FPE 596

Culminating Experience in Fire Protection Engineering

Spring 2013
Telecommunications Switching Facility
(Evaluation of Current Telco Design Practices)

The Cal Poly logo is located in the bottom left corner of the slide. It consists of the words "CAL POLY" in a teal, serif font, with a horizontal line underneath. The logo is set against a green background with a diagonal hatching pattern.

CAL POLY

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Building Description – FPE 596

- ▶ Wireless Telecommunications Master Switch Center
- ▶ Business Case: **Corporate Merger**-*Retrofit to National Standards*
- ▶ Located in Southern Mississippi
- ▶ **Single Story, 14,398 ft²** (New Side)
- ▶ Occupancy: **Industrial *Low Occupancy***
- ▶ Type of Construction: Type II-B (Non-Combustible - 0,0,0)

Project Scope

- Build outer structural shell on “Retro-Fit Side, Network”.
- No disruption to the network allowable through construction.

Applicable Codes-Regulations/-Standards

- ▶ Building Code
 - IBC-2003-International Building Code

- ▶ Fire Safety
 - 2003 IFC, International Fire Code
 - NFPA 101-2000 Life Fire Safety
 - 2010 NFPA-72 National Fire Alarm and Signaling Code, and
 - 2009 NFPA-76 Standard for the Fire Protection of Telecommunication Facilities
 - NFPA 13 Automatic Sprinkler Systems
 - NFPA 2001- Standard on Clean Agent Fire Extinguishing System
 - NFPA 92B-Standard for Smoke Management Systems in Malls, Atria, and Large Spaces (Optional Owners Requirement)

Occupancies

ROOM OCCUPANT LOAD & EGRESS REQUIREMENTS									
ROOM NUM.	ROOM NAME		AREA (SF)	OCCUPANT LOAD FACTOR	SPACE OCCUPANT LOAD	COMMON PATH OF TRAVEL?	DOOR WIDTH (NOMINAL)	(IBC) 0.15 person/in	# MEANS OF EGRESS REQUIRED
100	VESTIBULE	*	98	100	1.0	YES	72	480	1
101	CONFERENCE ROOM	*	782	15	52.1	-	36	240	2
102	HALLWAY	*	300	100	3.0	YES	72	480	1
103	BREAK ROOM	*	350	100	3.5	-	36	240	1
104	MENS RESTROOM		222	50	4.4	-	36	240	1
105	WOMENS RESTROOM		190	50	3.8	-	36	240	1
106	TECHNICAL STAFF OPEN OFFICE	*	1378	100	13.8	NO	36	240	1
107	BATTERY ROOM		1323	300	4.4	-	108	720	1
108	HALLWAY	*	240	100	2.4	YES	36	240	1
109	TELCO ROOM		370	300	1.2	-	36	240	1
110	ELECTRICAL ROOM		362	300	1.2	-	36	240	1
111	JANITOR	*	33	100	0.3	-	36	240	1
112	SHIPPING/RECEIVING		1410	500	2.8	-	72	480	1
113	SWITCH ROOM		3376	300	11.3	-	72	480	1
114	SWITCH MECHANICAL ROOM		764	300	2.5	-	48	320	1
115	CONTROL ROOM	*	413	100	4.1	-	36	240	1
116	OFFICE	*	136	100	1.4	-	36	240	1
117	OFFICE	*	136	100	1.4	-	36	240	1
118	OFFICE	*	571	100	5.7	-	36	240	1
120	SPARES ROOM	*	528	300	1.8	-	36	240	1
120	HALLWAY	*	163	100	1.6	YES	36	240	1
121	SHOWER	*	64	50	1.3	-	36	240	1
122	RISER ROOM	*	64	300	0.2		36	240	1
123	MECHANICAL ROOM		235	300	0.8	-	36	240	1
	TOTAL OCCUPANT LOAD:				126.1				

Area Protection Features

➤ Switch Room

Dimensions: 40'-0" x 84'-0"

Detection: **Cross Zoned:** Aspirating and Photo-electric Spot Detectors

Suppression: **FM200, Clean Agent**

Smoke Management (Owner Required)

➤ Switch Mechanical Room

Dimensions: 40'-0" x 18'-0"

Detection: **Cross Zoned:** Aspirating and Photo-electric Spot Detectors

Suppression: **FM200, Clean Agent**

Smoke Management (Owner Required)

➤ Electrical Room

Dimensions: 12'-0" x 36'-0"

Detection: **Cross Zoned:** Aspirating and Photo-electric Spot Detectors

Suppression: **FM200, Clean Agent**

Smoke Management (Owner Required)

NEC-Exit and Separation

➤ Data/IT Room

Dimensions: 12'-0" x 36'-0"

Detection: **Cross Zoned:** Aspirating and Photo-electric Spot Detectors

Suppression: **FM200, Clean Agent**

Smoke Management (Owner Required)

➤ DC Power Room

Dimensions: 31'-0" x 45'-0"

Dimensions: 12'-0" x 36'-0"

Detection: **Cross Zoned:** Aspirating and Photo-electric Spot Detectors

Suppression: **FM200, Clean Agent**

Smoke Management (Owner Required)

IFC 608.6-Ventilation For Hydrogen Producing Batteries

Continuous Hydrogen Exhaust –IFC Section 608

➤ Shipping and Receiving Area

Dimensions: 40'-0" x 36'-0"

Detection: Spot Smoke Detectors.

Suppression: Dual action pre-action

➤ Control Room

Dimensions: 13'-0" x 32'-0"

Detection: Spot Smoke Detectors.

Suppression: Dual action pre-action

Continuous line type heat detectors in concealed spaces – fixed temperature ratings of 190 deg. F.

➤ Administrative Areas

Detection: Spot Smoke Detectors in Occupied Areas.

Suppression: Dual action pre-action

Continuous line type heat detectors in concealed spaces – fixed temperature ratings of 190 deg. F.

Exits

EXHIBIT 110.17 Basic Rule, **110.26(C)(2)**. For equipment rated 1200 amperes or more and over 6 ft wide, one entrance not less than 24 in. wide and 6½ ft high is required at each end.

Fire Separations

- The need for rated corridor walls **are exempt** per 40.3.6 from LSC 7.1.3.1 due to the operational nature of the industrial processes.

Pre-Movement Considerations

Tech Areas- limited call of attention to fire alarms or events.

- high ambient lighting noise +
- high ambient sound noise +
- occupied in detailed tasks +
- sound isolating head phones +
- isolated, independent tasks +

= prolonged inattentiveness to the fire/life safety event.

It will take up to **120 seconds** for the occupants to realize the incident and decide to take actions.

Evacuation Stages

28.9 SECONDS FOR FULL EVACUATION

DEPOWERING

FIGURE A.6.5.1 Depowering Decision Tree.

SELECTIVE MEANS OF DEPOWERING (NFPA-76-SEC-6.05)

FIGURE A.6.5.2(a) Typical Telecommunications Facility Power Sources Indicating Selective Disconnect Points.

SELECTIVE MEANS OF DEPOWERING (NFPA-76-SEC-6.05)

Should this apply to social networks?

FIGURE A.6.5.2(a) Typical Telecommunications Facility Power Sources Indicating Selective Disconnect Points.

Hydrogen Exhaust Requirement

BATTERY ROOM VENTILATION CALCULATION

$V = NIK$, WHERE:

V = VOLUME OF HYDROGEN (FT^3) GAS PRODUCED PER HOUR

N = NUMBER OF CELLS = 24 CELLS PER STRING. 10 STRINGS

I = CHARGING CURRENT IN AMPERES = 40 AMPS BASED ON CHARGING CURRENT FOR 4,300 AMPS

K = $0.016 \text{ FT}^3/\text{A-H}$

CHARGING CURRENT FOR 3000 TO 4000 AMP-HOUR BATTERY = 40 AMPS

CHARGING CURRENT FOR 2000 TO 3000 AMP-HOUR BATTERY = 30 AMPS

CHARGING CURRENT FOR 0 TO 2000 AMP-HOUR BATTERY = 20 AMPS

TO OBTAIN EXHAUST AIR REQUIRED (CFM) TO MAINTAIN MAXIMUM HYDROGEN BUILD UP OF 1%, DIVIDE V VALUE BY 1%.

$N = 240 \text{ CELLS} \times 40 \text{ AMPS} \times 0.016 (\text{FT}^3/\text{A-H})$

$N = 153 \text{ CFH} \rightarrow 2.56 \text{ CFM}$

EXHAUST AIR REQUIRED IN CFM = $2.56/1\% = 256 \text{ CFM}$

MINIMUM FAN FLOW: 500 CFM

HYDROGEN
EXHAUST
DUCT

BATTERY ACID VOLUME

VOLUME ACID PER CELL (GAL) X NUMBER OF CELLS

15 GAL/CELL X 240 CELLS

TOTAL VOLUME = 3,600 GAL

Detection and Notification

VESDA Requirements

The system shall comply with 8.5.3.1.2 VEWFD Sensor and Port Installation as follows;

8.5.3.1.2.1

Where one level of sensors or ports is installed in an area, it shall be limited to a maximum coverage area of 200 ft².

8.5.3.1.2.2

Where two levels (high and low) of ports or sensors are provided, the following requirements shall be met:

- (1) Each level shall be limited to a coverage of 400 ft² or less per port or sensor.*
- (2) The coverage limitation between high and low levels shall be limited to 200 ft² or less providing for staggered port or sensor arrangements between each level.*

VESDA Requirements (cont.)

8.5.3.1.2.3

Sensors or ports shall be installed to monitor return air from the space.

(A) Where stand-alone packaged HVAC units are installed, sensors or ports shall be installed where return air is brought back to the unit.

(B) Sensors or ports shall be installed such that each covers no greater than 4 ft² of the return air opening.

8.5.3.1.2.4

Where air-sampling systems are installed, the systems shall be designed using manufacturer-provided listed criteria.

VESDA Requirements (cont.)

8.5.3.1.2.5

Minimum sensitivity settings above ambient airborne levels for the VEWFD systems installed shall be as follows:

(1) Alert condition includes the following:

*(a) Air-sampling systems: 0.2 percent per foot obscuration
(effective sensitivity at each port)*

(b) Spot-type sensors: 0.2 percent per foot obscuration

(2) Alarm condition includes the following:

(a) Air-sampling systems: 1.0 percent per foot obscuration (effective sensitivity at each port)

(b) Spot-type sensors: 1.0 percent per foot obscuration

8.5.3.1.2.6

Maximum transport time from the most remote port to the detection unit of an air-sampling system shall not exceed 60 seconds.

Sequence of Operations (excerpt)

CLEAN AGENT PROTECTED ZONE FUNCTIONS	FACP OR FSCP PANEL(S) TROUBLE CONDITION
	KEY OPERATED HVAC INHIBIT SWITCH IN THE INHIBIT POSITION
	MANUAL CLEAN AGENT RELEASE PULL STATION - AT ALL EXITS BY DOOR(S) FROM FM-200 SPACE
	CLEAN AGENT ABORT STATION - AT ALL EXITS BY DOOR(S) FROM FM-200 PROTECTED SPACE
	ANY ONE (1) EWFD SMOKE DETECTOR IN THE PROTECTED ZONE IN PRE-ALARM (0.5%/FT)
	ANY ONE (1) EWFD SMOKE DETECTOR IN THE PROTECTED ZONE IN ALARM (2%/FT)
	ANY TWO (2) EWFD SMOKE DETECTORS IN THE PROTECTED ZONE IN ALARM (2%/FT)
	ANY ONE (1) VEWFD SMOKE DETECTOR IN THE PROTECTED ZONE IN PRE-ALARM (0.02%/FT)
	ANY ONE (1) VEWFD SMOKE DETECTOR IN THE PROTECTED ZONE IN ALARM (1%/FT)
	ANY ONE (1) VEWFD AND ONE (1) EWFD SMOKE DETECTOR IN THE PROTECTED ZONE IN ALARM
	45 SECOND TIME DELAY EXPIRES (ABORT STATION NOT ACTIVATED)
	KEY OPERATED CLEAN AGENT INHIBIT SWITCH IN THE INHIBIT POSITION

Suppression: Type and Zones

Water Flow Data

The total hydraulic demand:

- 243 GPM +
- 100 GPM hose stream allowance
- 54 psi.

WATER DISTRICT FLOW DATA TEST REPORT			
BLDG. LOCATION:	200 COUNTRY PLACE PKWY, PEARL MS	DATE:	1/5/2011
TEST MADE BY:	LT. CHRIS FLAHERTY	TIME:	10AM
REPRESENTATIVE OF:	PEARL FIRE DEPARTMENT		
CONTROL HYDRANT NO.:			
LOCATION:	ACROSS THE STREET FROM BLDG.,		
RESIDUAL PRESSURE:	55PSI		
STATIC PRESSURE:	60PSI		
FLOW HYDRANT NO.:			
LOCATION:	200 COUNTRY PLACE PKWY		
RESIDUAL PRESSURE:	50 PSI		
TOTAL GPM:	950		
TEST MADE ON MAIN SIZE?:	YES		
CONSUMPTION RATE DURING TEST:			
SIZE NOZZLE:

Project Location: JACKSON, MS

Flow Test: Hydrant Elev.= 202 ft., Static Pressure= 60 psi, Residual Pressure= 55 psi, Flow= 950 gpm

Tester and/or Witness By: CHRIS FLAHERTY

Phone:

Date:

System Demand Data: Pressure = 54 psi, Flow = 254 gpm, Hose Stream = 100 gpm

Designer: Eric Kumar

Phone: 650 862-4762

A.H.J.

FM-200 Design Concentration

ESTIMATED FM-200 CLEAN AGENT VOLUMETRIC CALCULATIONS										
BASED ON 7.0% DESIGN CONCENTRATION										
ZONE NO.	ROOM NO.	ROOM NAME	AREA SQ. FT.	CEILING HT. FT.	VOLUME CU. FT.	FLOODING FACTOR	MIN. LBS. AGENT REQ. PER RM.	MIN. LBS. AGENT PER ZONE	* EST. CYL. PER RM.	ROOM NOTES:
1	113	SWITCH EQUIPMENT ROOM	3,376	21.00	70,896	0.0341	2,418	2,418	4	SWITCH ROOM ZONE IS SWITCH MECHANICAL ROOM.
	114	SWITCH MECHANICAL ROOM	764	21.00	16,044	0.0341	547	547	1	
2	107	BATTERY ROOM	1,253	21.00	26,313	0.0341	897	897	2	
3	110	ELECTRICAL ROOM	362	21.00	7,602	0.0341	259	259	1	
4	109	TELCO ROOM	370	21.00	7,770	0.0341	265	265	1	
ESTIMATED TOTAL AGENT FOR ALL ZONES:								4,121		
NOTES:										
1. ACTUAL HFC-227ea DESIGN SHALL BE BASED ON NFPA 2001 - CURRENT EDITION AND THE MANUFACTURERS UL LISTING AND FM APPROVAL.										
2. AGENT QUANTITIES ARE APPROXIMATE AND BASED ON ROOM VOLUME.										
3. IT IS THE CONTRACTORS RESPONSIBILITY TO VERIFY THE ROOM VOLUME FOR THE CORRECT AMOUNT OF AGENT FOR EACH ZONE BEING PROTECTED.										
* BASIS OF DESIGN IS FIKE FM-200 CYLINDERS. QUANTITY OF CYLINDERS BASED ON SIZES PROVIDED BY FIKE CORPORATION AND IS BASED ON AMOUNT OF AGENT PER CYLINDER. EACH MANUFACTURER PROVIDES THEIR OWN CYLINDER SIZES AND QUANTITY OF AGENT PER CYLINDER. QUANTITY OF CYLINDERS ON THE DRAWINGS IS BASED ON FIKE FM-200 CYLINDER SIZES. IF OTHER MANUFACTURERS ARE PROVIDED QUANTITY OF CYLINDERS CHANGE BASED ON THEIR REQUIREMENTS.										

USE
FLOODING
FACTOR OF
0.0341

5.5.1* The amount of halocarbon agent required to achieve the design concentration shall be calculated from the following formula:

$$W = \frac{V}{S} \left(\frac{C}{100 - C} \right) \quad (5.5.1)$$

where:

W = weight of clean agent [lb (kg)]

V = net volume of hazard, calculated as the gross volume minus the volume of fixed structures impervious to clean agent vapor [ft^3 (m^3)]

S = specific volume of the superheated agent vapor at 1 atm and the minimum anticipated temperature [$^{\circ}\text{F}$ ($^{\circ}\text{C}$)] of the protected volume [ft^3/lb (m^3/kg)]

C = agent design concentration (volume percent)

FM-200 Installation Requirements

- The clean agent system shall be tested in accordance with the NFPA 2001-Chapter 4 and AHJ requirements.
- Perform operational testing per the sequence of operations and verify all alarms/troubles are received by on-site monitoring.

FM-200 Installation Requirements

ENCLOSURE
INTEGRITY
TESTING
PER NFPA 2001
APPENDIX C

FM-200 Installation Requirements

- At the completion of the clean agent installation, fan tests shall be performed by the contractor and witnessed by the authority having jurisdiction. All penetrations shall be sealed prior to the testing.
- Below are typical leakages for wall/floor areas per HB Smoke Control Engineering. This building is considered to have a tight construction due to its critical applications.
 - Exterior Building Walls: $0.0072 \text{ in}^2/\text{ft}^2$
 - Floors (applied to roof): $0.00095 \text{ in}^2/\text{ft}^2$
- Fan test results must show that room integrity is sufficient enough to maintain the HFC-227EA (FM-200) suppression agent interface height to a level of not less than 10 feet above the floor for a period not less than 10 minutes.

Products of Combustion

- Products of combustion in a telecom facility include
 - chlorine from combusted plastics
 - tin and lead from solder connection
 - zinc from transistor chip coatings
 - copper and bromine from circuit boards;
 - manganese, silicon, and so forth.
- When combined with moisture, chlorine forms gaseous hydrochloric acid and electrically conducting ionic chloride compounds.
- The compounds can lead directly to corrosion damage, electrical shorts or signal noise in the system.
- Soot is an efficient absorber of HCL gas, which by adhering to circuit boards promotes corrosion.

Exposure to contaminants

Particle deposition onto circuit packs leads to bridging and resultant current leakage that contribute to the deterioration of telecommunications equipment performance and a loss of reliability.

Zinc Chloride Accumulation

Normal : $30\mu\text{g}/\text{in}^2$ to $60\mu\text{g}/\text{in}^2$ (20 year life)

Clean: $10\mu\text{g}/\text{in}^2$

Fire Exposed : $30\mu\text{g}/\text{in}^2$ to $6000\mu\text{g}/\text{in}^2$

Restoration is easy and CHEAP for accumulation below $200\mu\text{g}/\text{in}^2$, but still feasible up to $600\mu\text{g}/\text{in}^2$.

Restoration is not cost effective for accumulation above $600\mu\text{g}/\text{in}^2$

“It is estimated that 95 percent of the fire damage in telephone central offices is attributed to the smoke products and only 5 percent is caused by the thermal effect of fires”-(NFPA 76-Annex D)

Smoke Management System

- All smoke management control panels shall be listed in accordance with UL-864 and all equipment must be rated for temperature they will be exposed to.
- Begin purging smoke from critical spaces immediately after “soak time” of suppression system.
- Remove smoke from cable trays, IT equipment, and associated packaging design fires.
- Provide conditioned make-up air throughout the smoke management process to maintain the temperature and humidity environment within the IT equipment spaces similar to normal conditions (the IT equipment must remain in operation during this time). The IT equipment must not be susceptible to *thermal shock*.

Smoke Management System

- All volume isolation dampers shall be rated in accordance with UL555/S.
- The system shall be fully automatic, fulfilling all control functions to shutdown normal HVAC, close all doors, and close all dampers in affected zone after detection of a fire.
- It shall return the HVAC system back to normal conditions after exhausting all the smoke.

Key Design Objectives

- Remove smoke quickly enough to maintain the smoke above the equipment racks during the worst-case design fire scenario by doing the following functions;
 - Maintain the smoke layer interface above 8'-0" elevation (above equipment racks)
 - Protect the equipment from smoke damage
 - Allow for depowering efforts,
 - Maintain smoke above door openings
- Smoke purge equipment must remove the smoke particles from the area within 60 minutes after a fire event and the release of the suppression agent.

Key Design Objectives

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 - Allow for depowering efforts,
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- Smoke purge equipment must remove the smoke particles from the area within 60 minutes after a fire event and the release of the suppression agent.

Are NFPA 92-B calculations sufficient to meet the noted requirements?

Design Fires

Case No.	Design Fire	Fuel	Max. HRR (kW)	Modeling Assumptions	Source
DF1	Cable Tray	PE and PVC Cable Insulation	1600	Model assumes the fire spreads the full length 40'-0" length of the tray. A T-square growth rate is modeled based on the analysis in the report.	Peak HRR Data from NRC-1805.
DF2	Computer Rack Burning	Primarily the plastic insulation of wires and other electronic components.	500	Tabulated HRR ramp functions	Nureg-4527-ST11UQ Cab Fire
DF3	Battery Cell Fire	Lead Acid Cells	1,220	Fire limited to 1 rack following the curves as defined by the source.	H.R. Bahadori, Hughes Associates (2006)

Case 1: Design Fire Simulations-DF1: Switch Room Cable Tray

CABLE TRAY FIRE

EXHAUST FANS

MAKE-UP FAN

Case 1: Switch Room Cable Tray

This design fire represents one cable trays (1'-6" x 0'-6" x 44'-0" each) in the Switch Room. The room is 40' x 84' and has a floor to ceiling height of 21'-0". The maximum HRR IS 1,600kW and has the following growth, burn, and decay profile.

DF1: Fire timeline

Case 1: Switch Room Cable Tray

SWITCH ROOM PHYSICAL MODEL

Case 1: Switch Room Cable Tray

Frame: 3600

Time: 3600.0

SMOKE OBSCURATION AT 0.5
M ELEV.: 85% obscuration per m
WITH BEAM DEVC.

SMOKE
LAYER
INTERFACE

Case 1: Switch Room Cable Tray

At 674 seconds the fire is only allowed to grow to 546 kW and the obscuration rate at the 8'-0" level is only 8.61%/m.

Frame: 674
Time: 674.0

SMOKE OBSCURATION AT
0.5m ELEV.: 8.05%/m WITH
BEAM DEVC.

SMOKE
LAYER
INTERFACE

Case 1: Switch Room Cable Tray

Plot3d
temp
C

HOTTEST TEMPERATURE AT
720 SECONDS 55.5°C (132°F)

Fire Products at Given Time

(sec)	(g)	(MJ)	(g)	(g)	(m)	(deg.C)	(g/m ³)	(g/m ³)
t	m _f	Q	m _s	m _{HCL}	y _t	T _g	C _s	C _{HCL}
0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00
31.30	0.61	1.18	0.00	0.03	0.00	22.29	0.94	9.14
76.31	8.84	6.99	0.02	0.20	0.02	27.51	0.94	9.14
676.31	6151.76	548.87	1.64	15.68	(Floor)	157.69	1.70	16.50
3676.31	988094.25	16218.31	48.38	463.29	(Floor)	Flame Impinges Ceiling	273.27	2649.93

Case 2: Switch Room IT Equipment Rack

This fire presents a equipment rack fire per the profile in NUREG-4527 testing. This test was conducted on a ITE rack with unqualified cables and no doors.

Case 2: Switch Room IT Equipment Rack : HRR

Case 2: Switch Room IT Equipment Rack : HRR

Frame: 0

Time: 0.0

Case 2: Switch Room IT Equipment Rack : HRR

Frame: 1168

Time: 1168.0

Case 2: Switch Room IT Equipment Rack : HRR

SOOT HAS REMAINED AT 3600 SECONDS

Frame: 3600
Time: 3600.0

Case 3: Battery Room: Round Cell Batteries

This design fire represents round cell batteries in acrylic stand located in the battery room. The room is 12' x 36' and has a floor to ceiling height of 18'-0".

Case 3: VRLA Battery Fire: HRR

The maximum HRR IS 1,220kW and has the following growth, burn, and decay profile.

Case 3: VRLA Battery Fire: HRR

Physical Model Set-up:

- The exhaust flows this fire has been nearly doubled to maintain the smoke layer interface in accordance with the clients requirement (39,730 vs 20,600 CFM for exhaust)
- and the make-up air has been increased nearly fourfold and 9,535 CFM vs. 2,331 CFM for make-up air).

Case 3: VRLA Battery Fire: HRR

Smoke Layer Interface at end of 1220 kW constant HRR phase.

Frame: 602

Time: 602.0

Case 3: VRLA Battery Fire: HRR

At $t=900$ the smoke has been completely purged from the space.

Frame: 902
Time: 902.0

Summary

- ▶ Effective detection and notification has been provided for the building.
- ▶ Egress is sufficient for the occupancy level.
- ▶ Special hazards have been properly addressed
- ▶ The early detection, flooded suppression by the clean agent, and smoke purge will maximum the uptime of the facility operations.
- ▶ The facility design and administrative procedures minimize hazards to fire fighters.
- ▶ A discrepancy between the smoke purge flow rate has been observed between the NFPA-92B calculations and FDS models.

Summary

- ▶ FDS simulations show that 4X exhaust and make-air is required compared to NFPA-92B to meet the key objectives.
- ▶ It is improbable that the fire will be able to reach its max. HRR, so the discrepancy **may not** present a major risk, as the fire will be suppressed close its inception stage.
- ▶ The NFPA-92 model aligns with C-FAST which has traditionally been used by the client based on a Hughes and Associates report for one of their facilities.
- ▶ Additional fire research is required for high air flow influence and large temperature gradients found in these data-com facilities.