring to the PEMS terminals on the mounting plate.
- Attach the speaker or speaker strobe to the mounting plate by inserting the product tabs into the mounting plate grooves. Rotate the device into position to lock the product pins into the mounting plate terminals. The device will temporarily hold in place with a catch until it is secured with a captured mounting screw.

Features

- Plug-in design
- Protective cover isolates speaker components, reduces ground faults
- Electrical compatibility with existing SpectrAlert products
- Field selectable candela settings on wall and ceiling units:
 - Standard: 15, 15/75, 30, 75, 95, 110, 115
 - High: 135, 150, 177, 185
- Shorting spring on mounting plate tests continuity before installation
- Rotary switch simplifies field selection of speaker voltage and power settings
- Universal mounting plate for wall- and ceiling-mount units
- Compatible with System Sensor synchronization protocol
- SP speakers offer high fidelity sound output
- SPV speakers offer high volume sound output
- Automatic selection of 12 or 24 volt operation at 15 and 15/75 candela
- No extension ring required
- Ceiling and wall mount application
- Optional tamper resistant Torx head screw included

Specifications

PHYSICAL SPECIFICATIONS

Operating Temperature: 32°F to 120°F (0°C to 49°C)

Humidity Range: 10 to 93% non-condensing

Dimensions, Wall-Mount: –

- SPS Speaker Strobe: 6.0"L x 5.0"W x 4.7"D (includes lens and speaker)

- SPSV Speaker Strobe: 6.0"L x 5.0"W x 4.9"D (includes lens and speaker)
- SP Speaker: 6.0"L x 5.0"W x 2.8"D
- SPSV Speaker: 6.0"L x 5.0"W x 2.9"D

Dimensions, Ceiling-Mount:

- SPS Speaker Strobe: 6.8"Dia x 4.7"D (includes lens and speaker)
- SPSV Speaker Strobe: 6.8"Dia x 4.8"D (includes lens and speaker)
- SP Speaker: 6.8"Dia x 2.8"D
- SPSV Speaker: 6.8"Dia x 2.9"D

ELECTRICAL/OPERATING SPECIFICATIONS

Nominal Voltage (speakers): 25 Volts or 70.7 Volts (nominal)

Maximum Supervisory Voltage (speakers): 50VDC

Strobe Flash Rate: 1 flash per second

Nominal Voltage (strobes): Regulated 12VDC/FWR or regulated 24DC/FWR

Operating Voltage Range (includes fire alarm panels with built-in sync): 8 to 17.5V (12V nominal) or 16 to 33V (24V nominal)

Operating Voltage with MDL Sync Module: 9 to 17.5V (12V nominal) or 17 to 33V (24V nominal)

Frequency Range: 400 to 4000 Hz

Power: ¼, ½, 1, 2 watts

Agency Listings and Approvals

In some cases, certain modules may not be listed by certain approval agencies, or listing may be in progress. *Consult factory for latest listing status.*

- **UL/ULC Listed:** S4048
- **MEA:** 10-08-E
- **CSFM:** 7320-1653:201
- **FM Approved**

UL Maximum Strobe Current Draw (mA RMS)					
	Candela	8 to 17.5 Volts		16 to 33 Volts	
		DC	FWR	DC	FWR
Standard Candela Range	15	123	128	66	71
	15/75	142	148	77	81
	30	NA	NA	94	96
	75	NA	NA	158	153
	95	NA	NA	181	176
	110	NA	NA	202	195
	115	NA	NA	210	205
High Candela Range	135	NA	NA	228	207
	150	NA	NA	246	220
	177	NA	NA	281	251
	185	NA	NA	286	258

Sound Output					
UL Reverberant (dBA @ 10ft)	2W	1W	1/2W	1/4W	
Wall Mount SP Series	86	83	80	77	
Wall Mount SPV Series	90	87	84	81	
Ceiling Mount SPC Series	86	83	80	77	
Ceiling Mount SPCV Series	90	87	84	81	
Wall Mount SPS Series	85	82	79	76	
Wall Mount SPSV Series	89	86	83	80	
Ceiling Mount SPSC Series	85	82	79	76	
Ceiling Mount SPSCV Series	89	86	83	80	

Architectural/Engineering Specifications

GENERAL

SpectrAlert Advance speaker and speaker strobes shall mount to a 4" x 4" x 2-1/8" backbox. A universal mounting plate shall be used for mounting ceiling and wall products. The notification appliance circuit and amplifier wiring shall terminate at the universal mounting plate. Also, SpectrAlert Advance speaker strobes, when used with the Sync Circuit. Module accessory, shall be powered from a non-coded notification appliance circuit output and shall operate on a nominal 12 or 24volts. When used with the Sync.Circuit Module, 12 volt rated notification appliance circuit outputs shall operate between nine and 17.5 volts; 24 volt rated notification appliance circuit outputs shall operate between 17 and 33 volts. Indoor SpectrAlert Advance products shall operate between 32°F and 120°F from a regulated DC, or full-wave rectified, unfiltered power supply. Speaker strobes shall have field-selectable candela settings including 15, 15/75, 30, 75, 95, 110, 115, 135, 150, 177, 185.

SPEAKER

The speaker shall be a System Sensor SpectrAlert Advance model dual-voltage transformer speaker capable of operating at 25.0 or 70.7 nominal Vrms. It should be listed to UL/ULC 1480 and shall be approved for fire protective service. The speaker shall have a frequency range of 400 to 4000Hz and shall have an operating temperature between 32°F and 120°F. Speaker shall have power taps and voltage that are selected by rotary switches.

SPEAKER STROBE COMBINATION

The speaker strobe shall be a System Sensor SpectrAlert Advance model listed to UL1480 and UL/ULC 1971 and be approved for fire protective signaling systems. Speaker shall be capable of operating at 25.0 or 70.7 nominal Vrms selected via rotary switch, and shall have a frequency range of 400 to 4000Hz. Speaker shall have power taps which are selected by rotary switch. The strobe shall comply with the NFPA 72 requirements for visible signaling appliances, flashing at 1Hz over the strobe's entire operating voltage range. The strobe light shall consist of a xenon flash tube and associated lens/reflector system.

SYNCHRONIZATION MODULE

The module shall be a System Sensor Sync Circuit model MDL listed to UL/ULC 464 and shall be approved for fire protective service. The module shall synchronize SpectrAlert strobes at 1Hz. The module shall mount to a 4-11/16" x 4-11/16" x 2-1/8" backbox. The module shall also control two Style Y (class B) circuits or one Style Z (class A) circuit. The module shall synchronize multiple zones. Daisy chaining two or more synchronization modules together will synchronize all the zones they control. The module shall not operate on a coded power supply.

Ordering Information

NOTE: (W) indicates white coloring; (R), red.

NOTE: "A" suffix indicates ULC-Listed model.

WALL MOUNT

SP(W)(R)(A): Speaker only.

SP(W)(R)V(A): Speaker only, high dB; white.

SPS(W)(R)(A)*: Speaker strobe, selectable candela (15, 15/75, 30, 75, 95, 110, 115).

SPS(W)(R)H(A)*: Speaker strobe, selectable candela, high cd (135, 150, 177, 185).

SPS(W)(R)V(A)*: Speaker strobe, selectable candela, high dB.

CEILING MOUNT

SPC(W)(R)(A): Speaker only.

SPC(W)(R)V(A): Speaker only, high dB.

SPSC(W*)(R)(A): Speaker strobe, selectable candela (15, 15/75, 30, 50, 75, 95, 110, 115)

SPSC(W*)(R)H(A): Speaker strobe, selectable candela, high cd (135, 150, 177, 185)

SPSC(W*)(R)V(A): Speaker strobe, selectable candela, high dB (15, 15/75, 30, 50, 75, 95, 110, 115).

SPSC(W*)(R)VH(A): Speaker strobe, selectable candela, high dB, high cd (135, 150, 177, 185).

ACCESSORIES

RFP(A): Retrofit plate (5 pack), red.

RFPW(A): Retrofit plate (5 pack), white.

SPBBSC(A): Ceiling mount backbox skirt, red.

SPBBSCW(A): Ceiling mount backbox skirt, white.

SPBBS(A): Wall mount backbox skirt, red.

SPBBSW(A): Wall mount backbox skirt, white.

TR(A): Wall mount trim ring, red, package of 5.

TRW(A): Wall mount trim ring, white, package of 5.

TRC(A): Ceiling mount trim ring, red, package of 5.

TRCW(A): Ceiling mount trim ring, white, package of 5.

MWBB(A): Wall mount, metal weatherproof backbox

MWBBW(A): Wall mount, metal weatherproof backbox, white

MWBBC(A): Ceiling mount, metal weatherproof backbox

MWBBCW(A): Ceiling mount, metal weatherproof backbox, white

***NOTE:** Add -P to model number for plain housing (no 'FIRE' marking on the cover), e.g. SPSW-P

SpectrAlert® is a registered trademark of Honeywell International Inc.
©2011 by Honeywell International Inc. All rights reserved. Unauthorized use of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

Made in the U.S.A.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

Outdoor, Selectable-Output Speaker Strobes and Dual-Voltage Evacuation Speakers for Wall Applications

SpectrAlert® Advance outdoor, selectable-output speaker strobes and dual-voltage evacuation speakers meet virtually any outdoor application requirement.

Features

- Weatherproof per NEMA 4X, IP56
- Rated from -40°F to 151°F
- Plug-in design reduces ground faults
- Universal mounting plate with onboard shorting spring that tests wiring continuity before devices are installed
- Field-selectable candela settings: 15, 15/75, 30, 75, 95, 110, 115, 135, 150, 177, and 185
- Automatic selection of 12- or 24-volt operation at 15 and 15/75 candela
- Rotary switch for speaker voltage (25 and 70.7 Vrms) and power settings (1/4, 1/2, 1 and 2 watts)
- Compatible with System Sensor synchronization protocol and legacy SpectrAlert products
- Tamper-resistant construction

Agency Listings

SPECTRAlert®
ADVANCE

SpectrAlert Advance offers the broadest line of outdoor speakers and speaker strobes in the industry. From metal and plastic outdoor back boxes, to white and red plastic housings, to wall and ceiling mounting options, SpectrAlert Advance can meet virtually any application requirement.

Wall-mount outdoor speakers and speaker strobes can be used indoors or outdoors in wet or dry applications, and can provide reliable operation from -40°F to 151°F. These speakers provide a broad frequency response range, low harmonic distortion and maintain a high sound pressure level at all tap settings to provide accurate and intelligible broadcast of evacuation messages.

Like the entire SpectrAlert Advance line, wall-mount outdoor speakers and speaker strobes include a variety of features that increase application flexibility and simplify installation. First, field-selectable settings, including candela, speaker voltage and power settings, and automatic selection of 12- or 24-volt operation enable installers to easily adapt devices to meet requirements.

Next, these devices use a universal mounting plate with an onboard shorting spring that ensures wiring continuity before devices are installed, so installers can verify proper wiring without mounting the devices and exposing them to potential construction damage. Once the plates are mounted, all SpectrAlert Advance devices utilize a plug-in design with a single captured screw to speed installation and virtually eliminate costly ground faults.

Outdoor devices ship with weatherproof plastic back boxes (metal back boxes are available separately) that accommodate in-and-out wiring for daisy chaining devices. Plastic back boxes feature removable side flanges and improved resistance to saltwater corrosion. Knock-outs located on the back eliminate the need to drill holes for screw-in mounting. Plastic and metal weatherproof back boxes come with 3/4-inch top and bottom conduit entries and 3/4-inch knock-outs at the back. A screw-in NPT plug with an O-ring gasket for a watertight seal is included with each back box.

SpectrAlert® Advance Outdoor Speaker and Speaker Strobe Specifications

Architectural/Engineering Specifications

General

SpectrAlert Advance outdoor speakers and speaker strobes shall mount to a weatherproof back box. A universal mounting plate shall be used for mounting ceiling and wall products. The notification appliance circuit and amplifier wiring shall terminate at the universal mounting plate. Also, SpectrAlert Advance speaker strobes, when used with the SyncCircuit™ Module accessory, shall be powered from a non-coded notification appliance circuit output and shall operate on a nominal 12 or 24 volts. When used with the SyncCircuit Module, 12-volt-rated notification appliance circuit outputs shall operate between 9 and 17.5 volts; 24-volt-rated notification appliance circuit outputs shall operate between 17 and 33 volts. Outdoor SpectrAlert Advance products shall operate between -40°F and 151°F from a regulated DC, or full-wave rectified, unfiltered power supply.

Speaker

Speaker shall be a System Sensor SpectrAlert Advance Model _____ dual-voltage transformer speaker capable of operating at 25.0 or 70.7 nominal Vrms. Speaker shall be listed to Underwriters Laboratories Standard S4048 for outdoor fire protective signaling systems. Speaker shall have a frequency range of 400 to 4,000 Hz and shall have an operating temperature from -40°F to 150.8°F. Speaker shall have power taps and wattage settings that are selected by rotary switches. The speaker must be installed with its weatherproof back box in order to remain outdoor approved per UL listing S4048. The speaker shall be suitable for use in air handling spaces and wet environments.

Speaker Strobe Combination

The speaker strobe shall be a System Sensor Model _____ listed to UL 1638 and UL 1480 and be approved for fire protective signaling systems. Speaker shall be capable of operating at 25.0 or 70.7 nominal Vrms and shall have a frequency range of 400 to 4,000 Hz. Speaker shall have power taps that are selected by rotary switch. The strobe shall consist of a xenon flash tube with associated lens/reflector system and operate on either 12 or 24 volts. The strobe shall also feature selectable candela output, providing options for 15 or 15/75 candela when operating on 12 volts and 15, 15/75, 30, 75, 110, 115, 135, 150, 177 or 185 candela when operating on 24 volts. The strobe shall comply with the Americans with Disabilities Act requirement for visible signaling appliances, flashing at 1 Hz over the strobe's entire operating voltage range. The speaker strobe must be installed with its weatherproof back box in order to remain outdoor approved per UL. The speaker strobe shall be suitable for use in wet environments.

Physical Specifications

Operating Temperature	-40°F to 151°F (-40°C to 66°C)
-----------------------	--------------------------------

Dimensions, Wall-Mount

SPS Speaker Strobe	6.0" L x 5.0" W x 4.7" D (including lens and speaker)
--------------------	---

SP Speaker	6.0" L x 5.0" W x 2.9" D
------------	--------------------------

Dimensions, Wall-Mount Weatherproof Back Box	6.5" L x 5.5" H x 2.9" D
--	--------------------------

Electrical/Operating Specifications

Nominal Voltage (speakers)	25 V or 70.7 V (nominal)
----------------------------	--------------------------

Maximum Supervisory Voltage (speakers)	50 VDC
--	--------

Strobe Flash Rate	1 flash per second
-------------------	--------------------

Nominal Voltage (strobes)	Regulated 12 VDC/FWR or regulated 24 DC/FWR
---------------------------	---

Operating Voltage Range (includes fire alarm panels with built in sync)	8 to 17.5 V (12 V nominal) or 16 to 33 V (24 V nominal)
---	---

Operating Voltage with MDL Sync Module	9 to 17.5 V (12 V nominal) or 17 to 33 V (24 V nominal)
--	---

Frequency Range	400 to 4,000 Hz
-----------------	-----------------

Power	¼, ½, 1, 2 watts
-------	------------------

UL Current Draw Data

UL Max. Strobe Current Draw (mA RMS)					
	Candela	8 to 17.5 Volts		16 to 33 Volts	
		DC	FWR	DC	FWR
Standard Candela Range	15	123	128	66	71
	15/75	142	148	77	81
	30	NA	NA	94	96
	75	NA	NA	158	153
	95	NA	NA	181	176
	110	NA	NA	202	195
	115	NA	NA	210	205
High Candela Range	135	NA	NA	228	207
	150	NA	NA	246	220
	177	NA	NA	281	251
	185	NA	NA	286	258
Sound Output					
UL Reverberant (dBA @ 10 ft.)		2W	1W	½ W	¼ W
Outdoor Speaker		90	87	84	81
Outdoor Speaker/Strobe		89	86	83	80

Candela Derating

For K series products used at low temperatures, listed candela ratings must be reduced in accordance with this table.

Strobe Output (cd)	
Listed Candela	Candela rating at -40°F
15	Do not use below 32°F
15/75	
30	
75	
95	44
110	70
115	110
135	115
150	135
177	150
185	177
	185

Dimensions

Wall-Mount Outdoor Speaker

Wall-Mount Outdoor Speaker Strobe

Surface Mounting

Wall-Mount Speaker Strobe with Plastic Weatherproof Back Box

Wall-Mount Speaker with Plastic Weatherproof Back Box

Wall-Mount Speaker Strobe with Metal Weatherproof Back Box

Wall-Mount Speaker with Metal Weatherproof Back Box

Ordering Information for SpectrAlert® Advance Outdoor Speakers and Speaker Strobes

Wall Mount		
White	Red	Description
SPWK*	SPRK*	Outdoor Speaker (includes plastic weatherproof back box)
SPSWK*†	SPSRK*†	Outdoor Speaker Strobe, Selectable Candela (15, 15/75, 30, 75, 95, 110, 115) (includes plastic weatherproof back box)
SPSWK-CLR-ALERT	—	Outdoor Speaker Strobe, Selectable Candela (15, 15/75, 30, 75, 95, 110, 115), ALERT Printed (includes plastic weatherproof back box)
—	SPSRHK	Outdoor Speaker Strobe, Selectable Candela (135, 150, 177, 185) (Includes plastic weatherproof back box)
Accessories		
White	Red	Description
MWBBW	MWBB	Wall, Metal Weatherproof Back Box

Notes:

*Add "-R" to model number for weatherproof replacement device (no back box included), e.g., SPWK-R.

†Add "-P" to model number for plain housing (no "FIRE" marking on cover), e.g., SPSWK-P.

3825 Ohio Avenue • St. Charles, IL 60174
Phone: 800-SENSOR2 • Fax: 630-377-6495

©2011 System Sensor.
Product specifications subject to change without notice. Visit systemsensor.com for current product information, including the latest version of this data sheet.
AVDS01001 • 12/11 • #2985

FST-851 Series

Intelligent Thermal (Heat) Detectors with FlashScan®

Intelligent / Addressable Devices

General

Notifier FST-851 Series intelligent plug-in thermal detectors with integral communication has features that surpass conventional detectors. Point ID capability allows each detector's address to be set with decade address switches, providing exact detector locations. FST-851 Series thermal detectors use an innovative thermistor sensing circuit to produce 135°F/57°C fixed-temperature (FST-851) and rate-of-rise thermal detection (FST-851R) in a low-profile package. FST-851H provides fixed high-temperature detection at 190°F/88°C. These thermal detectors provide effective, intelligent property protection in a variety of applications. FST-851 Series detectors are compatible with all Notifier intelligent Fire Alarm Control Panels, except FireWarden series panels.

FlashScan® (U.S. Patent 5,539,389) is a communication protocol developed by Notifier Engineering that greatly enhances the speed of communication between analog intelligent devices and certain NOTIFIER systems. Intelligent devices communicate in a grouped fashion. If one of the devices within the group has new information, the panel's CPU stops the group poll and concentrates on single points. The net effect is response speed greater than five times that of earlier designs.

Features

- Sleek, low-profile, stylish design.
- State-of-the-art thermistor technology for fast response.
- Rate-of-rise model (FST-851R), 15°F (8.3°C) per minute.
- Factory preset at 135°F (57°C); high-temperature model at 190°F (88°C).
- Addressable by device.
- Compatible with FlashScan® and CLIP protocol systems.
- Direct dial entry of address 01-159 for FlashScan® loops, 01-99 CLIP mode loops.
- Two-wire SLC connection.
- Visible LEDs "blink" every time the unit is addressed.
- 360°-field viewing angle of the visual alarm indicators (two bi-color LEDs). LEDs blink green in Normal condition and turn on steady red in Alarm.
- Integral communications and built-in device-type identification.
- Remote test feature from the panel.
- Built-in functional test switch activated by external magnet.
- Walk test with address display (an address of 121 will blink the detector LED 12-(pause)-1).
- Low standby current.
- Backward-compatible.
- Built-in tamper-resistant feature.
- Designed for direct-surface or electrical-box mounting.
- Sealed against back pressure.
- Plugs into separate base for ease of installation and maintenance. Separate base allows interchange of photoelectric, ionization and thermal sensors.
- SEMS screws for wiring of the separate base.
- Constructed of off-white Bayblend®, designed to commercial standards, and offers an attractive appearance.

FST-851 Series in B710LP base

- 94-5V plastic flammability rating.
- Remote LED output connection to optional RA400Z remote LED annunciator.
- Optional sounder, relay, and isolator bases.
- Optional recessed (RMK400) or surface (SMK400E) base mounting kits.

Specifications

Size: 2.1" (5.3 cm) high x 4.1" (10.4 cm) diameter installed in B501 base, 6.1" (15.5 cm) diameter installed in B710LP base.

Shipping weight: 4.8 oz. (137 g).

Operating temperature range: FST-851 Series, FST-851R: -20°C to 38°C (-4°F to 100°F); FST-851H: -20°C to 66°C (-4°F to 150°F).

Detector spacing: UL approved for 50 ft. (15.24 m) center to center. FM approved for 25 x 25 ft. (7.62 x 7.62 m) spacing.

Relative humidity: 10% - 93% noncondensing.

Thermal ratings: fixed-temperature setpoint 135°F (57°C), rate-of-rise detection 15°F (8.3°C) per minute, high temperature heat 190°F (88°C).

Altitude rating: 10,000 feet.

ELECTRICAL SPECIFICATIONS:

Voltage range: 15 - 32 volts DC peak.

Standby current (max. avg.): 300 µA @ 24 VDC (one communication every 5 seconds with LED enabled).

LED current (max.): 6.5 mA @ 24 VDC ("ON").

BASES AVAILABLE:

B710LP: 6.1" (15.5 cm) diameter.

B501: 4.1" (10.4 cm) diameter.

B501BH-2 or B501BHT-2: Sounder base assembly.

B224RB Relay Base: Screw terminals: up to 14 AWG (2.0 mm²). Relay type: Form-C. Rating: 2.0 A @ 30 VDC resistive; 0.3 A @ 110 VDC inductive; 1.0 A @ 30 VDC inductive. Dimensions: 6.2" (15.748 cm) x 1.2" (3.048 cm).

B224BI Isolator Base: Dimensions: 6.2" (15.748 cm) x 1.2" (15.748 cm). Maximum: 25 devices between isolator bases. See Note 2 under Installation.

Applications

Use thermal detectors for protection of property. For further information, go to systemsensor.com for manual I56-407-00, Applications Manual for System Smoke Detectors, which pro-

vides detailed information on detector spacing, placement, zoning, wiring, and special applications.

Installation

The FST Series plug-in intelligent thermal detector uses a separate base to simplify installation, service, and maintenance. Installation instructions are shipped with each detector.

Mount base (all base types) on an electrical backbox which is at least 1.5" (3.81 cm) deep. Suitable boxes include:

- 4.0" (10.16 cm) square box.
- 3.5" (8.89 cm) or 4.0" (10.16 cm) octagonal box.
- Single-gang box (except relay or isolator base).
- With B501BH-2 or B501BHT-2 base, use a 4.0" (10.16 cm) square box.
- With B224RB or B224BI base, use a 3.5" (8.89 cm) or 4.0" (10.16 cm) octagonal box, or a 4.0" (10.16 cm) square box.

NOTE: 1) Because of the inherent supervision provided by the SLC loop, end-of-line resistors are not required. Wiring "T-taps" or branches are permitted for Style 4 (Class "B") wiring. **2)** When using relay or sounder bases, consult data sheet DN-2243 (ISO-X) for device limitations between isolator modules and isolator bases.

Agency Listings and Approvals

These listings and approvals apply to the modules specified in this document. In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL Listed:** S747
- **ULC Listed:** S6978MEA **Listed:** 383-02-E
- **FM Approved**
- **CSFM:** 7270-0028:196
- **BSMI:** CI313066760025
- **CCCF:** Certif. # 2004081801000018
- **U.S. Coast Guard:** 161.002/23/3 (AFP-200); 161.002/27/3 (AFP1010/AM2020); 161.002/42/1 (NFS-640)
- **Lloyd's Register:** 03/60011

Product Line Information

"A" suffix indicates ULC Listed model.

FST-851: Intelligent thermal detector. Must be mounted to one of the bases listed below.

FST-851A: Same as FST-851 but with ULC Listing.

FST-851R: Intelligent thermal detector with rate-of-rise feature.

FST-851RA: Same as FST-851R but with ULC Listing.

FST-851H: Intelligent high-temperature thermal detector.

FST-851HA: Same as FST-851H but with ULC Listing.

BASES:

B710LP: Standard U.S. low-profile base

B710LPBP: Standard U.S. low-profile base, pkg. of 10.

B710LP: Standard U.S. low-profile base.

B710LP(A): Standard U.S. low-profile base.

B501BP: Standard European flangeless base, pkg. of 10.

B501: Standard European flangeless base.

B501(A): Standard European flangeless base, ULC Listing.

BH501BH-2: Sounder base, includes **B501**base above.

BH501BHT-2: Same as B501BH-2, but includes temporal sounder.

BH501BHA: Sounder base, includes **B501**base above

BH501BHTA: Same as BH501BHA, but includes temporal sounder.

B224BI(A): Intelligent isolator base. Isolates SLC from loop shorts.

ACCESSORIES:

F110: Retrofit replacement flange for older style high profile bases. Converts bases for use with FlashScan® detectors.

RA400Z(A): Remote LED annunciator. 3 – 32 VDC. Fits U.S. single-gang electrical box. Supported by B710LPBP(A) and B501(A) bases only.

SMK400E: Surface mounting kit provides for entry of surface wiring conduit. For use with B501(A) base only.

RMK400: Recessed mounting kit. For use with B501(A) base only.

SMB600: Surface mounting kit for use with B710LPBP(A).

BCK-200B: Black detector covers, box of 10.

M02-04-00: Test magnet.

M02-09-00: Test magnet with telescope stick.

XR2B: Detector removal tool. Allows installation and/or removal of FlashScan® Series detector heads from base in high ceiling installations.

T55-127-010: Detector removal tool without pole.

XP-4: Extension pole for XR2B. Comes in three 5-ft. sections.

Notifier® and FlashScan® are a registered trademark of Honeywell International Inc. Bayblend® is a registered trademark of Bayer Corp. ©2009 by Honeywell International Inc. All rights reserved. Unauthorized use of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

Made in the U.S. A.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

Intelligent Non-Relay Photoelectric Duct Smoke Detector

The InnovairFlex™ Series are the only duct smoke detectors flexible enough to fit configurations from square to rectangular and everything in between.

Innovairflex™

Features

- Photoelectric, integrated low-flow technology (detector head sold separately)
- Air velocity rating from 300 ft/min to 4000ft/min (1.52m/s to 20.32m/sec)
- Versatile mounting options: square or rectangular configuration
- Broad ranges for operating temperature (–4°F to 158°F) and humidity (0% to 95% non-condensing)
- Patented sampling tube installs from front or back of the detector with no tools required
- New Cover tamper signal
- Increased wiring space with a newly added ¾-inch conduit knockout
- Available space within housing to accommodate mounting of relay module
- Clear cover for convenient visual inspection
- UL 268A listed
- Remote testing capability
- Requires com line power only

The InnovairFlex DNRECL intelligent non-relay photoelectric duct smoke detector features a pivoting housing that fits both square and rectangular footprints capable of mounting to a round or rectangular duct.

The intelligent non-relay photoelectric duct smoke detector senses smoke in the most challenging conditions, operating in airflow speeds of 300 to 4000 feet per minute, temperatures of –4°F to 158°F, and a humidity range of 0 to 95 percent (non-condensing).

An improved cover design isolates the sensor head from the low-flow feature for simple maintenance. A cover tamper feature was added to indicate a trouble signal for a removed or improperly installed sensor cover. The InnovairFlex housing provides a ¾-inch conduit knockout and ample space to facilitate easy wiring and mounting of relay module.

The InnovairFlex duct smoke detector can be customized to meet local codes and specifications without additional wiring. The new InnovairFlex product line is compatible with all previous Innovair models, including remote test accessories.

WARNING: Duct smoke detectors have specific limitations.

DUCT SMOKE DETECTORS ARE:

NOT a substitute for an open area smoke detector,
NOT a substitute for early warning detection, and
NOT a replacement for a building's regular fire detection system.
Refer to NFPA 72 and 90A for additional duct smoke detector application information.

Agency Listings

InnovairFlex Duct Smoke Detector Specifications

Architectural/Engineering Specifications

The air duct smoke detector shall be a System Sensor InnovairFlex™ DNRECL Intelligent Non-Relay Photoelectric Duct Smoke Detector. The detector housing shall be UL listed per UL 268A specifically for use in air handling systems. The flexible housing of the duct smoke detector fits both square and rectangular footprints. The detector shall operate at air velocities of 300 ft/min to 4000 ft/min (1.52 m/sec to 20.32 m/sec). The unit shall be capable of providing a trouble signal in the event that the sensor cover is removed or improperly installed. It shall be capable of remote testing using the RTS151KEY remote test station. Terminal connections shall be of the strip and clamp method suitable for 12–18 AWG wiring.

Physical Specifications

Size: (Rectangular) (Square)	14.38 in (37 cm) Length; 5 in (12.7 cm) Width; 2.5 in (6.35 cm) Depth
	7.75 in (19.7cm) Length; 9 in (22.9cm) Width ; 2.5 in (6.35cm) Depth
Weight:	1.6 lb (0.73 kg)
Operating Temperature Range:	–4°F to 158°F (–20°C to 70°C)
Storage Temperature Range:	–22°F to 158°F (–30°C to 70° C)
Operating Humidity Range:	0% to 95% relative humidity (non-condensing)
Air Duct Velocity:	100 to 4000 ft/min (0.5 to 20.32 m/s)

Electrical Ratings

Please see detector head installation manual for electrical specifications

Accessory Current Loads at 24 VDC

Device	Standby	Alarm
RA100Z	0 mA	12 mA Max.
RTS151/RTS151KEY	0 mA	12 mA Max.

Installing the InnovairFlex Sampling Tube

The InnovairFlex sampling tube may be installed from the front or back of the detector. The tube locks securely into place and can be removed by releasing the front or rear locking tab (front locking tab shown below right).

Wiring for Intelligent Non-Relay Duct Smoke Detector

System wiring diagram for DNRECL:

DNRECL to RA100Z:

DNRECL to RTS151/RTS151KEY with "R" Remote Test Capable Detector Head Option::

Accessories

System Sensor provides system flexibility with a variety of accessories, including two remote test stations and different means of visible and audible system annunciation. As with our duct smoke detectors, all duct smoke detector accessories are UL listed.

RTS151 UL S2522

RTS151KEY UL S2522

RA100Z UL S2522

Ordering Information

Part No.	Description
DNRECL	Intelligent non-relay photoelectric low-flow duct smoke detector
Accessories	
DST1	Metal sampling tube duct width up to 1ft (0.3m)
DST1.5	Metal sampling tube duct widths 1 ft to 2 ft (0.3 to 0.6 m)
DST3	Metal sampling tube duct widths 2 ft to 4 ft (0.6 to 1.2 m)
DST5	Metal sampling tube duct widths 4 ft to 8 ft (1.2 to 2.4 m)
DST10	Metal sampling tube duct widths 8 ft to 12 ft (2.4 to 3.7 m)
DH400OE-1	Weatherproof enclosure
M02-04-00	Test magnet
P48-21-00	End cap for metal sampling tubes
RA100Z	Remote annunciator alarm LED
RTS151	Remote test station
RTS151KEY	Remote test station with key lock

3825 Ohio Avenue • St. Charles, IL 60174
Phone: 800-SENSOR2 • Fax: 630-377-6495

©2010 System Sensor.
Product specifications subject to change without notice. Visit systemsensor.com for
current product information, including the latest version of this data sheet.
HVD500200 • 7/10 • #2443

FTM-1(A)

Firephone Control Module FlashScan® Mode Only

Intelligent/Addressable Devices

General

The FTM-1 Addressable Firephone Control Module (FlashScan® only) gives NOTIFIER's NFS-640, NFS2-640, NFS-3030, NFS2-3030 control panels the capability to monitor and control a circuit of up to two firefighter phones. The FTM-1 has the ability to differentiate between normal, off-hook, and trouble conditions. This module is used to connect a remote firefighter telephone to a centralized telephone console. A ringing sound is provided at each off-hook handset until it is connected to the console. The user can then connect that off-hook phone to the main riser for the voice evac system.

Wiring to individual telephone jacks and handsets is supervised, and status is reported to the panel as NORMAL, TROUBLE, or OFF HOOK. This module has two pairs of output termination points available for fault-tolerant wiring (Style Z), and includes a panel-controlled LED indicator.

FlashScan® (U.S. Patent 5,539,389) is a communication protocol that greatly increases the speed of communication between analog intelligent devices. Intelligent devices communicate in a grouped fashion. If one of the devices within the group has new information, the panel CPU stops the group poll and concentrates on single points. The net effect is response speed greater than five times that of other protocols.

Features

- Supports two firefighter telephones in either NFPA Style Y or Style Z (Fault Tolerant) telephone circuits.
- Direct-dial entry of address 01– 159 for FlashScan®.
- Built-in type identification automatically identifies itself to the control panel.
- Internal circuitry and relay powered directly by two-wire SLC loop.
- Integral LED “blinks” green each time a communication is received from the control panel.
- LED blink may be deselected globally (affects all devices).
- High noise immunity (EMF/RFI).
- Wide viewing angle of LED.
- SEMS screws with clamping plates for wiring ease.

Construction

- The face plate is made of off-white Noryl®.
- Controls include two rotary switches for direct-dial entry of address (01-159).
- The FTM-1 is configured for either a single Class B (Style Y) or Class A (Style Z) telephone circuit.

Agency Listings and Approvals

These listings and approvals apply to the modules specified in this document. In some cases, certain modules or applications may not be listed by certain approval agencies, or listing may be in process. Consult factory for latest listing status.

- **UL Listed:** S635
- **ULC Listed:** S635 (FTM-1A)
- **FM Approved**
- **CSFM:** 7300-1653:0182, 7165-0028:0224, 7165-0028:0243
- **FDNY:** COA #6065, #6067

Operation

The FTM-1 uses one of 159 possible module addresses on a SLC loop. It responds to regular polls from the control panel and reports its type and status, including NORMAL, TROUBLE, or OFF HOOK status of its telephone circuits. The LED blinks with each poll received.

Upon code command from the panel, the FTM-1 will disconnect the supervision and connect the telephone riser to its telephone circuit. The telephone riser is always relay isolated from the communication loop so that a trouble condition on the riser will never interfere with the rest of the system.

Rotary switches set a unique address for each module. The address may be set before or after mounting. The built-in TYPE CODE (not settable) will identify the module to the control panel.

Specifications

Normal operating voltage: 15 to 32 VDC.

Maximum current draw: 7.5 mA (LED on).

Average operating current: 7.5 mA group poll (FlashScan® mode) with LED flashing.

External supply voltage (*between Terminals T3 and T4*): maximum 28 VDC.

EOL resistance: 3.9K ohms.

Temperature range: 32°F to 120°F (0°C to 49°C).

Humidity range: 10% to 93% non-condensing.

Dimensions: 4.5" (11.43 cm) high x 4" (10.16 cm) wide x 1.25" (3.175 cm) deep. Mounts to a 4" (10.16 cm) square x 2.125" (5.398 cm) deep box.

Weight: 6.3 oz.

SOFTWARE COMPATIBILITY

- NFS-640 - As of Version 3.1.3
- NFS2-640 - As of version 10.0
- NFS-3030 - As of Version 2.2.9
- NFS2-3030 - As of version 10.0
- LCM - As of Version 2.3.7

Product Line Information

FTM-1: Intelligent Addressable Firephone Control Module, 3.9K ohm End-of-Line Resistor included.

FTM-1A: Same as FTM-1 with ULC listing.

SMB500: Optional Surface-Mount Electrical Backbox.

CB500: Control Module Barrier — required by UL for separating power-limited and non-power-limited wiring in the same junction box as FTM-1.

Notifier® and FlashScan® are registered trademarks of Honeywell International Inc. Microsoft® and Windows® are registered trademarks of Microsoft Corporation.

©2011 by Honeywell International Inc. All rights reserved. Unauthorized use of this document is strictly prohibited.

This document is not intended to be used for installation purposes.
We try to keep our product information up-to-date and accurate.
We cannot cover all specific applications or anticipate all requirements.
All specifications are subject to change without notice.

For more information, contact Notifier. Phone: (203) 484-7161, FAX: (203) 484-7118.
www.notifier.com

Made in the U.S. A.

SSM/SSV Series Alarm Bells

System Sensor's SSM and SSV series alarm bells are low current, high decibel notification appliances for use in fire and burglary systems or other signaling applications.

Features

- Approved for indoor and outdoor use
- Low current draw
- High dB output
- Available in six-inch, eight-inch, and ten-inch sizes
- AC and DC models
- DC models polarized for use with supervision circuitry
- Mount directly to standard four-inch square electrical box indoors
- SSM and SSV series come pre-wired

Reliable Performance. The SSM and SSV series provide loud resonant tones. The SSM series operates on 24VDC and are motor driven, while the SSV series operates on 120VAC utilizing a vibrating mechanism.

Simplified Installation. For indoor use, the SSM and SSV series mount to a standard four-inch square electrical box. For outdoor applications, weatherproof back box, model number WBB, is used.

The SSM and SSV series come pre-wired, to reduce installation time. The SSM series incorporates a polarized electrical design for use with supervision circuitry.

Agency Listings

SSM/SSV Specifications

Architectural/Engineering Specifications

Model shall be a SSM or SSV Series alarm bell. Bells shall have underdome strikers and operating mechanisms. Gongs on said bells shall be no smaller than nominal 6"8"/10" (specify size) with an operating voltage of 24VDC or 120VAC (specify by part number). Bells shall be suitable for surface or semi-flush mounting. Outdoor surface mounted installations shall be weatherproof (using optional WBB weatherproof electrical box). Otherwise bells shall mount to a standard 4" square electrical box having a maximum projection of 2½". Bells shall be located as shown on the drawings or as determined by the Authority Having Jurisdiction. Bells shall be listed for indoor/outdoor use by Underwriters Laboratories and the California State Fire Marshal, and approved by Factory Mutual and MEA.

Physical/Operating Specifications

Operating Temperature Range	-31°F to 140°F
Operating Voltage	SSM series: 24 VDC SSV series: 120 VAC
Termination	Provided with 2 sets of leads for in/out wiring
Service Use	Fire Alarm, General Signaling, Burglar Alarm
Warranty	3 years

Electrical Specifications

Model	Gong Diameter (inches)	Nominal Voltage	Operating Voltage Limit	Maximum Current	Sound Output (dBA)
SSM24-6	6	Regulated 24VDC	16 to 33VDC	DC-31.1mA/ FWR-53.5mA	82
SSM24-8	8	Regulated 24VDC	16 to 33VDC	DC-31.1mA/ FWR-53.5mA	80
SSM24-10	10	Regulated 24VDC	16 to 33VDC	DC-31.1mA/ FWR-53.5mA	81
SSV120-6	6	Regulated 120VAC	96 to 132VAC	53mA	85
SSV120-8	8	Regulated 120VAC	96 to 132VAC	53mA	82
SSV120-10	10	Regulated 120VAC	96 to 132VAC	53mA	82

* Sound output measured at Underwriter Laboratories, as specified in UL464

Ordering Information

UL/FM Model No.	ULC/Canadian Model No.	Description
SSM24-6	SSM24-6A	Bell, 6", 24VDC, Polarized, 82dBA
SSM24-8	SSM24-8A	Bell, 8", 24VDC, Polarized, 80dBA
SSM24-10	SSM24-10A	Bell, 10", 24VDC, Polarized, 81dBA
SSV120-6	SSV120-6A	Bell, 6", 120VAC, 85dBA
SSV120-8	SSV120-8A	Bell, 8", 120VAC, 82dBA
SSV120-10	SSV120-10A	Bell, 10", 120VAC, 82dBA
WBB		Weatherproof back box for SSM and SSV series, when installed outdoors

3825 Ohio Avenue • St. Charles, IL 60174
Phone: 800-SENSOR2 • Fax: 630-377-6495

©2011 System Sensor.
Product specifications subject to change without notice. Visit systemsensor.com for current product information, including the latest version of this data sheet.
A05-0260-010 • 08/11 • #2870

OSID Smoke Detection

Open-area Smoke Imaging Detection (OSID) by Xtralis is a new innovation in projected beam smoke detection technology. By using advanced dual wavelength projected beams and optical imaging technology for early warning smoke detection, OSID provides a low-cost, reliable and easy-to-install solution that overcomes typical beam detection issues such as false alarm incidents and alignment difficulties.

Unique Detection Technology

The OSID system measures the level of smoke entering beams of light projected over an area of protection. A single OSID Imager can detect up to seven Emitters to provide a wide coverage area. Two innovations in smoke detection technology have been developed for the revolutionary OSID smoke detector:

Dual Wavelength Particle Detection

The beam projected from each Emitter contains a unique sequence of ultraviolet (UV) and infrared (IR) pulses that are synchronised with the Imager and enable the rejection of any unwanted light sources.

By using two wavelengths of light to detect particles, the system is able to distinguish between particle sizes. The shorter UV wavelength interacts strongly with both small and large particles while the longer IR wavelength is affected only by larger particles. Dual wavelength path loss measurements therefore enable the detector to provide repeatable smoke obscuration measurements, while rejecting the presence of dust particles or solid intruding objects.

Optical Imaging with a CMOS Imaging Chip

An optical imaging array in the OSID Imager provides the detector with a wide viewing angle to locate and track multiple Emitters. Consequently, the system can tolerate a much less precise installation and can compensate for the drift caused by natural shifts in building structures.

Optical filtering, high-speed image acquisition and intelligent software algorithms also enable the OSID system to provide new levels of stability and sensitivity with greater immunity to high level lighting variability.

Operation

Status information (Fire Alarm, Trouble and Power) is communicated through the Imager via Status LEDs, dedicated Trouble and Alarm relays, and the Remote Indicator interface. Specific Trouble (Fault) conditions are identified through coded flashes of the Trouble LED.

An internal heating option is also provided on the Imager to prevent condensation on the optical surface, and a reset input enables an external signal to reset the device.

Simple Installation and Maintenance

The OSID system consists of up to seven Emitters, for the 45° and 90° Imager units, located along the perimeter of the protected area, and an Imager mounted opposite. Each component can be mounted directly to the surface or can be secured with the supplied mounting brackets. Battery powered Emitters with up to five years battery life are also available to reduce installation time and cost.

Features

- Maximum detection range of 150 m (492 ft) for the OSI-10
- Status LEDs for Fire, Trouble and Power
- High false alarm immunity
- Dust and intrusive solid object rejection
- Easy alignment with large adjustment and viewing angles
- No need for precise alignment
- Tolerant of alignment drift
- Automatic commissioning in under ten minutes
- Simple DIP switch configuration
- Dual wavelength LED-based smoke detection
- Simple and easy maintenance requirements
- Conventional alarm interface for straightforward fire system integration
- Three selectable alarm thresholds

Listings/Approvals

- UL
- ULC
- AFNOR
- CE - EMC and CPD
- VdS
- ActivFire
- Major Agency Approvals pending

OSID Smoke Detection

On the Imager, a termination card provides all field wiring terminals, and DIP switches enable the user to configure the detector for particular applications.

Alignment of the Emitter is simply achieved using a laser alignment tool to rotate the optical spheres until the laser beam projected from the alignment tool is close to the Imager.

The Imager is aligned in a similar way so that its Field of View (FOV) encompasses all Emitters. A Trouble or Fault will be indicated if an Emitter is missing or outside the Imager field of view.

The OSID system is highly tolerant to dust and dirt and requires little maintenance in practice. Preventative maintenance is limited to occasionally cleaning the optical faces of the detector components.

Configuration Options

OSID systems may be configured to suit a range of detection spaces by selecting the number of Emitters and type of Imager. Each type of Imager differs by the lens used in the unit, which determines the field of view and range of the system.

Imager	Field of View		Detection Range				Max. Number of Emitters
	Horizontal	Vertical	Standard Power		High Power		
			Min	Max	Min	Max	
10°	7°	4°	30 m (98 ft)	150 m (492 ft)	--	--	1
45°	38°	19°	15 m (49 ft)	60 m (197 ft)	30 m (98 ft)	120 m (393 ft)	7
90°	80°	48°	6 m (20 ft)	**34 m (111 ft)	12 m (39 ft)	**68 m (223 ft)	7

** Maximum Distances measured for the Center Field of View of the Imager. For more details on distances for the Imager, see the OSID Product Guide.

Emitter / Imager Dimensions

Ordering Codes

OSI-10	Imager - 7° coverage	OSID-INST	OSID Installation Kit
OSI-45	Imager - 38° coverage	OSP-001	FTDI Cable 1.5m
OSI-90	Imager - 80° coverage	OSP-002	Laser Alignment tool
OSE-SP	Emitter - Standard Power		
OSE-SPW	Emitter - Standard Power, Wired		
OSE-HPW	Emitter - High Power, Wired		

Specifications

Supply Voltage

20 to 30 VDC (24 VDC nominal)

Imager Current Consumption

Nominal (at 24 VDC):

8mA (1 Emitter)

10mA (7 Emitters)

Peak (at 24 VDC) during training mode:
31mA

Emitter Current Consumption

Wired Version (at 24 VDC):

350µA Std Power, 800µA High Power

Battery Version:

Built-in 5 Year Battery

Field Wiring

Cable Gauge

0.2 - 4mm² (26-12 AWG)

Alarm Threshold Levels:

Low - Highest sensitivity / earliest alarm:
20% (0.97 dB)

Medium - Medium sensitivity:

35% (1.87 dB)

High - Lowest sensitivity / maximum immunity to nuisance smoke conditions:
50% (3.01 dB)

Adjustment Angle

±60° (horizontal)

±15° (vertical)

Maximum Misalignment Angle

±2°

Dimensions (WHD)

Emitter / Imager:

198 mm x 130 mm x 96 mm

(7.80 in. x 5.12 in. x 3.78 in.)

Operating Conditions*

Temperature:

-10 °C to 55 °C (14 °F to 131 °F)*

Humidity:

10 to 95% RH (non-condensing)

Please consult your Xtralis office for operation outside these parameters.

IP Rating

IP 44 for Electronics

IP 66 for Optics Enclosure

Status LEDs

Fire Alarm (Red)

Trouble / Power (Bi-color Yellow / Green)

Approvals Compliance

Please refer to the Product Guide for details regarding compliant design, installation and commissioning.

* Product UL listed for use from 0°C to 39°C (32°F to 103°F)

www.xtralis.com

The Americas +1 781 740 2223 **Asia** +852 2916 8894 **Australia and New Zealand** +61 3 9936 7000
Europe, Middle East & Africa +44 1442 242 330

The contents of this document are provided on an "as is" basis. No representation or warranty (either express or implied) is made as to the completeness, accuracy or reliability of the contents of this document. The manufacturer reserves the right to change designs or specifications without obligation and without further notice. Except as otherwise provided, all warranties, express or implied, including without limitation any implied warranties of merchantability and fitness for a particular purpose are expressly excluded.

This document includes registered and unregistered trademarks. All trademarks displayed are the trademarks of their respective owners. Your use of this document does not constitute or create a licence or any other right to use the name and/or trademark and/or label.

This document is subject to copyright owned by Xtralis AG ("Xtralis"). You agree not to copy, communicate to the public, adapt, distribute, transfer, sell, modify or publish any contents of this document without the express prior written consent of Xtralis.

Doc. No. 15211_18

Part No. 29573

OSID
by **xtralis**

ATTACHMENT 2: FIRE ALARM AND VOICE EVACUATION SYSTEM
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52

Attachment 2: Fire Alarm and Voice Evacuation System

See attached Fire Alarm and Voice Evacuation System designed by Deep Blue Integration. This was the design as of February 2012 and may not accurately reflect the current design.

Pages	Drawing Index	
1	FA0.0	COVER
1	FA1.0	RISER DIAGRAM
1	FA3.01W	FIRST FLOOR WEST
1	FA3.02E	SECOND FLOOR EAST
1	FA3.02W	SECOND FLOOR WEST
1	FA3.03E	THIRD FLOOR EAST
1	FA3.03W	THIRD FLOOR WEST
1	FA3.04E	FOURTH FLOOR EAST
1	FA3.04W	FOURTH FLOOR WEST
1	FA3.05E	FIFTH FLOOR EAST
1	FA3.05W	FIFTH FLOOR WEST
1	FA3.06E	SIXTH FLOOR EAST
1	FA3.07E	SEVENTH FLOOR EAST
1	FA4.0	CALCULATIONS
1	FA5.0	DETAILS

Attachment 2 contains 15 pages total.

GENERAL NOTES

1. NOTIFICATION DEVICES CANNOT BE T-TAPPED. ADDRESSABLE (IDC) DEVICES CAN BE T-TAPPED. ALL FIRE ALARM CABLING SHALL BE RUN FROM DEVICE TO DEVICE, WITH NO SPLICES. ANY REQUIRED TERMINATIONS MUST BE MADE IN APPROVED BOX.

2. ALL INTERIOR INITIATING DEVICES, NOTIFICATION DEVICES, AND MODULES REQUIRE 4"SQUARE SPECIAL DEEP BACK BOXES U.O.N.

3. PANEL BACK BOXES AND OTHER LISTED BACK BOXES SHALL BE PROVIDED TO THE EC BY DBI. ALL CONTROL PANELS, POWER SUPPLIES, AND BATTERY BOXES SHALL UTILIZE ONLY FACTORY KNOCKOUTS NEAR THE TOP OF THE CAN TO ALLOW PLACEMENT OF BATTERIES.

4. ALL FIRE ALARM CONDUIT TO BE $\frac{3}{4}$ " EMT MINIMUM U.O.N. FIRE ALARM CONDUIT SHALL BE SEPARATE FROM CONDUIT SYSTEM FOR SECURITY ALARM CABLING AND OTHER SYSTEMS.

5. WALL MOUNT AUDIO/VISUAL DEVICES SHALL BE MOUNTED 80" AFF TO BOTTOM OF THE STROBE LENS.

6. MANUAL PULL STATIONS SHALL BE MOUNTED 48" AFF TO CENTERLINE OF BOX. MPS SHALL BE DOUBLE ACTION AND KEYED THE SAME AS THE FACP.

7. DEDICATED 120 VAC CIRCUIT WITH LOCKOUT @ BREAKER TO BE PROVIDED BY OTHERS AT LOCATION OF PANELS AND POWER SUPPLIES.

8. KNOX BOX, PIV, SUPERVISORY SWITCHES, FLOW SWITCHES, SOLENOIDS, AND SPRINKLER BELLS SHALL BE PROVIDED BY OTHERS.

9. SMOKE DETECTORS SHALL NOT BE PLACED WITHIN 3' OF ANY SUPPLY AIR REGISTER OR WHERE THE AIR MOVEMENT EXCEEDS THE MANUFACTURER'S LISTING.

10. FIRE FIGHTER TELEPHONE RISER IS CLASS A, STYLE Z

11. VOLTAGE DROP CALCULATIONS FOR NOTIFICATION DEVICES ARE BASED ON THE LAYOUT SHOWN. DEVIATION FROM THESE PLANS COULD RESULT IN ADDITIONAL CONDUIT WORK, REENGINEERING, UPSIZED CABLE AND/OR ADDITIONAL POWER REQUIREMENTS.

12. PAINT ALL FIRE ALARM JUNCTION BOXES AND COVERS RED IN UNFINISHED AREAS (IE ABOVE CEILINGS, MECHANICAL ROOMS ETC.) IN FINISHED AREAS CONDUIT AND JUNCTION BOXES CAN BE PAINTED TO MATCH THE ROOM FINISH, THE INSIDE COVER IF THE JUNCTION BOX MUST BE IDENTIFIED AS "FIRE ALARM" AND THE CONDUIT MUST HAVE PAINTED RED BANDS $\frac{3}{4}$ " WIDE AT 10' CENTERS AND AT EACH SIDE OF A FLOOR, WALL, OR CEILING PENETRATION.

13. UPON COMPLETION OF INSTALLATION OF THE FIRE ALARM SYSTEM A SATISFACTORY TEST OF THE ENTIRE SYSTEM SHALL BE MADE IN THE PRESENCE OF THE AUTHORITY HAVING JURISDICTION (AHJ).

14. ALL NOTIFICATION DEVICES SHALL BE SYNCHRONIZED.

15. A STAMPED SET OF APPROVED FIRE ALARM PLANS SHALL BE AT THE JOBSITE AND USED FOR INSTALLATION.

16. SIGNALING LINE CIRCUIT IS CLASS B, STYLE 4

17. NOTIFICATION APPLIANCE CIRCUIT IS CLASS B, STYLE Y

CODE REGULATIONS

CALIFORNIA CODE OF REGULATIONS		
Applicable Codes (Latest Edition)		
2007	Building Standards Administrative Code	Title 24 Part 1
2007	California Building Code (CBC)	Title 24 Part 2
2007	California Electrical Code (CEC)	Title 24 Part 3
2007	California Mechanical Code (CMC)	Title 24 Part 4
2007	California Plumbing Code (CPC)	Title 24 Part 5
2007	California Energy Code	Title 24 Part 6
2010	California Elevator Safety Construction Code	Title 24 Part 7
2007	California Historical Building Code	Title 24 Part 8
2007	California Fire Code (CFI)	Title 24 Part 9
2007	California Referenced Standards Code	Title 24 Part 12

Applicable Standards & Guides (Latest Edition)	
2007 Automatic Sprinkler Systems	NFPA 13
2007 Stationary Pumps	NFPA 20
2007 National Fire Alarm Codes (California Amended)	NFPA 72
2002 Standard for Installation of Air-Conditioning	NFPA 90A
2006 Standard for Installation of Warm Air Heating	NFPA 90B

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CALIFORNIA 93047
FIRE ALARM & VOICE EVACUATION SYSTEM

SITE PLAN

PROJECT DESCRIPTION

1. Occupancy type : B, A, and H3

2. System Type : Class B, addressable, manual

3. Method of communication : Telephone

4. Scope of work: New Manual Fire Alarm System for new laboratory building.

5. Fire Alarm System is exempt from CA SB575 Green Oaks Family Academy Elementary School Fire Protection Act.

SEQUENCE OF OPERATIONS MATRIX

EVENT	ACTION														
	SUPERVISORY CONDITION (T F) (F)	TRouble CONDITION (T F) (F)	NOTIFY THE FIRE ALARM ANNUNCIATOR	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY	ACTIVATE SHUNT TRIP POWER SUPPLY
FIRE ALARM CONTROL UNIT															
PANEL SUPERVISORY CONDITION (TEST BYPASS) ON ACM 24 AT	X		X						X						X
PANEL TROUBLE CONDITION (AC POWER FAIL, LOW BATTERY, OPEN CIRCUIT, GROUND FAULT, ETC.)		X	X	X						X	X				X
PANEL ALARM CONDITION			X	X	X				X						X
MANUAL PULL STATION ACTIVATION			X	X	X										X
SPOT SMOKE DETECTOR ACTIVATION			X	X	X										X
DUCT SMOKE DETECTOR ACTIVATION			X	X	X					X	X				X
AIR HANDLING UNIT DUCT SMOKE DETECTOR ACTIVATION			X	X	X				X						X
SPRINKLER WATER FLOW ACTIVATION	X	X	X	X	X			X	X						X
SPRINKLER TAMPER SWITCH	X		X							X					X
FIRE PUMP RUNNING		X		X							X				X
FIRE PUMP LOSS OF PH ASE	X	X		X							X				X
FIRE PUMP PHASE REVERSAL	X										X				X
HEAT DETECTOR ACTIVATION (ELEVATOR EQUIPMENT)			X	X	X							X			X
ELEVATOR LOBBY EMR SMOKE			X	X	X			X	X			X			X
SHUNT TRIP POWER SUPERVISION	X		X	X	X					X	X				X

SYMBOL LEGEND

COUNT	FIRE ALARM SYMBOLS		CSFM LISTING #
29		MANUAL PULL STATION	7150-0028:0199
72		STROBE ONLY	7320-1653:201
151		SPEAKER/STROBE	7320-1653:201
6		SPEAKER ONLY	7320-1653:201
6		SPEAKER - WEATHER PROOF	7320-1653:201
1		BELL	BY OTHERS
2		HEAT DETECTOR	7270-0028:196
16		SMOKE DETECTOR	7272-0028:206
61		SMOKE DETECTOR - DUCT	3242-1653:209
1		FIRE ALARM CONTROL PANEL	7165-0028:0243
5		REMOTE NOTIFICATION POWER SUPPLY	7315-0028:248
3		FIRE ALARM TERMINAL CABINET	N/A
32		END OF LINE RESISTOR	N/A
2		REMOTE ANNUNCIATOR	7120-0028:209
8		MAGNETIC DOOR HOLDER	BY OTHERS
62		ADDRESSABLE MODULE	7300-0028:0219
8		RELAY MODULE	7300-0028:219
16		WATER FLOW SWITCH	BY OTHERS
16		VALVE TAMPER SWITCH	BY OTHERS
18		DUAL MONITOR MODULE	7300-0028:0219
12		FIRE FIGHTER'S PHONE JACKS	7300-1652:0182
4		DIGITAL AUDIO AMPLIFIERS	7170-0028:223/224

WIRING LEGEND

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01W
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02W
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03W
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04W
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05W
12	SIXTH FLOOR EAST	FA 3.06E
13	SEVENTH FLOOR EAST	FA 3.07E
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

FIRE ALARM COVER SHEET

Consulting - Design - Installation
Service - Monitoring
Deep Blue Integration, Inc
47 S Tassajara Drive
San Luis Obispo, CA 93405
C-10, C-16 #943465 ACO#6864
Toll Free: 888-6000-DBI FAX:
805-781-2037
www.deepblueintegration.com

Revisions

REVISION COMMENTS	DATE	SYMBOL	DESCRIPTION
	6/14/2011		

DESIGNED BY:
LAURA PADLE

DRAWN BY:
LAURA PADLE

CHECKED BY:
CURTIS STREETER, SET MNET IV #10272

PROJECT ENGINEER:

January 5, 2012

DATE:

1/8" = 1'0" (U.O.M.)

SCALE:

DRAWING CODE:

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA

CSFM #18-40-03-0001

SHEET ID

FA-0

SHEET 1 OF 15

SYMBOL LEGEND

COUNT	FIRE ALARM SYMBOLS	CSFM LISTING #
29	[F]	MANUAL PULL STATION 7150-0028:0199
72	[V]	STROBE ONLY 7320-1653:201
151	[V]	SPEAKER/STROBE 7320-1653:201
6	[F]	SPEAKER ONLY 7320-1653:201
6	[WP]	SPEAKER - WEATHER PROOF 7320-1653:201
1	[B]	BELL BY OTHERS
2	[H]	HEAT DETECTOR 7270-0028:196
16	[S]	SMOKE DETECTOR 7272-0028:206
61	[S] _D	SMOKE DETECTOR - DUCT 3242-1653:209
1	[FACP]	FIRE ALARM CONTROL PANEL 7165-0028:0243
5	[RNPS]	REMOTE NOTIFICATION POWER SUPPLY 7315-0028:248
3	[FATC]	FIRE ALARM TERMINAL CABINET N/A
32	[RL]	END OF LINE RESISTOR N/A
2	[RA]	REMOTE ANNUNCIATOR 7120-0028:209
8	[MD]	MAGNETIC DOOR HOLDER BY OTHERS
62	[AM]	ADDRESSABLE MODULE 7300-0028:0219
8	[RM]	RELAY MODULE 7300-0028:219
16	[WFS]	WATER FLOW SWITCH BY OTHERS
16	[VTS]	VALVE TAMPER SWITCH BY OTHERS
18	[FDM]	DUAL MONITOR MODULE 7300-0028:0219
12	[FJ]	FIRE FIGHTER'S PHONE JACKS 7300-1652:0182
4	[DAA2]	DIGITAL AUDIO AMPLIFIERS 7170-0028:223/224

GENERAL NOTES:

1. The Notification Appliance Circuits vary between 14 AWG and 12 AWG, see voltage drops for correct sizing.

SHEET NOTES:

- 1 The fire alarm control panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The control panel cabinet shall be grounded securely to either a cold water pipe or grounding rod.
- 2 The riser going between floors will be in 2" conduit or larger.
- 3 6.10.1.16* All circuits necessary for the operation of two-way telephone communication systems shall be installed using one of the following methods:
- (1) A 2-hour fire rated circuit integrity (CI) cable
 - (2) A 2-hour fire rated cable system (electrical circuit protective system)
 - (3) A 2-hour fire rated enclosure
 - (4) Performance alternatives approved by the authority having jurisdiction
 - (5) Buildings fully protected by an automatic sprinkler system installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, with the wiring or cables installed in metal raceways and in accordance with Article 760 of NFPA 70
- A.6.10.1.16 One or more of the following means might be considered acceptable to provide a level of survivability consistent with the intent of this requirement:
- (1) Routing two-way telephone circuits separately
 - (2) Using short-circuit fault tolerant circuits

Consulting - Design - Installation
Service - Monitoring
Deep Blue Integration, Inc
47 S Tassajara Drive
San Luis Obispo, CA 93405
C-10, C-16 #943465 ACO#6864
Toll Free: 888-600-0811 FAX:
805-731-1237
www.deepblueintegration.com

Revisions

REVIEW COMMENTS	DATE	APPROVED	SYMBOL
6/14/2011			

DESIGNED BY:
LAURA RADLE

DRAWN BY:
LAURA RADLE

CHECKED BY:
CURTIS STREETER, SET NCET IV #102672

DATE:
January 9, 2012

SCALE:
1/8" = 10' (U.O.N.)

DRAWING CODE:
PROJECT ENGINEER

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA

CSFM #18-40-03-0001

SHEET ID

FA 1.0

SHEET 2 OF 15

FIRE ALARM RISER DIAGRAM

WIRING LEGEND

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTER'S PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01W
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02W
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03W
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04W
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05W
12	SIXTH FLOOR EAST	FA 3.06E
13	SEVENTH FLOOR EAST	FA 3.07E
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

SYMBOL LEGEND

COUNT	FIRE ALARM SYMBOLS		CSFM LISTING
29		MANUAL PULL STATION	7150-0028:0199
72		STROBE ONLY	7320-1653:201
151		SPEAKER/STROBE	7320-1653:201
6		SPEAKER ONLY	7320-1653:201
6	<i>WP</i>	SPEAKER - WEATHER PROOF	7320-1653:201
1		BELL	BY OTHERS
2		HEAT DETECTOR	7270-0028:196
16		SMOKE DETECTOR	7272-0028:206
61		SMOKE DETECTOR - DUCT	3242-1653:209
1		FIRE ALARM CONTROL PANEL	7165-0028:0243
5		REMOTE NOTIFICATION POWER SUPPLY	7315-0028:248
3		FIRE ALARM TERMINAL CABINET	N/A
32		END OF LINE RESISTOR	N/A
2		REMOTE ANNUNCIATOR	7120-0028:209
8		MAGNETIC DOOR HOLDER	BY OTHERS
62		ADDRESSABLE MODULE	7300-0028:0219
8		RELAY MODULE	7300-0028:219
16		WATER FLOW SWITCH	BY OTHERS
16		VALVE TAMPER SWITCH	BY OTHERS
18		DUAL MONITOR MODULE	7300-0028:0219
12		FIRE FIGHTER'S PHONE JACKS	7300-1652:0182
4		DIGITAL AUDIO AMPLIFIERS	7170-0028-223/2

WIRING LEGEND

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01
4	SECOND FLOOR EAST	FA 3.02
5	SECOND FLOOR WEST	FA 3.02
6	THIRD FLOOR EAST	FA 3.03
7	THIRD FLOOR WEST	FA 3.03
8	FOURTH FLOOR EAST	FA 3.04
9	FOURTH FLOOR WEST	FA 3.04
10	FIFTH FLOOR EAST	FA 3.05
11	FIFTH FLOOR WEST	FA 3.05
12	SIXTH FLOOR EAST	FA 3.06
13	SEVENTH FLOOR EAST	FA 3.07
14	CALCULATIONS	FA 4.0
15	DETAIL S	FA 5.0

[illegible]

DESIGNED BY: LAURA RADLE	DATE: January 9, 2012
DRAWN BY: LAURA RADLE	SCALE: 1/8" = 1'0" (U.O.N.)
CHECKED BY:	DRAWING CODE:
CURTIS STREETER, SET NOCET IV #102672	
PROJECT ENGINEER:	

**CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY**

SFM #18-40-03-0001

SHEET ID

FA 3.01W

↑ FIRE ALARM FIRST FLOOR WEST
SCALE 1/8" = 1'0"

Revisions

REVIEW COMMENTS	DATE	DESCRIPTION	SYMBOL
	6/14/2011		

DESIGNED BY:
LAURA RADLE

DRAWN BY:
LAURA RADLE

CHECKED BY:
CURTIS STREETER, SET NCT IV #102672

PROJECT ENGINEER:

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA

CSF# #18-40-03-0001

SYMBOL LEGEND

COUNT	FIRE ALARM SYMBOLS	CSFM LISTING #
29	MANUAL PULL STATION	7150-0028:0199
72	STROBE ONLY	7320-1653:201
151	SPEAKER/STROBE	7320-1653:201
6	SPEAKER ONLY	7320-1653:201
6	SPEAKER - WEATHER PROOF	7320-1653:201
1	BELL	BY OTHERS
2	HEAT DETECTOR	7270-0028:196
16	SMOKE DETECTOR	7272-0028:206
61	SMOKE DETECTOR - DUCT	3242-1653:209
1	FIRE ALARM CONTROL PANEL	7165-0028:0243
5	REMOTE NOTIFICATION POWER SUPPLY	7315-0028:246
3	FIRE ALARM TERMINAL CABINET	N/A
32	END OF LINE RESISTOR	N/A
2	REMOTE ANNUNCIATOR	7120-0028:209
8	MAGNETIC DOOR HOLDER	BY OTHERS
62	ADDRESSABLE MODULE	7300-0028:0219
8	RELAY MODULE	7300-0028:219
16	WATER FLOW SWITCH	BY OTHERS
16	VALVE TAMPER SWITCH	BY OTHERS
18	DUAL MONITOR MODULE	7300-0028:0219
12	FIRE FIGHTER'S PHONE JACKS	7300-1652:0182
4	DIGITAL AUDIO AMPLIFIERS	7170-0028:223/224

WIRING LEGEND

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01W
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02W
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03W
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04W
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05W
12	SIXTH FLOOR EAST	FA 3.06E
13	SEVENTH FLOOR EAST	FA 3.07E
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

[illegible]

LAURA RADLE	DATE:	ISSUING OFFICE:
DRAWN BY: LAURA RADLE	SCALE: 1/8" = 10' (U.C.N.)	
CHECKED BY:	DRAWING CODE:	
	CURTIS STREETER, SET NICET IV #102672	
PROJECT ENGINEER:		

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA
CSFM #18-40-03-0001

SHEET ID

FA 3.02W

SHEET 5 OF 15

SYMBOL LEGEND			WIRING LEGEND			
COUNT	FIRE ALARM SYMBOLS	CSFM LISTING #	LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
29	MANUAL PULL STATION	7150-0028:0199	A	16/2	SLC	WEST PENN D990
72	STROBE ONLY	7320-1653:201	B	16/2	SPEAKER	WEST PENN D991
151	SPEAKER/STROBE	7320-1653:201	C	14	NAC VISUAL	THHN
6	SPEAKER ONLY	7320-1653:201	E	16/4	ANNUNCIATOR	WEST PENN 993
6	WP SPEAKER - WEATHER PROOF	7320-1653:201	F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995
1	BELL	BY OTHERS				
2	HEAT DETECTOR	7270-0028:196				
16	SMOKE DETECTOR	7272-0028:206				
61	SMOKE DETECTOR - DUCT	9242-1653:209				
1	FIRE ALARM CONTROL PANEL	7165-0028:0243				
5	REMOTE NOTIFICATION POWER SUPPLY	7315-0028:248				
3	FIRE ALARM TERMINAL CABINET	N/A				
32	END OF LINE RESISTOR	N/A				
2	REMOTE ANNUNCIATOR	7120-0028:209				
8	MAGNETIC DOOR HOLDER	BY OTHERS				
62	ADDRESSABLE MODULE	7300-0028:0219				
8	RELAY MODULE	7300-0028:219				
16	WATER FLOW SWITCH	BY OTHERS				
16	VALVE TAMPER SWITCH	BY OTHERS				
18	DUAL MONITOR MODULE	7300-0028:0219				
12	FIRE FIGHTER'S PHONE JACKS	7300-1652:0182				
4	DIGITAL AUDIO AMPLIFIERS	7170-0028:223/224				

DRAWING INDEX		
1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01W
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02W
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03W
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04W
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05W
12	SIXTH FLOOR EAST	FA 3.06E
13	SEVENTH FLOOR EAST	FA 3.07E
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

FIRE ALARM SECOND FLOOR WEST
 SCALE 1/8" = 1'0"

REVISIONS	DATE	DESCRIPTION	APPR.
6/14/2011			
REVIEW COMMENTS			

DESIGNED BY: LAURA PADLE	DATE: January 5, 2012	SCALE: 1/8" = 1'0" (U.O.M.)	DRAWING CODE: CURTIS STEETER, SET NOCT IV #10272
DRAWN BY: LAURA PADLE			PROJECT ENGINEER:
CHECKED BY:			

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA
CSFM #18-40-03-0001

SYMBOL LEGEND			WIRING LEGEND		
COUNT	FIRE ALARM SYMBOLS	CSFM LISTING #	LABEL	GAUGE	USE TYPE (OR EQUIVALENT)
29	[P]	MANUAL PULL STATION 7150-0028:0199	A	16/2	SLC WEST PENN D990
72	[V]	STROBE ONLY 7320-1853:201	B	16/2	SPEAKER WEST PENN D991
151	[V]	SPEAKER/STROBE 7320-1853:201	C	14	NAC VISUAL THHN
6	[V]	SPEAKER ONLY 7320-1853:201	E	16/4	ANNUNCIATOR WEST PENN 993
6	[WP]	SPEAKER - WEATHER PROOF 7320-1853:201	F	14/2	FIRE FIGHTERS PHONE WEST PENN D995
1	[B]	BELL BY OTHERS			
2	[H]	HEAT DETECTOR 7270-0028:196			
16	[S]	SMOKE DETECTOR 7272-0028:206			
61	[S] _D	SMOKE DETECTOR - DUCT 3242-1853:209			
1	[FACP]	FIRE ALARM CONTROL PANEL 7165-0028:0243			
5	[RNPS]	REMOTE NOTIFICATION POWER SUPPLY 7315-0028:248			
3	[FATC]	FIRE ALARM TERMINAL CABINET N/A			
32	[ELR]	END OF LINE RESISTOR N/A			
2	[RA]	REMOTE ANNUNCIATOR 7120-0028:209			
8	[MD]	MAGNETIC DOOR HOLDER BY OTHERS			
62	[AM]	ADDRESSABLE MODULE 7300-0028:0219			
8	[RM]	RELAY MODULE 7300-0028:219			
16	[WFS]	WATER FLOW SWITCH BY OTHERS			
16	[VTS]	VALVE TAMPER SWITCH BY OTHERS			
18	[FDM]	DUAL MONITOR MODULE 7300-0028:0219			
12	[FJ]	FIRE FIGHTER'S PHONE JACKS 7300-1852:0182			
4	[DAA2]	DIGITAL AUDIO AMPLIFIERS 7170-0028:223/224			

DRAWING INDEX		
1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01W
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02W
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03W
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04W
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05W
12	SIXTH FLOOR EAST	FA 3.06E
13	SIXTH FLOOR WEST	FA 3.06W
14	SEVENTH FLOOR EAST	FA 3.07E
15	SEVENTH FLOOR WEST	FA 3.07W
16	CALCULATIONS	FA 4.0
17	DETAILS	FA 5.0

Revisions		DATE	DESCRIPTION	BY
REVIEW COMMENTS		8/14/2011		

DESIGNED BY: LAURA RADLE	DATE: January 9, 2012
DRAWN BY: LAURA RADLE	SCALE: 1/8" = 1'0" (U.O.N.)
CHECKED BY: CURTIS STREETER, SET NICET IV #102672	DRAWING CODE:
PROJECT ENGINEER:	

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA
CSFM #18-40-05-0001

SYMBOL LEGEND

COUNT	FIRE ALARM SYMBOLS	CSFM LISTING #
29	[F] MANUAL PULL STATION	7150-0028:0199
72	[F] STROBE ONLY	7320-1653:201
151	[F] SPEAKER/STROBE	7320-1653:201
6	[F] SPEAKER ONLY	7320-1653:201
6	[WP] SPEAKER - WEATHER PROOF	7320-1653:201
1	[B] BELL	BY OTHERS
2	[H] HEAT DETECTOR	7270-0028:196
16	[S] SMOKE DETECTOR	7272-0028:206
61	[SD] SMOKE DETECTOR - DUCT	3242-1653:209
1	[FACP] FIRE ALARM CONTROL PANEL	7165-0028:0243
5	[RNPS] REMOTE NOTIFICATION POWER SUPPLY	7315-0028:248
3	[FATC] FIRE ALARM TERMINAL CABINET	N/A
32	[ELR] END OF LINE RESISTOR	N/A
2	[RA] REMOTE ANNUNCIATOR	7120-0028:209
8	[MD] MAGNETIC DOOR HOLDER	BY OTHERS
62	[AM] ADDRESSABLE MODULE	7300-0028:0219
8	[RM] RELAY MODULE	7300-0028:219
16	[WFS] WATER FLOW SWITCH	BY OTHERS
16	[VTS] VALVE TAMPER SWITCH	BY OTHERS
18	[FDM] DUAL MONITOR MODULE	7300-0028:0219
12	[FJ] FIRE FIGHTER'S PHONE JACKS	7300-1652:0182
4	[DAA2] DIGITAL AUDIO AMPLIFIERS	7170-0028:223/224

WIRING LEGEND

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01W
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02W
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03W
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04W
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05W
12	SIXTH FLOOR EAST	FA 3.06E
13	SEVENTH FLOOR EAST	FA 3.07E
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

FIRE ALARM THIRD FLOOR WEST SCALE 1/8" = 1'0"

REVISIONS	REVIEW COMMENTS	DATE	APPR.
1		8/12/2011	

DESIGNED BY: LAURA RAGLE	DATE: January 9, 2012
DRAWN BY: LAURA RAGLE	SCALE: 1/8" = 1' (U.O.A.)
CHECKED BY: CURTIS STREETER, SET NICK IV #10272	DRAWING CODE
PROJECT ENGINEER:	

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA
CSFM #18-40-03-0001

SYMBOL LEGEND

COUNT	FIRE ALARM SYMBOLS	CSFM LISTING #
29	[F] MANUAL PULL STATION	7150-0028:0199
72	[V] STROBE ONLY	7320-1653:201
151	[VF] SPEAKER/STROBE	7320-1653:201
6	[F] SPEAKER ONLY	7320-1653:201
6	[WP] SPEAKER - WEATHER PROOF	7320-1653:201
1	[B] BELL	BY OTHERS
2	[H] HEAT DETECTOR	7270-0028:196
16	[S] SMOKE DETECTOR	7272-0028:206
61	[SD] SMOKE DETECTOR - DUCT	3242-1653:209
1	[FACP] FIRE ALARM CONTROL PANEL	7165-0028:0243
5	[RNPS] REMOTE NOTIFICATION POWER SUPPLY	7315-0028:248
3	[FATC] FIRE ALARM TERMINAL CABINET	N/A
32	[ELR] END OF LINE RESISTOR	N/A
2	[RA] REMOTE ANNUNCIATOR	7120-0028:209
8	[MD] MAGNETIC DOOR HOLDER	BY OTHERS
62	[AM] ADDRESSABLE MODULE	7300-0028:0219
8	[RM] RELAY MODULE	7300-0028:219
16	[WFS] WATER FLOW SWITCH	BY OTHERS
16	[VTS] VALVE TAMPER SWITCH	BY OTHERS
18	[FDM] DUAL MONITOR MODULE	7300-0028:0219
12	[FJ] FIRE FIGHTER'S PHONE JACKS	7300-1652:0182
4	[DA42] DIGITAL AUDIO AMPLIFIERS	7170-0028:223/224

WIRING LEGEND

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01W
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02W
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03W
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04W
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05W
12	SIXTH FLOOR EAST	FA 3.06E
13	SEVENTH FLOOR EAST	FA 3.07E
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

FIRE ALARM FOURTH FLOOR EAST

SCALE 1/8" = 1'0"

Revisions					
	REVIEW COMMENTS				
			6/14/2011		
SYMBOL	DESCRIPTION	DATE	APPR.		

DESIGNED BY: LAURA RADLE	DATE: January 9, 2012
DRAWN BY: LAURA RADLE	SCALE: 1/8" = 1'0" (U.O.N.)
CHECKED BY: CURTIS STREETER, SET NICET IV #102672	DRAWING CODE:
PROJECT ENGINEER:	

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA

CSFM #18-40-03-0001

SHEET 11

FA 3.04W

SHEET 9 OF 15

SYMBOL LEGEND

COUNT	FIRE ALARM SYMBOLS	CSFM LISTING
29	MANUAL PULL STATION	7150-0028:0199
72	STROBE ONLY	7320-1653:201
151	SPEAKER/STROBE	7320-1653:201
6	SPEAKER ONLY	7320-1653:201
6	SPEAKER - WEATHER PROOF	7320-1653:201
1	BELL	BY OTHERS
2	HEAT DETECTOR	7270-0028:196
16	SMOKE DETECTOR	7272-0028:206
61	SMOKE DETECTOR - DUCT	3242-1653:209
1	FIRE ALARM CONTROL PANEL	7165-0028:0243
5	REMOTE NOTIFICATION POWER SUPPLY	7315-0028:248
3	FIRE ALARM TERMINAL CABINET	N/A
32	END OF LINE RESISTOR	N/A
2	REMOTE ANNUNCIATOR	7120-0028:209
8	MAGNETIC DOOR HOLDER	BY OTHERS
62	ADDRESSABLE MODULE	7300-0028:0219
8	RELAY MODULE	7300-0028:219
16	WATER FLOW SWITCH	BY OTHERS
16	VALVE TAMPER SWITCH	BY OTHERS
18	DUAL MONITOR MODULE	7300-0028:0219
12	FIRE FIGHTER'S PHONE JACKS	7300-1652:0182
4	DIGITAL AUDIO AMPLIFIERS	7170-0028:223/2

WIRING LEGEND

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01V
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02V
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03V
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04V
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05V
12	SIXTH FLOOR EAST	FA 3.06E
13	SEVENTH FLOOR EAST	FA 3.07E
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

FIRE ALARM FOURTH FLOOR WEST
SCALE 1/8" = 1'0"

[illegible]

DESIGNED BY: LAURA RADLE	DATE: January 8, 2012
DRAWN BY: LAURA RADLE	SCALE: 1/8" = 1'0" (U.O.N.)
CHECKED BY: CURTIS STREETER, SET NICET IV #128272	DRAWING CODE:
PROJECT ENGINEER:	

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA

CSFM #18-40-03-0001

SHEET ID: 10

FA 3.05E

SHEET 10 OF 15

WIRING LEGEND

COUNT	FIRE ALARM SYMBOLS	CSFM LISTING #
29	MANUAL PULL STATION	7150-0028-0199
72	STROBE ONLY	7320-1653-201
151	SPEAKER/STROBE	7320-1653-201
6	SPEAKER ONLY	7320-1653-201
6	<i>WP</i> SPEAKER - WEATHER PROOF	7320-1653-201
1	BELL	BY OTHERS
2	HEAT DETECTOR	7270-0028-196
16	SMOKE DETECTOR	7272-0028-206
61	SMOKE DETECTOR - DUCT	3242-1653-209
1	FIRE ALARM CONTROL PANEL	7165-0028-0243
5	REMOTE NOTIFICATION POWER SUPPLY	7315-0028-248
3	FIRE ALARM TERMINAL CABINET	N/A
32	END OF LINE RESISTOR	N/A
2	REMOTE ANNUNCIATOR	7120-0028-209
8	MAGNETIC DOOR HOLDER	BY OTHERS
62	ADDRESSABLE MODULE	7300-0028-0219
8	RELAY MODULE	7300-0028-219
16	WATER FLOW SWITCH	BY OTHERS
16	VALVE TAMPER SWITCH	BY OTHERS
18	DUAL MONITOR MODULE	7300-0028-0219
12	FIRE FIGHTERS PHONE JACKS	7300-1652-0182
4	DIGITAL AUDIO AMPLIFIERS	7170-0028-223/224

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.0
4	SECOND FLOOR EAST	FA 3.0
5	SECOND FLOOR WEST	FA 3.0
6	THIRD FLOOR EAST	FA 3.0
7	THIRD FLOOR WEST	FA 3.0
8	FOURTH FLOOR EAST	FA 3.0
9	FOURTH FLOOR WEST	FA 3.0
10	FIFTH FLOOR EAST	FA 3.0
11	FIFTH FLOOR WEST	FA 3.0
12	SIXTH FLOOR EAST	FA 3.0
13	SEVENTH FLOOR EAST	FA 3.0
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

FIRE ALARM THIRD FLOOR WEST
SCALE 1/8" = 1'0"

SHEET 10 OF 15

WIRING LEGEND			
LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

FIRE ALARM FIFTH FLOOR WEST
SCALE 1/8" = 1'0"

SHEET ID

FA 3.05W

SHEET 11 OF 15

Deep Blue Integration

Consulting - Design - Installation

Service - Monitoring

Deep Blue Integration, Inc

47 S Tassajara Drive

San Luis Obispo, CA 93405

C-10, C-16 #943465 - ACO#6864

Toll Free: 888-660-0000 • DSN FAX: 805-791-2037

www.deepblueintegration.com

REVISIONS	REVIEW COMMENTS	DATE	APPR.
6/14/2011			

DESIGNED BY: LAURA RADLE	DATE: January 9, 2012	SCALE: 1/8" = 1/0" (U.O.M.)	DRAWING CODE: CURTIS STREETER SET NCET IV #10272
DRAWN BY: LAURA RADLE			PROJECT ENGINEER:
CHECKED BY: CURTIS STREETER			

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA
CSFM #18-40-03-0001

SHEET ID
FA 3.06E
SHEET 12 OF 15

SYMBOL LEGEND

COUNT	FIRE ALARM SYMBOLS	CSFM LISTING #
28	[MANUAL PULL STATION]	7150-0028:0199
72	[STROBE ONLY]	7320-1653:201
151	[SPEAKER/STROBE]	7320-1653:201
6	[SPEAKER ONLY]	7320-1653:201
6	[SPEAKER - WEATHER PROOF]	7320-1653:201
1	[BELL]	BY OTHERS
2	[HEAT DETECTOR]	7270-0028:196
16	[SMOKE DETECTOR]	7272-0028:206
61	[SMOKE DETECTOR - DUCT]	3242-1653:209
1	[FACP]	7165-0028:0243
5	[RNPS]	7315-0028:248
3	[FATC]	N/A
32	[END OF LINE RESISTOR]	N/A
2	[RA]	7120-0028:209
8	[MD]	BY OTHERS
62	[AM]	7300-0028:0219
8	[RM]	7300-0028:219
16	[WFS]	BY OTHERS
16	[VTS]	BY OTHERS
18	[FDM]	7300-0028:0219
12	[FJ]	7300-1652:0182
4	[DAA2]	7170-0028:223/224

WIRING LEGEND

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01W
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02W
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03W
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04W
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05W
12	SIXTH FLOOR EAST	FA 3.06E
13	SEVENTH FLOOR EAST	FA 3.07E
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

FIRE ALARM SIXTH FLOOR EAST
SCALE 1/8" = 1'0"

SYMBOL LEGEND

COUNT	FIRE ALARM SYMBOLS		CSFM LISTING #
29		MANUAL PULL STATION	7150-0028:0199
72		STROBE ONLY	7320-1653:201
151		SPEAKER/STROBE	7320-1653:201
6		SPEAKER ONLY	7320-1653:201
6		SPEAKER - WEATHER PROOF	UNKNOWN
1		BELL	UNKNOWN
2		HEAT DETECTOR	7270-0028:196
16		SMOKE DETECTOR	7272-0028:206
61		SMOKE DETECTOR - DUCT	3242-1653:209
1		FIRE ALARM CONTROL PANEL	7165-0028:0243
5		REMOTE NOTIFICATION POWER SUPPLY	UNKNOWN
3		FIRE ALARM TERMINAL CABINET	N/A
32		END OF LINE RESISTOR	N/A
2		REMOTE ANNUNCIATOR	7120-0028:209
8		MAGNETIC DOOR HOLDER	FBO
62		ADDRESSABLE MODULE	7300-0028:0219
8		RELAY MODULE	7300-0028:219
16		WATER FLOW SWITCH	FBO
16		VALVE TAMPER SWITCH	FBO
18		DUAL MONITOR MODULE	7300-0028:0219
12		FIRE FIGHTER'S PHONE JACKS	UNKNOWN
4		DIGITAL AUDIO AMPLIFIERS	7170-0028:223/224

WIRING LEGEND

LABEL	GAUGE	USE	TYPE (OR EQUIVALENT)
A	16/2	SLC	WEST PENN D990
B	16/2	SPEAKER	WEST PENN D991
C	14	NAC VISUAL	THHN
E	16/4	ANNUNCIATOR	WEST PENN 993
F	14/2	FIRE FIGHTERS PHONE	WEST PENN D995

DRAWING INDEX

1	COVER SHEET	FA 0.0
2	RISER DIAGRAM	FA 1.0
3	FIRST FLOOR WEST	FA 3.01W
4	SECOND FLOOR EAST	FA 3.02E
5	SECOND FLOOR WEST	FA 3.02W
6	THIRD FLOOR EAST	FA 3.03E
7	THIRD FLOOR WEST	FA 3.03W
8	FOURTH FLOOR EAST	FA 3.04E
9	FOURTH FLOOR WEST	FA 3.04W
10	FIFTH FLOOR EAST	FA 3.05E
11	FIFTH FLOOR WEST	FA 3.05W
12	SIXTH FLOOR EAST	FA 3.06E
13	SEVENTH FLOOR EAST	FA 3.07E
14	CALCULATIONS	FA 4.0
15	DETAILS	FA 5.0

FIRE ALARM SEVENTH FLOOR EAST
SCALE 1/8" = 1'0"

Consulting - Design - Installation
Service - Monitoring
Deep Blue Integration, Inc
47 S Tassajara Drive
San Luis Obispo, CA 93405
C-10, C-18 #943465 AC048884
Toll Free: 888-6000-DBI FAX:
805-791-2037
www.deepblueintegration.com

Revisions		DATE	DESCRIPTION	BY
8/14/2011				
REVIEW COMMENTS				

DESIGNED BY: LAURA PADLE	DATE: January 9, 2012	SCALE: 1/8" = 1'0" (U.O.N.)	DRAWING CODE: CURTIS STREETER SET NUCT IV #102672
DRAWN BY: LAURA PADLE			
CHECKED BY: CURTIS STREETER			
PROJECT ENGINEER:			

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA
CSFM #18-40-03-0001

SHEET ID
FA 3.07E
SHEET 13 OF 15

Deep Blue Integration
Consulting - Design - Installation
Service - Monitoring
Deep Blue Integration, Inc
47 S Tassajara Drive
San Luis Obispo, CA 93405
C-10, C-16 #943485 ACO#6864
Toll Free: 888-6000-031
805-791-2037
www.deepblueintegration.com

Revisions		REVIEW COMMENTS	DATE	APPR.
8/10/2011				

DESIGNED BY: LAURA BAILE	DATE: January 2, 2012
DRAWN BY: LAURA BAILE	SCALE: 1/8" = 1" (U.O.N.)
CHECKED BY: CURTIS STREETER, SET INCT IV #10272	DRAWING CODE:
PROJECT ENGINEER:	

CENTER FOR SCIENCE AND MATHEMATICS
CALIFORNIA STATE POLYTECHNIC UNIVERSITY
SAN LUIS OBISPO, CA
CSFM #18-40-03-0001

**ATTACHMENT 3: SMOKE MANAGEMENT STUDY
FIRE AND LIFE SAFETY ANALYSIS FOR THE CENTER FOR SCIENCE AND MATHEMATICS BUILDING #52**

Attachment 3: Smoke Management Study

See attached Smoke Management Study performed by Arup.

Attachment 3 contains 37 pages total.

Zimmer Gunsul Frasca
Architects, LLC

**Cal Poly San Luis
Obispo Laboratory
Building**

Smoke Management
Study - Atrium Smoke
Control

ARUP

Zimmer Gunsul Frasca
Architects, LLC

**Cal Poly San Luis
Obispo Laboratory
Building**

Smoke Management
Study - Atrium Smoke
Control

October 2009

Arup North America Ltd
12777 West Jefferson Boulevard,
Suite 200,
Los Angeles, California 90066
Tel +1 310 578-4182 Fax +1 310 577-7011
www.arup.com

This report takes into account the
particular instructions and requirements
of our client.

It is not intended for and should not be
relied upon by any third party and no
responsibility is undertaken to any third
party

Job number 131392

Contents

	Page
1 Introduction	1
1.1 Overview	1
1.2 Applicable Codes, Standards and Regulations	1
1.3 Building Description	2
2 Approach	2
2.1 Design Objectives	2
2.2 Design Methodology	2
3 Analysis Methodology	3
3.1 Fire Dynamics Simulator Overview	3
3.2 STEPS Dynamic Egress Model Overview	4
4 Design Fire Definition	7
4.1 General	7
4.2 Fire Sizes	9
4.3 Summary of Design Fire Scenarios	10
5 Tenability Criteria	11
5.1 Temperature	11
5.2 Visibility	11
5.3 Radiant Flux	12
5.4 Carbon Monoxide Dosing	12
6 Required Safe Egress Time	12
6.1 Overview	12
6.2 Detection and Notification Time	13
6.3 Pre-Movement Time	13
6.4 Travel Time	14
6.5 Total Evacuation Time	15
7 Results – Design Fire Assessment	16
7.1 Effects – Design Fire #1	17
7.2 Effects – Design Fire #2	20
7.3 Effects – Design Fire #3	21
7.4 Effects – Design Fire #4	23
8 Conclusions and Summary	24
9 References	26

Appendices

Appendix A

Sprinkler Activation Modeling

Appendix B

Design Fire Location Schematics

1 Introduction

1.1 Overview

Arup North America, Ltd. (Arup Fire) has prepared this report to document the performance-based fire and life safety engineering analysis that is being conducted for the Cal Poly San Luis Obispo New Laboratory Building in San Luis Obispo, California. This document describes key assumptions, design criteria and analysis methodology associated with the performance-based design of the smoke management system serving the facility. The methodology proposed by Arup Fire conforms to industry-standard practices and is in keeping with the design intent of the applicable codes, standards and regulations are identified in Section 1.2 of this Smoke Management Study (SMS).

1.2 Applicable Codes, Standards and Regulations

The following major codes, standards and regulations have been utilized for this project and contain requirements pertaining to fire safety.

- *California Building Code*, 2007 Edition, based on the 2006 International Building Code (CBC) [1]
- *California Fire Code*, 2007 Edition, based on the 2006 International Building Code (CFC) [2]

CBC Section 108.7 discusses provisions for alternative materials, design and method of construction and equipment. It states:

The provisions of this code, as adopted by the Department of Housing and Community Development are not intended to prevent the use of any alternate material, appliance, installation, device, arrangement, method, design or method of construction not specifically prescribed by this code. Consideration and approval of alternates shall comply with Section 108.7.2 for local building departments and Section 108.7.3 for the Department of Housing and Community Development.

Approval of alternates. The consideration and approval of alternates by a local building department shall comply with the following procedures and limitations:

1. The approval shall be granted on a case-by-case basis.
2. Evidence shall be submitted to substantiate claims that the proposed alternate, in performance, safety and protection of life and health, conforms to, or is at least equivalent to, the standards contained in this code and other rules and regulations promulgated by the Department of Housing and Community Development.
3. The building department may require tests performed by an approved testing agency at the expense of the owner or owner's agent as proof of compliance.
4. If the proposed alternate is related to accessibility in covered multifamily dwellings or in facilities serving covered multifamily dwellings as defined in Chapter 11A, the proposed alternate must also meet the threshold set for "Equivalent Facilitation" as defined in Chapter 11A.

It is this provision that permits a performance-based design to be conducted and subsequently reviewed by the Authority Having Jurisdiction for compliance with the intent of the California Building Code.

1.3 Building Description

This project involves the construction of a new laboratory building containing a five story atrium. Adjacent spaces include offices and teaching laboratory spaces as well as supporting circulation and assembly occupancies. The design team is seeking to implement a natural ventilation smoke control system that complies with Section 909 of the 2007 California Building Code (CBC).

The unique geometry of the atrium creates opportunities and challenges with respect to the implementation of a natural ventilation smoke control system. From a design standpoint, the placement and space allocation for outside supply air will likely present the greatest challenge to the design. Inlet flow velocities will be required to be limited to 200 ft/min *towards the fire*, and total free areas of louvered vents or operable windows will therefore become critical to implementing an effective and practical design. Location of mechanical supply, where used in conjunction with natural supply means, will have to be coordinated with natural make-up air sources. Wind, and the treatment of exhaust vents/openings, will require special care such that adequate area is provided under typical severe wind conditions.

2 Approach

2.1 Design Objectives

The fire and life safety strategy promulgated in this SMS is intended to safeguard life, health, property and public welfare for building occupants and fire fighters alike. In the design of the New Laboratory Building, several objectives are directly or indirectly considered with regard to the fire/life safety of the system:

- Fire Prevention - to identify fire risks and to implement policies that will lead to the reduction of these risks.
- Fire Protection - to install suitable systems for the detection and suppression of fires, incorporating active and passive measures to separate smoke and fire from people.
- Fire Planning - to recommend that procedures are developed and enforced to provide for safe evacuation of people and facilitation of fire department operations.
- Fire Fighting - to provide suitable systems to assist the fire department, as well as protect the life lives of emergency personnel.

2.2 Design Methodology

Where performance-based approaches are used, they follow the guidelines set out in the Society of Fire Protection Engineers document SFPE Engineering Guide to Performance-based Fire Protection Analysis and Design of Buildings [3]. Except as specifically identified herein, applicable building and fire codes are being followed.

3 Analysis Methodology

3.1 Fire Dynamics Simulator Overview

The computer model Fire Dynamics Simulator v4.0 (FDS v4.0) [4],[5], developed by the National Institute of Standards and Technology (NIST), is being used to model fire development and smoke movement in the common spaces of the building. FDS is a Computational Fluid Dynamics (CFD) model that uses Large Eddy Simulation (LES) techniques to solve the mildly-compressible (Low Mach Number approximation) form of the Navier-Stokes equation. It has been designed specifically for fire safety applications and uses a mixture fraction based combustion model.

When using FDS to model fire development and smoke movement, a three-dimensional virtual model of the space is assembled within the computer. This “computational domain” is divided into several hundred thousand cells, and the conservation laws for mass, momentum, species, and (indirectly) energy, are solved at each cell. Time marches forward with small incremental time steps. The end result is a three-dimensional representation of the temperature, smoke, and velocity distributions throughout the computational domain as a function of time.

One of the most critical steps in performing a CFD analysis of fire and smoke effects is taking the real-world configuration and translating it into terms that can be understood by the computer software so that an “adequate” model of reality can be generated within the computer. This involves not only specifying the geometry of the problem being studied, but also prescribing many “input parameters” that affect the simulation results or the manner in which data is reported.

Although FDS can address most fire scenarios, there are limitations in all of its various algorithms [5]. Some of the more prominent limitations of the model are discussed below.

3.1.1 Low Speed Flow Assumption

The use of FDS is limited to low-speed flow (sub-sonic) with an emphasis on smoke and heat transport from fires. This assumption rules out using the model for any scenario involving flow speeds approaching the speed of sound, such as explosions, choke flow at nozzles, and detonations.

3.1.2 Rectilinear Geometry

The efficiency of FDS is derived from the simplicity of its rectilinear numerical grid and the use of fast, direct solvers for the pressure field. This can be a limitation in some situations where certain geometric features do not conform to the rectangular grid, although most building components do. There are techniques in FDS to lessen the effect of “sawtooth” obstructions used to represent nonrectangular objects, but these cannot be expected to produce good results if, for example, the intent of the calculation is to study boundary layer effects. For most practical large-scale simulations, the increased grid resolution afforded by the fast pressure solver offsets the approximation of a curved boundary by small rectangular grid cells.

3.1.3 Fire Growth and Spread

Because the model was originally designed to analyze industrial-scale fires, it can be used reliably when the Heat Release Rate (HRR) of the fire is specified and the transport of heat and exhaust products is the principal aim of the simulation. In these cases, the model predicts flow velocities and temperatures to an accuracy within 5 % to 20 % of experimental measurements, depending on the resolution of the numerical grid. However, for fire scenarios where the heat release rate is predicted rather than prescribed, the uncertainty of the model is higher. There are several reasons for this: (1) properties of real materials and

real fuels are often unknown or difficult to obtain, (2) the physical processes of combustion, radiation and solid phase heat transfer are more complicated than their mathematical representations in FDS, (3) the results of calculations are sensitive to both the numerical and physical parameters. Current research is aimed at improving this situation, but it is safe to say that modeling fire growth and spread will always require a higher level of user skill and judgment than that required for modeling the transport of smoke and heat from prescribed fires.

3.1.4 Combustion

For most applications, FDS uses a mixture fraction combustion model. The mixture fraction is a conserved scalar quantity that is defined as the fraction of gas at a given point in the flow field that originated as fuel. The model assumes that combustion is mixing-controlled, and that the reaction of fuel and oxygen is infinitely fast, regardless of the temperature. For large-scale, well-ventilated fires, this is a good assumption. However, if a fire is in an under-ventilated compartment, or if a suppression agent like water mist or CO₂ is introduced, fuel and oxygen may mix but may not burn. Also, a shear layer with high strain rate separating the fuel stream from an oxygen supply can prevent combustion from taking place. The physical mechanisms underlying these phenomena are complex, and even simplified models still rely on an accurate prediction of the flame temperature and local strain rate. Sub-grid scale modeling of gas phase suppression and extinction is still an area of active research in the combustion community. Until reliable models can be developed for building-scale fire simulations, simple empirical rules can be used that prevent burning from taking place when the atmosphere immediately surrounding the fire cannot sustain the combustion.

3.1.5 Radiation

Radiative heat transfer is included in the model via the solution of the radiation transport equation for a non-scattering gray gas, and in some limited cases using a wide band model. The equation is solved using a technique similar to finite volume methods for convective transport, thus the name given to it is the Finite Volume Method (FVM). There are several limitations of the model. First, the absorption coefficient for the smoke-laden gas is a complex function of its composition and temperature. Because of the simplified combustion model, the chemical composition of the smokey gases, especially the soot content, can affect both the absorption and emission of thermal radiation. Second, the radiation transport is discretized via approximately 100 solid angles. For targets far away from a localized source of radiation, like a growing fire, the discretization can lead to a non-uniform distribution of the radiant energy. This can be seen in the visualization of surface temperatures, where "hot spots" show the effect of the finite number of solid angles. The problem can be lessened by the inclusion of more solid angles, but at a price of longer computing time. In most cases, the radiative flux to far-field targets is not as important as those in the near-field, where coverage by the default number of angles is much better.

3.2 STEPS Dynamic Egress Model Overview

STEPS (Simulation of Transient Evacuation and Pedestrian movements) [6] is a computer evacuation model for building evacuation. Both ordinary pedestrian movement and evacuation scenarios can be modeled using STEPS. STEPS allows simulation of phased evacuation scenarios and other more complex schemes not allowed by simple parametric equations. STEPS also allows the user to watch the entire building three-dimensionally, to assess where queuing or choked flow occurs.

STEPS is a grid-based evacuation model where simulated occupants are placed individually on floor planes within the program. Floors can be linked together by user-defined

intermediate planes to simulate stairs and landings. CAD drawings are modified to be consistent with the STEPS grid to allow for full use of egress paths.

3.2.1 Modeling Inputs

Individuals are given various sizes and travel speeds, which affect their movement. A person will move with the assigned speed but will remain at pre-set distances from any other simulated occupants. Effective travel speeds are thus reduced due to crowding and queuing.

User-defined settings within STEPS include grid-size(s), travel speed(s), delay times, and occupant loads. Several of the input settings are dependent on the scenario being reviewed, such as occupant load and delay times (to start evacuation movement). The nominal inputs that have been applied across all scenarios for this study are summarized in Table 1.

Table 1 STEPS Modeling Assumptions

FACTOR	VALUE	COMMENTS
Grid Size (Floor planes)	1.6 ft (0.50 m)	Since only one occupant can occupy one grid cell at any one time, a grid size of 0.5m was chosen as the default value by the program developers. This value provides a good estimate of the space required for an average person.
Grid Size (Stair/Escalator Planes)	1.6 ft (0.50 m)	See comment above.
Walking Speed	98 to 256 fpm (0.5 to 1.3 m/s)	Demographic data was collected, along with corresponding walking speed data.

3.2.2 Demographics

The characteristics of the building population are based on information provided by a report titled, "Assessment of Photoluminescent Material during Office Evacuation" [7]. This report provided the demographics for young, middle and old persons to be 15%, 66% and 19% respectively. It also provided the information that of those age groups, approximately 6% of the middle and old occupants are disabled. Table 2 indicates the demographics that were used for the models.

Table 2 Demographic Distribution used in STEPS Models

OCCUPANT TYPE	PERCENTAGE OF POPULATION
Young	15%
Middle	63%
Old	16%
Disabled	6%

3.2.3 Travel Speeds

The horizontal and vertical travel speeds for occupants are dependent on the age and mobility of the occupant. Table 3 indicates the values that were used in the model for walking speeds of the occupants.

Table 3 Occupant Walking Speeds

OCCUPANT TYPE	WALKING SPEED			REFERENCES
	Horizontal	Down stairs	Up stairs	
Young	1.3 m/sec (4.27 ft/sec)	0.8 m/sec (2.62 ft/sec)	0.6 m/sec (1.96 ft/sec)	[8][9]
Middle	1.2 m/sec (3.94 ft/sec)	0.7 m/sec (2.3 ft/sec)	0.5 m/sec (1.64 ft/sec)	[8][9]
Old	1.0 m/sec (3.28 ft/sec)	0.6 m/sec (1.96 ft/sec)	0.4 m/sec (1.31 ft/sec)	[8]
Disabled	0.5 m/sec (1.64 ft/sec)	0.27 m/sec (0.89 ft/sec)	0.216 m/sec (0.71 ft/sec)	[8][10]

4 Design Fire Definition

4.1 General

The design fires form the basis upon which the proposed fire strategy and mitigation features were evaluated. The process to develop these scenarios is outlined below:

- **Qualitative Hazard Analysis.** The peak fire growth rate or maximum heat release rate and duration of a fire within a given space is dependant upon the type, quantity and configuration of the materials within the space, as well as the effect of sprinklers. A qualitative hazard analysis was performed to determine the expected range of fire scenarios. Potential fuel sources and potential ignition sources were reviewed based upon representative materials and equipment within various areas where a performance-based approach was used. Fuel sources were chosen based upon the potential for a developing fire to cause conditions where occupants or the structure may be threatened.
- **Heat Release Rate Curves.** The fire scenarios were quantified by assuming a fast t^2 fire [6]. This assumption is a reasonable estimate for the types of hazards that are likely in the building.
- **Maximum Heat Release Rate.** The maximum heat release rate was estimated by determining the expected time for sprinkler activation and by estimating the maximum fire size of a given fuel package.
- **Determination of Smoke Production.** Soot yields corresponding to polyurethane foam with some cellulosic material were used (effective yield of 5%). This generally results in conservative predictions of visibility.

Fire growth and heat release rates are dependent on the fuel type and its configuration. The fuel source material, shape, orientation and location determine how rapidly an item will burn. The heat release rate is measured in BTU (British thermal units) or kW (kilowatts). Heat release rate histories are typically characterized by a fire growth rate and can be determined by empirical fire tests on various items of fuels and combustibles. Fire growth rates are often designated as slow, medium, fast or ultra-fast, based upon on how quickly an item burns, in relation to other items. Figure 1 is included to provide perspective as to the order-of-magnitude maximum heat release rates. Figure 2 compares various standard fire growth rates.

Figure 1 Relative Fire Sizes

Figure 2 Typical Fire Growth Rates

Figure 3 provides a comparison of the standard fire curves to the heat release rates for selected fuel packages; this information was excerpted from Appendix C of NFPA 92B [6].

Figure 3 Standard Fire Curves and Rates of Heat Release for Selected Fuels

4.2 Fire Sizes

To account for the range of possible design fire scenarios, four design fire locations were identified based upon a review of the architectural floor plans. Please note that The First Floor was not considered in the design fire analysis owing to its separation from the Second Floor, which serves as the entry floor. The design fires have been identified as follows:

4.2.1 Design Fire #1 – Second Floor Center of Atrium

The Second Floor is open to the Third Floor at two principal locations. As a result of these openings, there is the potential for a balcony spill plume condition to be created from a fire on the Second Floor. Design Fire #1 examines the potential for a sizable fire to develop within the atrium below the balcony located within the center of the space. The fire examined is assumed to be a sprinkler controlled fire, the maximum heat release rate of approximately 1,411 kW being governed by an approximate 16 foot ceiling height at the sloped floor/ceiling slab. Fuel loads would be transient in nature, but are assumed to be a mixture of cellulosic and hydrocarbon materials of a generally non-hazardous and non-toxic nature. Within the FDS model, this fire will grow in accordance with a fast-growth t^2 fire, similar to the second curve in Figure 2, until it reaches its maximum, at which point the heat release rate would remain constant at the maximum value as a result of sprinkler control. Sprinkler control calculations using the DETACT algorithm are provided in Appendix A.

4.2.2 Design Fire #2 – Second Floor On Balcony Adjacent to Stair

Design Fire #2 looks at the potential hazard associated with a fire originating on the Second Floor in the high-bay space on either side of the balcony. In these areas, the maximum floor-to-ceiling height is approximately 80 feet, which would result in a fire that would not likely be controlled by automatic fire suppression systems. Alternatively, a fuel-controlled fire of approximately 2,500 kW could result from the light to moderate fuel load located in these spaces. Such a fire would be representative of boxes, several full trash bags, miscellaneous light furniture, or cleaning materials and similar items. This fire size correlates well with peak and sustained heat releases for miscellaneous items documented in sources such as the Appendix to NFPA 92B.

Based on the fact that the spaces are predominantly used for circulation, the assumption of the maximum HRR being less than 2,500 kW is reasonable and conservative. Within the FDS model, this fire will grow in accordance with a fast-growth t^2 fire, similar to the second curve in Figure 2, until it reaches its maximum, at which point the heat release rate would remain constant at the maximum value.

4.2.3 Design Fire #3 – Fourth Floor Student Work Space

This is a sprinkler-controlled fire on the Third Floor near an opening communicating with the atrium. In consideration of the potential for a high and uncontrolled combustible fuel load within the Student Work Space, a sprinkler controlled transient fire having a maximum HRR of 1,250 kW will be studied.

Within the FDS model, this fire will grow in accordance with a fast-growth t^2 fire, similar to the second curve in Figure 2, until it reaches its maximum, then the heat release rate will remain constant at the maximum value. Sprinkler control calculations using the DETACT algorithm are provided in Appendix A.

4.2.4 Design Fire #4 – Fifth Floor Center of Atrium

This fire is located in the center of the atrium on the Fourth Floor. Smoke and heat generated as a result of this fire would spread along the balcony of the Fifth Floor, and spill through the two openings adjacent to the exit stairs. Due to its location below the balcony floor/ceiling assembly above, the maximum HRR is controlled via the automatic sprinkler system, reaching approximately 1,411 kW prior to sprinkler activation and subsequent control.

Within the FDS model, this fire will grow in accordance with a fast-growth t^2 fire, similar to the second curve in Figure 2, until it reaches its maximum, then the heat release rate will remain constant at the maximum value. Sprinkler control calculations using the DETACT algorithm are provided in Appendix A.

4.3 Summary of Design Fire Scenarios

Table 4 provides a summary of the design fire details.

Table 4 Summary of Design Fires

ID	Location	Calculated Fire Size ¹	FDS Fire Size ²
DF1	Second Floor, Center of Atrium	1,411 kW	1,500 kW
DF2	Second Floor, High-Bay Space Adjacent to Stair	2,500 kW	2,500 kW
DF3	Fourth Floor Student Work Space	1,250 kW	1,300 kW
DF4	Fifth Floor Center of Atrium	1,411 kW	1,500 kW

¹ Fire size at sprinkler activation was based on calculation developed by Heskestad and Delichastios.

² The FDS fire size is slightly different due to the manner in which the fire parameters are entered into the model.

Design fire schematics are provided in Appendix B.

5 Tenability Criteria

The temperature, visibility and radiant flux tenability limits are proposed to serve as design criteria on which to base the level of safety for the atrium. These tenability limits will be evaluated at a height of 6 feet above the finished floor level.

Tenability design criteria are different for analyses using Computational Fluid Dynamics (CFD) models than for systems designed using parametric equations such as those found in either the IBC Section 909 or NFPA 92B. For the purposes of this project, temperature, visibility and radiant flux are considered, and the life safety strategy is intended to provide tenable conditions for a duration that enables safe evacuation of building occupants. The design criteria are discussed in detail in the following sections.

5.1 Temperature

In order to assess the temperature of the hot gas layer and associated gas flows originating from the fire source, a number of sampling points are created within the model to estimate the average temperature at specific intervals above the egress path. Measurements will be specified at 6 and 10 feet above the egress paths for each scenario, and are visually measured throughout the model. This data is used to track the smoke temperature, radiant flux and atmospheric visibility as time elapsed.

It is necessary to provide evacuating occupants with tenable conditions during the evacuation period. Therefore, a maximum layer temperature must be identified. NFPA 130 – Standard for Fixed Guideway and Passenger Rail Systems [13] suggests thermal burns to the respiratory tract can occur upon inhalation of air above 140°F (60°C) that is saturated with water vapor. Therefore, the tenable design temperature of 140°F (60°C) is used for this project.

5.2 Visibility

Occupants attempting to exit the facility must also be provided with sufficient visibility in order to evacuate. Since most occupants of the building will likely be only moderately familiar with the building layout and exact location of emergency exits, it is necessary for the smoke management system to provide suitable visibility levels.

As stated in the FDS User's Manual, estimates of visibility through smoke can be made using the equation:

$$S = \frac{C}{K} \quad [\text{EQ1}]$$

where C is a non-dimensional constant, K is the light extinct coefficient, and S is the visibility through the smoke. K varies with the density of smoke particulate and a mass specific extinction coefficient. However, C is specified according to the object being viewed through the smoke. For example, C = 8 for a light-emitting sign and C = 3 for a light-reflecting sign. For these analyses C is specified as 8 since the exit signs in the building will be the light-emitting type.

As discussed by Jin [14], proposed allowable smoke visibility that permits safe escape ranges from approximately 4 ft to 66 ft, depending on the nature of the space and the awareness level of the occupants. This large variation in proposed values is likely due to the various test methods used in the individual studies. For example, test geometry, composition of the test population, and test population familiarity of the surroundings can greatly affect the outcome of this type of study.

Jin's work suggests that an allowable visibility for occupants unfamiliar with their surroundings is 13 m (42 ft); therefore, the visibility design criteria for this project will be 42 ft (13 m). However, consideration will be given to areas with less than 42 ft of visibility if the travel distance to an exit in that area is less than 42 ft.

5.3 Radiant Flux

In situations where a sustained hot smoke layer has been developed, it is possible that the hot smoke layer can radiate heat down to the evacuating occupants. Consideration is given to this possibility by calculating the upper layer temperature required to impart a critical radiant heat flux upon the occupants.

The CIBSE Guide E – Fire Engineering [15] indicates that a 2.5 kW/m² incident radiant flux upon the skin of an occupant would result in severe with a short exposure and recommends using a lower flux. Another reference, the SFPE Engineering Guide, "Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation" indicates that an incident radiant flux greater than 1.7 kW/m² would cause pain on the exposed skin of an occupant with a prolonged exposure. Based upon these two references, a thermal flux of 2.0 kW/m² was chosen as the design criteria. To provide perspective for this, intense incident radiant flux originating from the sun are approximately 0.6 to 1.0 kW/m².

If smoke temperatures are maintained below (350°F) 180°C, the thermal radiation from the hot upper layer to the occupants below will not exceed the tenability criteria.

5.4 Carbon Monoxide Dosing

CO concentrations will not specifically be measured for this analysis because previous analyses of similar spaces have shown that visibility is a far more restrictive tenability criterion.

6 Required Safe Egress Time

6.1 Overview

The Required Safe Egress Time (RSET) is the predicted time necessary to evacuate a building or component. The total time for escape from an area can be expressed as a combination of detection and notification time, pre-movement time, and travel time.

$$t_{esc} = t_o + t_{pre} + t_{mov}$$

where,

t_o is the detection and notification time,

t_{pre} is the pre-movement time (includes response and recognition time), and

t_{mov} is the movement time (queuing time or travel time).

Figure 4 illustrates the components of the total time needed for building evacuation.

Figure 4 Components of Evacuation Time

6.2 Detection and Notification Time

The detection and notification time is the time from the start of established burning to the time at which the occupants are aware of the fire and the need to evacuate. It is assumed that detection will occur when occupants become aware of smoke through either visual awareness or when smoke detectors, sprinklers, or manual alarms are activated and the building alarm is initiated. Occupants in the room or compartment of the fire and in close proximity can also be alerted to a fire by visual cues from the various fire-induced conditions, such as smoke and heat.

Given the openness of the atrium, the likely source of primary detection is the building occupants seeing smoke rise through the atrium, which would occur quickly in the event of a fire. Based upon the design fire scenarios, it is likely that the detection and notification time would be between 30-60 seconds. For the purposes of this egress analysis, a notification time of 60 seconds will be used.

6.3 Pre-Movement Time

Pre-movement time is the time taken to perform activities that people are engaged in prior to actual evacuation of the area. These activities may include investigating, assessing danger, warning others, collecting belongings, and seeking assistance [16]. This behavior is a complex, cognitive thought process and is not easily characterized.

The SFPE Handbook [16] provides a discussion regarding pre-movement times in various types of buildings for three different emergency notification scenarios. The three notification scenarios are defined as follows:

- W1: live directives using a voice communication system from a control room with closed-circuit television facility, or live directives in conjunction with well-trained, uniformed staff that can be seen and heard by all occupants in the space
- W2: nondirective voice messages (pre-recorded) and/or informative warning visual display with trained staff
- W3: warning system using fire alarm signal and staff with no relevant training

Pre-movement times from a university building where occupants are awake and familiar with their surroundings such as the building discussed herein are suggested as follows in conjunction with the type of emergency notification:

- W1: less than 1 minutes
- W2: 3 minutes
- W3: 4 minutes or more

The SFPE Handbook further suggests that the fire scenarios should be taken into consideration, as they will impact the pre-movement time. Since all of the design fires are in relatively close proximity to occupied spaces where occupants would clearly be able to see smoke and flames, it is reasonable to consider the W1 condition for pre-movement time. As such, a pre-movement time of 60 seconds will be assumed.

6.4 Travel Time

The occupant travel time was modelled using the computer evacuation model, STEPS, which was discussed in Section 3.2. The floor plans of the atrium levels were incorporated into the STEPS model and exits were identified at each level of the atrium in order to allow the building occupants to exit from the atrium space. Figure 5 provides a screenshot of the STEPS model. Figure 6 shows a graph of the calculated evacuation times from each level within the atrium. Table 5 provides a summary of the occupant loads on each floor and the evacuation times.

Figure 5 STEPS Screenshot

Figure 6 Evacuation Travel Times from Atrium

Table 5 Summary of Travel Times

Floor	Number of Occupants	Travel Time (s)
2	81	21
3	164	37
4	73	34
5	77	40
6	74	39

6.5 Total Evacuation Time

Table 6 provides a summary of the total evacuation times for each level. CBC Section 909.4 requires that a smoke control system is to operate for a duration of 20 minutes or 1.5X the calculated evacuation time, whichever is less.

Table 6 Total Evacuation Times

Floor	Notification Time (s)	Pre-Movement Time (s)	Travel Time (s)	Total Time (s)	1.5X Total Time (s)
2	60	60	21	141	212
3	60	60	37	157	236
4	60	60	34	154	231
5	60	60	40	160	240
6	60	60	39	159	239

CBC Section 909.4 requires that a smoke control system is to operate for a duration of 20 minutes or 1.5X the calculated evacuation time, whichever is less.

7 Results – Design Fire Assessment

In order to predict the effects of a fire scenario on the interior environment of the Cal Poly San Luis Obispo New Laboratory Building, each of the four design fires was simulated. Of primary interest are the effects of the design fire scenarios on visibility and temperature.

Ventilation conditions were identical for all design fire scenarios and consistent with the geometry of the building as currently designed. The instances where the interior environment communicates with the exterior air include two sets of double-doors at the north and south ends of the space in question and two roof vents located at the highest level of the atrium. The areas of these ventilation openings are as follows:

- North Double-Doors area = 133.5 ft²
- South Double-Doors area = 133.5 ft²
- North roof vent area = 100 ft²
- South roof vent area = 100 ft² (8 m²)

Figure 7 and Figure 8 provide overviews of the FDS model geometry.

Figure 7 FDS Model – View from southeast

Figure 8 FDS Model – View from East

7.1 Effects – Design Fire #1

The simulated sprinkler-controlled 1,500 kW fire located on the second floor within the atrium and below the balcony has the following effects on temperature and visibility within the interior environment:

- As evidenced by Figure 9, the temperatures in areas other than within the plume are maintained below the tenable limit of 60°C for the duration of the 1200s simulation. The average temperature within the atrium is approximately 44°C, which is elevated from ambient, is within the tenable limits and will provide occupants with a safe evacuation path.
- Figure 10 shows that the visibility approximately 6ft above the third floor walking surface is maintained above 42ft (13m) for a duration of 240s. Figure 11 provides a series of visibility images for this scenario from 600 through 1200s. These images demonstrate that by 600s the third floor balcony experiences reduce visibility of approximately 33ft (10m); however, visibility is maintained above 42ft (13m) on the remainder of the levels.

Figure 9 DF #1: Temperature at 1200 seconds (from east)

Figure 10DF #1: Visibility at 240 seconds (Plan View @ 2.0m above L03)

Figure 11 DF #1: Visibility over Time (from east)

7.2 Effects – Design Fire #2

The simulated fuel-controlled 2,500 kW fire located on the second floor within the atrium adjacent to (but not below) the balcony has the following effects on temperature and visibility within the interior environment:

- Figure 12 provides the temperatures through the north-south cross section of the atrium. The temperatures 6 ft above the egress walking surface on all levels is maintained below the tenability limit of 60°C.
- Figure 13 demonstrates the visibility levels 6 ft above the floor for each level. Tenability is maintained as follows: Level 6 – 260s; Level 5 – 360s; Level 4 – 400s; Levels 2 and 3 – 1200s.

Figure 12DF #2: Temperature at 1200 seconds (from east)

Figure 13 DF #2: Visibility @ 6ft above Walking Surfaces

7.3 Effects – Design Fire #3

The simulated sprinkler-controlled 1,250 kW fire located on the fourth floor adjacent to an opening communicating within the atrium (west of the northern atrium opening) has the following effects on temperature and visibility within the interior environment:

- As shown in Figure 14, the temperatures 6 feet above the walking surface on Levels 4-6 are maintained below the tenability threshold of 60°C, with the exception of the area on Level 4 that is within the fire plume. Note that since the fire is located on Level 4, the temperature at Level 3 is not impacted.
- The visibility conditions resulting from Design Fire #3 are provided in Figure 15. Level 3 is not impacted by this design fire and tenability is maintained on Level 4 for the duration of the 1200s simulation for areas outside of the fire plume. Tenable visibility conditions are maintained for durations of 320s and 400s on Level 5 and 6, respectively.

Figure 14 DF #3: Temperature @ 6ft above Walking Surfaces

Figure 15 DF #3: Visibility @ 6ft above Walking Surfaces

7.4 Effects - Design Fire #4

The simulated sprinkler-controlled 1,500 kW fire located on the fifth floor in the center of the atrium has the following effects on temperature and visibility within the interior environment:

- The temperatures 6 feet above the Level 5 walking surface remain tenable in areas outside of the fire plume. Elevated temperatures are experienced at an elevation 6 feet above the Level 6 walking surface. Temperatures below 60°C are maintained for a duration of 240 seconds after flaming ignition of the fire as shown in Figure 16.
- Figure 17 illustrates that a visibility in excess of 13m is maintained above the Level 6 walking surface for a duration of 180s, at which time isolated areas experience visibilities less than 13m. However, the visibility above Level 5 is maintained tenable in areas other than the fire plume for the duration of the 1200s simulation.

Figure 16 DF #4: Temperature @ 6ft above Walking Surfaces

Figure 17 DF #4: Visibility @ 6ft above Walking Surfaces

8 Conclusions and Summary

This Smoke Management Study documents the assessment of the effectiveness of a natural ventilation smoke management system for the Cal Poly San Luis Obispo New Laboratory Building in San Luis Obispo, California. Included in the documentation are the results of Fire Dynamics Simulator modelling, as well as the supporting approach, methodology, key input parameters and tenability criteria used to generate quantitative data and develop a more complete understanding of the level of safety provided by the natural ventilation system.

Table 7 provide a summary of the evacuation times for each floor and the duration for which tenability is maintained.

Table 7 Summary of RSET vs. ASET

Floor	RSET (1.5X Total Evacuation Time)	ASET (Time to Untenable Conditions)	Comments
2	212	1200	Tenability at Level 2 is not compromised by any of the design fire scenarios
3	236	240	DF #3 is the severe case scenario for Level 3. After 240s, the visibility begins to be reduced below 13m; however, temperatures are maintained tenable for over 1200s. the ASET exceeds 1.5X the total evacuation time and provides tenable conditions for the duration required by the code.
4	231	400	DF #2 is the severe case scenario for Level 4. Tenability is maintained for the duration required by the code.
5	240	320	DF #3 is the severe case condition for Level 5. Tenability is maintained for the duration required by the code.
6	239	180 (240)	DF #4 is the server case condition for Level 6. The visibility becomes reduced below 13m after approximately 180s at the eastern exit from the atrium; however, the visibility in other areas of the atrium at this level is maintained for a duration of 240s. It is also worth nothing that while the temperatures above level 6 become elevated above 60°C at a time of 240s in one isolated located at the eastern exit from the atrium, the average temperature on the remainder of the level is approximately 48°C, which is within the tenable limits.

Based upon these results, the natural ventilation smoke control system as described herein provides a level of safety commensurate with that required by the California Building Code.

9 References

- [1] California Building Code. International Code Council. 2007.
- [2] California Fire Code. International Code Council. 2007.
- [3] SFPE Engineering Guide to Performance-based Fire Protection Analysis and Design of Buildings. Society of Fire Protection Engineers. 2000.
- [4] McGrattan, K. and G. Forney. Fire Dynamics Simulator (Version 4) User's Guide. NIST Special Publication 1019. Building and Fire Research Laboratory, National Institute of Standards and Technology. February 2005.
- [5] McGrattan, K. Fire Dynamics Simulator (Version 4) Technical Reference Guide. NIST Special Publication 1018. Building and Fire Research Laboratory, National Institute of Standards and Technology. February 2005.
- [6] MMSG. Simulation of Transient Evacuation and Pedestrian Movements (STEPS), Version 2.0. Surrey, UK: Mott MacDonald Simulation Group, www.mottmac.com. 2004.
- [7] Proulx, Tiller, Kyle, and Creek, Assessment of Photoluminescent Material During Office Occupant Evacuation, Internal Report 774, National Research Council of Canada, Ottawa ON, April, 1999.
- [8] Fruin, John J., Pedestrian Planning and Design, Revised Edition, Elevator World, Inc., Mobile, Alabama, 1987. - Public Spaces.
- [9] Fahy, Rita F. and Proulx, Guylene, Toward Creating a Database on Delay Times to Start Evacuation and walking Speeds for use in Evacuation Modeling, Human Behavior in Fire- Proceedings of the 2nd International Symposium, MIT, March 2001. Drill in Mid-Rise.
- [10] Boyce, Shields, and Silcock, Towards the Characterization of Building Occupancy for Fire Safety Engineering: Capabilities. of Disabled People Moving Horizontally and on an Incline, Fire Technology, 35, 1, 1999.
- [11] Alpert, Ronald L., *Ceiling Jet Flows*, The SFPE Handbook of Fire Protection Engineering, 3rd Edition, Society of Fire Protection Engineers. 2002.
- [12] NFPA 92B – Guide for Smoke Management Systems in Malls, Atria and Large Areas. National Fire Protection Association. 1995.
- [13] NFPA 130 – Standard for Fixed Guideway Transit and Passenger Rail Systems. National Fire Protection Association. 2001.
- [14] Jin, Tadahisa. “Visibility and Human Behavior in Fire Smoke.” The SFPE Handbook of Fire Protection Engineering, 3rd Edition. SFPE and NFPA. 2002.
- [15] CIBSE Guide E – Fire Engineering. The Chartered Institution of Building Services Engineers. London. 1997.
- [16] Proulx, G., “Movement of People: The Evacuation Timing” Section 3, Chapter 13 in *SFPE Handbook of Fire Protection Engineering*, Third Edition. Quincy, MA: National Fire Protection Association, 2002.

Appendix A

Sprinkler Activation Modeling

This sheet predicts sprinkler/heat detector activation based on the method of Heskestad and Delichatsios
Input in the green areas.

<i>green</i>	=input in these areas
<i>yellow</i>	=output in these areas
<i>blue</i>	=titles and other messages

alpha [kW/s^2]	0.0469
r [m]	3.4
g [m/s^2]	9.81
Ceiling Height [ft]	14
Convective Fraction	0.7
Tamb [F]	68
Cp	1
RTI (m-s)^(1/2)	50
Tact [F]	165
Tact [K]	347.03889
Tamb [K]	293.15
Ceiling Height [m]	4.2682927
Q [kW]	1249.5306
Q [Btu/sec]	1185.5129
t [sec]	163.22513
rho [lb/ft^3]	0.075
rho [kg/m^3]	1.2004746
A	0.0278757
t2*	13.547634
t2*f	1.546848
dT2*	116.34272
u2*/(dT2*^(1/2))	0.6808955
U2*	7.3442937
D	0.3387703
U [m/s]	2.6018405
u/u2*	0.3542669
dT [K]	102.22736
T [K]	395.37736
Y	3.4983629
Td [K]	347.03974
delta	-0.000846

Detector Activation Time [s]
163.2

Fire Size @ Activation [kW]
1250

**Fire in Student Work
3rd Floor**

This sheet predicts sprinkler/heat detector activation based on the method of Heskestad and Delichatsios
 Input in the green areas.

<i>green</i>	=input in these areas
<i>yellow</i>	=output in these areas
<i>blue</i>	=titles and other messages

alpha [kW/s^2]	0.0469
r [m]	3.4
g [m/s^2]	9.81
Ceiling Height [ft]	16
Convective Fraction	0.7
Tamb [F]	68
Cp	1
RTI (m-s)^(1/2)	50
Tact [F]	165
Tact [K]	347.03889
Tamb [K]	293.15
Ceiling Height [m]	4.8780488
Q [kW]	1411.383
Q [Btu/sec]	1339.0731
t [sec]	173.47465
rho [lb/ft^3]	0.075
rho [kg/m^3]	1.2004746
A	0.0278757
t2*	12.939542
t2*f	1.461117
dT2*	120.9749
u2*/(dT2*^(1/2))	0.740654
U2*	8.1463486
D	0.314674
U [m/s]	2.9640943
u/u2*	0.3638556
dT [K]	98.113338
T [K]	391.26334
Y	3.9740808
Td [K]	347.03908
delta	-0.000194

**Fire in Atrium
4th Floor**

Detector Activation Time [s]
173.5

Fire Size @ Activation [kW]
1411

Appendix B

**Design Fire Location
Schematics**

LEVEL TWO EAST
 SCALE: 1/8" = 1'-0"

ARCHITECT
 ZGF
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

ENGINEER
 HKS
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.hks.com

CONSULTANT
 HKS
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.hks.com

OWNER
 UNIVERSITY OF CALIFORNIA
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.universityofcalifornia.edu

DATE
 11/11/21

PROJECT
 CENTER FOR SCIENCE AND MATHEMATICS

LOCATION
 1000 15th Street, Suite 1000
 San Francisco, CA 94103

DESCRIPTION
 ARCHITECTURAL FLOOR PLAN
 LEVEL TWO EAST

REVISIONS

NOTES

LEVEL 100 EAST
 SCALE: 1/8" = 1'-0"

ARCHITECT
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

ENGINEERING
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

MECHANICAL ENGINEERING
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

ELECTRICAL ENGINEERING
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

PLUMBING ENGINEERING
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

STRUCTURAL ENGINEERING
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

LANDSCAPE ARCHITECTURE
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

INTERIOR DESIGN
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

CONSTRUCTION MANAGEMENT
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

GENERAL CONTRACTOR
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

MECHANICAL CONTRACTOR
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

ELECTRICAL CONTRACTOR
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

PLUMBING CONTRACTOR
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

STRUCTURAL CONTRACTOR
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

LANDSCAPE CONTRACTOR
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

INTERIOR DESIGNER
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com

CONSTRUCTION MANAGER
 1000 15th Street, Suite 1000
 San Francisco, CA 94103
 Tel: 415.774.2500
 Fax: 415.774.2501
 www.zgf.com