Workshop Problems for Task 1: Plant Boundary Definition and Partitioning

Workshop Problem Set 01-01

Step 1 - Selection of Global Plant Analysis Boundary: Using Drawing # 01 in the Sample Package and the information provided in other drawings, identify the Global Plant Analysis Boundaries in terms of plant areas. Make a complete list of plant areas shown on Drawing #01 in the matrix provided below. Specify whether or not the area shall be included within the Global Plant Analysis Boundaries and then provide the basis of your decision.

Plant Area	Included?	Basis
Auxiliary Building	Yes	Contains equipment and cables that may be included in the fire PRA analysis
Containment	Yes	Contains equipment and cables that may be included in the fire PRA analysis
Diesel Generator Building	Yes	Contains equipment and cables that may be included in the fire PRA analysis
Turbine Building	Yes	Contains equipment and cables that may be included in the fire PRA analysis
Yard	Yes	Contains equipment and cables that may be included in the fire PRA analysis
Security Building	No	There are no equipment or cables in this building needed for safe shutdown
Switchyard	No	Offsite power is impacted from equipment or cable failure in the Switchyard. However, the impact of a fire event in the switchyard would be limited to loss of offsite power and no other safe shutdown related functions. Therefore, switchyard fires are considered a part of loss of offsite
Intake Structure	Yes	Contains equipment and cables that may be included in the fire PRA analysis

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Workshop Problem Set 01-02

Step 2: Plant Partitioning: Using the drawings provided in the Sample Package, identify the set of fire compartments that you will consider for the fire PRA. In the following matrix (1) list selected compartments, (2) give each an identification number, (3) identify the associated plant area for each compartment from the Solution Statement for Problem Set 01-01. Provide comments where warranted.

Fire Comp. ID #	Fire Compartment Descriptor	Plant Area	Comments
1	Main Control Room	Auxiliary Building	Includes the kitchen and Shift Supervisor's Office
2	Aux Bldg El. 0 Ft	Auxiliary Building	
3	Cable Spreading Room	Auxiliary Building	
4A	Aux Bldg. El. -20 Ft, RHR Room	Auxiliary Building	
4B	Aux Bldg. El. -20 Ft, AFW Room	Auxiliary Building	
5	Battery Room A	Auxiliary Building	1 hour rated walls and 2 hour rated ceiling within the Switchgear rooms
6	Battery Room B	Auxiliary Building	1 hour rated walls and 2 hour rated ceiling within the Switchgear rooms
7	Containment	Containment	
8A	DG-A Room	Diesel Generator Building	

Fire Comp. ID #	Fire Compartment Descriptor	Plant Area	Comments
8B	DG-B Room	Diesel Generator Building	
9	SWG Access Room	Auxiliary Building	
10	Switchgear Room A	Auxiliary Building	
11	Switchgear Room B	Auxiliary Building	
12	Turbine Bldg El. 0 Ft	Turbine Building	
13	Yard	Yard	Includes the Transformers next to the Diesel Generator Building and the two safety related tanks.
14	Intake Structure	Intake Structure	A long building with some divisions with large openings among them with no doors isolating each compartment from other compartments.
15	Battery Room 1	Turbine Building	1 hour rated walls and 2 hour rated ceiling within the Switchgear rooms
16	Stairway	Auxiliary Building	All doors are 1 hour rated
17	Control Room Access	Auxiliary Building	

Workshop Example

Step 3: Compartment Information Gathering and Characterization: The following tabulation provides an example of the information about fire compartments that may be used in a fire PRA project.

Item	**Resolution**
Fire Compartment ID #	9
Fire Compartment	Switchgear Access Room
Building	Auxiliary Building
Boundary Characteristics	The compartment is bounded by 3-hr rated fire walls, ceiling and floor.
Ventilation Features	The ventilation is provided by the Auxiliary Building HVAC system (1). The equipment housed in this compartment can function properly and perform their safe shutdown duties in case of total loss of the HVAC system.
Fire Protection Features	The fire protection features of this compartment includes: 1. Handheld extinguishers inside the compartment (2 units) (1) 2. Wet hose reel outside the door inside the stairwell(1) 3. Smoke detectors attached to the ceiling (6 units) (1) 4. Automatic CO_2 system
Fire Sources	The following ignition sources were identified in this compartment. 1. MCC-A 2. MCC-B 3. 125VAC-A 4. 125VAC-B 5. ATS 6. Lighting Fixtures (10 units)(1) Additionally the following combustibles are present: 1. Cable trays containing thermoset control cables 2. Wooden desk used by the electrical department(1)
Adjacent Compartments	The following compartments share a wall, ceiling or floor with this compartment: 1. Switchgear Room A 2. Switchgear Room B 3. Stairwell 4. Charging pump room 5. Cable spreading room
Access Routes	1. This room can be accessed from outside through the stairwell 2. Switchgear Rooms A and B are accessed through this room
Components /Systems / Cables Present	See the component and cable lists provided in Tasks 2 and 3.
SSD Human Actions Credited in this Compartment	To be completed after Task 12 is completed.

(1) Provided here to demonstrate how this part of the step may be addressed. These features are not intended to be included in the Fire PRA of this Sample Package.

Workshop Problems for Task 6: Fire Ignition Frequency

Workshop Problem Set 06-01

Step 1: Mapping plant ignition sources to generic sources: Using the information provided in this Sample Package, map the items listed in the following table to generic sources.

Equipment ID	Equipment Description	Equipment Type	Bin #	Bin Description / Comment\
HPI-B	High pressure safety injection pump B	Pump	21	Pumps
MOV-1	HPI valve	MOV	14	Electric Motors
MOV-5	RWST isolation valve	MOV	--	Less than 5hp motor
BAT-B	Train B Battery	Battery	1	Batteries
RCP-1	Reactor coolant pump 1	Pump	2	Reactor Coolant Pump
AOV-1 / (SOV-1)	Pressure operated relief valve	AOV	--	Assumed as insignificant ignition source.
PT-1	RCS pressure	Instrument	--	Assumed as insignificant ignition source.
EDG-A	Train A Emergency Diesel Generator	Diesel Generator	8	Diesel Generators
MCC-B1	Train B 480 V Motor Control Center	Motor Control Center	15	Electrical Cabinets
ATS-1	Automatic Transfer Switch	ATS	15	Electrical Cabinets
VITAL-A	Train A 120 VAC Vital Bus	120VAC Bus	15	Electrical Cabinets
SWGR-A	Train A 4160 V Bus	Switchgear	15/16	Electrical Cabinets/HEAF
LC-A	Train A 480 V Load Center	Load Center	15/16	Electrical Cabinets/HEAF
SST-A	Train A Station Service Transformer	Transformer	23a	Transformers (Dry)
BC-A	Train A Battery Charger	Battery Charger	10	Battery Chargers
DC BUS-A	Train A 125 VDC Bus	DC Bus	15	Electrical Cabinets
PNL-A	Train A 125 VDC Panel	Panelboard	15	Electrical Cabinets
INV-A	Train A Inverter	Inverter	15	Electrical Cabinets
AFW-A	Motor driven AFW pump A	Pump	21	Pumps
AFW-B	Steam driven AFW Pump B	Pump	21	Pumps
SUT-1	Startup Transformer	Transformer	29	Yard transformers (Others)

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The following table provides the components specifically addressed in the Fire PRA of this Sample Package.

Equipment ID	Equipment Description	Equipment Type	Bin #	Bin Description / Comment\
TI-1	Letdown heat exchanger outlet temp	Instrument	--	Comment 1 (below)
HPI-A	High pressure safety injection pump A	Pump	21	Pumps
HPI-B	High pressure safety injection pump B	Pump	21	Pumps
AOV-2 / (SOV-2)	Letdown isolation valve	AOV	--	Comment 1
AOV-3 / (SOV-3)	Charging pump injection valve	AOV	--	Comment 1
MOV-1	HPI valve	MOV	14	Electric Motors
MOV-2	VCT isolation valve	MOV	14	Electric Motors
MOV-5	RWST isolation valve	MOV	--	Less than 5hp motor
MOV-6	RWST isolation valve	MOV	--	Less than 5hp motor
MOV-9	HPI valve	MOV	14	Electric Motors
RHR-B	RHR pump B	Pump	21	Pumps
MOV-3	Cont. sump recirc valve	MOV	14	Electric Motors
MOV-4	Cont. sump recirc valve	MOV	14	Electric Motors
MOV-8	RHR outboard suction valve	MOV	14	Electric Motors
BAT-A	Train A Battery	Battery	1	Batteries
BAT-B	Train B Battery	Battery	1	Batteries
RCP-1	Reactor coolant pump 1	Pump	2	Reactor Coolant Pump
AOV-1 / (SOV-1)	Pressure operated relief valve	AOV	--	Comment 1
MOV-7	RHR inboard suction valve	MOV	14	Electric Motors
MOV-13	PORV block valve	MOV	--	Comment 2
LI-3	Containment sump level	Instrument	--	Comment 1
LI-4	Containment sump level	Instrument	--	Comment 1
PT-1	RCS pressure	Instrument	--	Comment 1
EDG-A	Train A Emergency Diesel Generator	Diesel Generator	8	Diesel Generators
EDG-B	Train B Emergency Diesel Generator	Diesel Generator	8	Diesel Generators
ANN-1	AFW motor high temp	Annunciator	--	Comment 1
MCC-A1	Train A 480 V Motor Control Center	Motor Control Center	15	Electrical Cabinets
MCC-B1	Train B 480 V Motor Control Center	Motor Control Center	15	Electrical Cabinets
ATS-1	Automatic Transfer Switch	ATS	15	Electrical Cabinets
VITAL-A	Train A 120 VAC Vital Bus	120VAC Bus	15	Electrical Cabinets
VITAL-B	Train B 120 VAC Vital Bus	120VAC Bus	15	Electrical Cabinets
SWGR-A	Train A 4160 V Bus	Switchgear	15/16	Electrical Cabinets/HEAF
LC-A	Train A 480 V Load Center	Load Center	15/16	Electrical Cabinets/HEAF
SST-A	Train A Station Service Transformer	Transformer	23a	Transformers (Dry)
BC-A	Train A Battery Charger	Battery Charger	10	Battery Chargers
DC BUS-A	Train A 125 VDC Bus	DC Bus	15	Electrical Cabinets
PNL-A	Train A 125 VDC Panel	Panelboard	15	Electrical Cabinets
INV-A	Train A Inverter	Inverter	15	Electrical Cabinets
SWGR-B	Train B 4160 V Bus	Switchgear	15/16	Electrical Cabinets/HEAF
LC-B	Train B 480 V Load Center	Load Center	15/16	Electrical Cabinets/HEAF

The following table provides the components specifically addressed in the Fire PRA of this Sample Package.

Equipment ID	Equipment Description	Equipment Type	Bin #	Bin Description / Comment\
SST-B	Train B Station Service Transformer	Transformer	23a	Transformers (Dry)
BC-B	Train B Battery Charger	Battery Charger	10	Battery Chargers
DC BUS-B	Train B 125 VDC Bus	DC Bus	15	Electrical Cabinets
PNL-B	Train B 125 VDC Panel	Panelboard	15	Electrical Cabinets
INV-B	Train B Inverter	Inverter	15	Electrical Cabinets
LC-1	Non-Safety 480 V Load Center	Load Center	15/16	Electrical Cabinets/HEAF
LC-2	Non-Safety 480 V Load Center	Load Center	15/16	Electrical Cabinets/HEAF
SWGR-1	Non-Safety 4160 V Bus	Switchgear	15/16	Electrical Cabinets/HEAF
SWGR-2	Non-Safety 4160 V Bus	Switchgear	15/16	Electrical Cabinets/HEAF
COMP-1	Instrument air compressor	Compressor	9	Air Compressors
MOV-10	AFW discharge valve	MOV	--	Comment 2
MOV-11	AFW discharge valve	MOV	--	Comment 2
MOV-18	AFW C Pump Discharge	MOV	--	Comment 2
SST-1	Non-Safety Station Service Transformer	Transformer	23b	Transformers (Oil filled)
SST-2	Non-Safety Station Service Transformer	Transformer	23b	Transformers (Oil filled)
MCC-1	Non-Safety 480 V Motor Control Center	Motor Control Center	15	Electrical Cabinets
MCC-2	Non-Safety 480 V Motor Control Center	Motor Control Center	15	Electrical Cabinets
BC-1	Non-Safety Swing Battery Charger	Battery Charger	10	Battery Chargers
BAT-1	Non-Safety Battery	Battery	1	Batteries
DC BUS-1	Non-Safety 250 VDC Bus	DC Bus	15	Electrical Cabinets
AFW-A	Motor driven AFW pump A	Pump	21	Pumps
AFW-B	Steam driven AFW Pump B	Pump	21	Pumps
AFW-C	AFW pump C	Pump	21	Pumps
MOV-14	AFW turbine steam line isolation valve	MOV	--	Comment 2
MOV-15	AFW steam inlet throttle valve	MOV	--	Comment 2
MOV-16	AFW test line isolation valve	MOV	--	Comment 2
MOV-17	AFW test line isolation valve	MOV	--	Comment 2
MOV-19	AFW test line isolation valve	MOV	--	Comment 2
V-12	CST isolation valve	MOV	--	Comment 2
LI-1	RWST level	Instrument	--	Comment 1
LI-2	RWST level	Instrument	--	Comment 1
SUT-1	Startup Transformer	Transformer	27/28	Yard transformers (Others)

Comment 1: Assumed as insignificant ignition source.
Comment 2: Less than 5hp motor

Workshop Problem Set 06-04

Step 4: Mapping Plant-Specific Locations to Generic Locations: Using the information provided in this Sample Package, map the items listed in the following table to the applicable generic locations provided in NUREG/CR 6850. Note that some of the compartments may map to more than one Generic Location.

Step 5: Location Weighting Factors: Assign the location weighting factors of the Fire Compartments in the following table.

Fire Comp. #	Plant Fire Compartment	Plant Area	Generic Location	W_L
1	Main Control Room	Auxiliary Building	See Note 1	1.0
2	Aux Bldg El. 0 Ft	Auxiliary Building	See Note 2	1.0
3	Cable Spreading Room	Auxiliary Building	See Note 2	1.0
4A	RHR Pump Room	Auxiliary Building	See Note 2	1.0
4B	AFW Pump Room	Auxiliary Building	See Note 2	1.0
5	Battery Room A	Auxiliary Building	See Note 3	1.0
6	Battery Room B	Auxiliary Building	See Note 3	1.0
9	SWG Access Room	Auxiliary Building	See Note 2	1.0
10	Switchgear Room A	Auxiliary Building	See Note 2	1.0
11	Switchgear Room B	Auxiliary Building	See Note 2	1.0
14	Stairway	Auxiliary Building	See Note 2	1.0
7	Containment	Containment	Containment	1.0
8A	DG-A Room	DG Bldg.	See Note 4	1.0
8B	DG-B Room	DG Bldg.	See Note 4	1.0
12	Turbine Bldg El. 0 Ft	Turbine Building	See Note 5	1.0
15	Battery Room 1	Turbine Building	See Note 6	1.0
13	Yard	Yard	See Note 7	1.0
14	Intake Structure	Intake Structure	Plant-Wide Components	1.0

Note 1: Control Room (for the Main Control Board) and Control/Aux/Reactor Building (for cable and transient fires)

Note 2: Control/Aux/Reactor Building (for cable and transient fires) and Plant-Wide Components for all other items

Note 3: Battery Room (for the batteries) and Control/Aux/Reactor Building (for cable and transient fires)

Note 4: Diesel Generator Room (for the Diesel Generators), Control/Aux/Reactor Building (for cable and transient fires), and Plant-Wide Components for all other items

Note 5: Turbine and Plant-Wide Components (for all items not specifically assigned to the Turbine Building)

Note 6: Battery Room (for the batteries) and Turbine Building (for cable and transient fires)

Note 7: Transformer Yard and Plant-Wide Components for all other items

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Workshop Problem Set 06-05

Step 5: Location Weighting Factors: At a two-unit nuclear power plant, the Main Control Room is shared between the two units. The control room consists of two separate Main Control Boards that do not share any controls and are dedicated to one unit each. There are 5 electrical cabinets in the control room in addition to the Main Control Boards that are shared between the two units.

a. For Unit 1, establish the Location Weighting Factor of the Main Control Board

$W_{L,\ MCR,\ Main\ Control\ Board} = 2.0$

b. For Unit 1, establish the Location Weighting Factor of the electrical cabinets.

$W_{L,\ MCR,\ Electrical\ Cabinets} = 2.0$

c. For Unit 1, establish the Location Weighting Factor of transient fires in the Main Control Room

$W_{L,\ MCR,\ Transients} = 2.0$

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Workshop Problem Set 06-06

Step 6: Fixed Fire Ignition Source Counts: Estimate the ignition source counts for only those items that are noted under each picture and are visible in the foreground of the picture:

Electrical Panels: _8 vertical sections

Electrical Panels: _7 vertical sections

Transformers: __1_

Transformers: _1_

Electrical Panels: _5 vertical sections

Transformers: __2_

Electrical Panels: _2 vertical sections

Electrical Panels: _3 vertical sections

Electrical Panels: _2 vertical sections

Electrical Panels: _1vertical sections

Electrical Panels: _No count –Sealed with low voltage circuits

Workshop Problem Set 06-07

Step 6: Fixed Fire Ignition Source Counts: Estimate the ignition source counts for the components identified in Step 1 above.

			Bin # and Description (per Table 6-1)												
			1	2	8	4	9	10	14	15	16	21	23a	23b	29
			Batteries	Reactor Coolant Pump	Diesel Generators	Main Control Board	Air Compressors	Battery Chargers	Electric Motors	Electrical Cabinets	High Energy Arcing Faults	Pumps	Transformers (Dry)	Transformers (Oil filled)	Yard transformers (Others)
#	Compartment	Plant Area	BAT	RCP	DG	MCB	AC	BC	EM	EC	HEAF	PMP	XFMR-Dry	XFMR-Oil	XFMR-Yard
1	Main Control Room	Control/Aux/Reactor Building	0	0	0	1	0	0	0	1	0	0	0	0	0
2	Aux Bldg El. 0 Ft	Control/Aux/Reactor Building	0	0	0	0	0	0	3	0	0	2	0	0	0
3	Cable Spreading Room	Control/Aux/Reactor Building	0	0	0	0	0	0	0	0	0	0	0	0	0
4A	RHR Pump Room	Control/Aux/Reactor Building	0	0	0	0	0	0	3	0	0	1	0	0	0
4B	AFW Pump Room	Control/Aux/Reactor Building	0	0	0	0	0	0	0	0	0	2	0	0	0
5	Battery Room A	Plant Wide Components	1	0	0	0	0	0	0	0	0	0	0	0	0
6	Battery Room B	Plant Wide Components	1	0	0	0	0	0	0	0	0	0	0	0	0
9	SWG Access Room	Plant Wide Components	0	0	0	0	0	0	0	31	0	0	0	0	0
10	Switchgear Room A	Plant Wide Components	0	0	0	0	0	1	0	25	14	0	1	0	0
11	Switchgear Room B	Plant Wide Components	0	0	0	0	0	1	0	24	14	0	1	0	0
14	Stairway	Plant Wide Components	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Containment	Containment	0	1	0	0	0	0	1	0	0	0	0	0	0
8A	DG-A Room	Plant Wide Components	0	0	1	0	0	0	0	0	0	0	0	0	0
8B	DG-B Room	Plant Wide Components	0	0	1	0	0	0	0	0	0	0	0	0	0
12	Turbine Bldg El. 0 Ft	Plant Wide Components		0	0	0	2	1	0	57	28	1	0	2	0
15	Battery Room 1	Plant Wide Components	1	0	0	0	0	0	0	0	0	0	0	0	0
13	Yard	Plant Wide Components	0	0	0	0	0	0	0	0	0	0	0	0	3
14	Intake Structure	Plant Wide Components	0	0	0	0	0	0	0	0	0	0	0	0	0
		Total	**3**	**0**	**2**	**1**	**2**	**3**	**7**	**136**	**56**	**6**	**2**	**2**	**3**

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Workshop Problem Set 06-08

Step 7: Ignition Source Weighting Factors: For an NPP, the fire PRA analysts have counted 23 pumps within the Plant Analysis Boundary.

- For RHR Pump RHRP-C located in RHR Pump room (FZ-03A), which in turn is located in the Reactor Building, establish the IS, J and L subscripts of:

  $W_{IS,J,L} = W_{RHRP\text{-}C,FZ\text{-}03A,AUX\ BLDG}$

- For the same RHR Pump, RHRP-C, calculate the Ignition Source Weighting Factor

  W = 1/23 = 0.043

- RHR Pump room FZ-03A contains three pumps. Calculate the ignition source weighting factor for the pumps in this compartment.

  W = 3/23 = 0.13

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Workshop Problem Set 06-09

Step 7: Ignition Source Weighting Factors: For an NPP, the fire PRA analysts have counted 351 electrical cabinet vertical sections within the Plant Analysis Boundary.

- 480VAC MCC-A is composed of 32 breakers arranged in 8 vertical segments. Calculate the ignition source weighting factor for this MCC.

  $W_{MCC\text{-}A} = 8/351 = 0.023$

- 4kV non-1E Switchgear 1 is composed of 8 breakers. Each breaker takes up one vertical segment of the switchgear. Calculate the ignition source weighting factor for this electrical panel.

  $W_{SWG\text{-}1} = 8/351 = 0.023$

- The local control panel, CP-1, for the chemicals addition system located in the Reactor Building has the following dimensions: 2' Deep, 12'Long, 8'High. There are no partitions within the panel. Calculate the ignition source weighting factor for this electrical panel.

  $W_{CP\text{-}1} = 1/351 = 0.0028$

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Workshop Problem Set 06-10

Step 7: Ignition Source Weighting Factors: Using the information provided in the solution for Problem Set 06-07, calculate the component weighting factors for the components listed below.

			Bin # and Description (per Table 6-1)												
			1	2	8	4	9	10	14	15	16	21	23a	23b	29
			Batteries	Reactor Coolant Pump	Diesel Generators	Main Control Board	Air Compressors	Battery Chargers	Electric Motors	Electrical Cabinets	High Energy Arcing Faults	Pumps	Transformers (Dry)	Transformers (Oil filled)	Yard transformers (Others)
#	Compartment	Plant Area	BAT	RCP	DG	MCB	AC	BC	EM	EC	HEAF	PMP	XFMR-Dry	XFMR-Oil	XFMR-Yard
1	Main Control Room	Control/Aux/Reactor Building				1.0E+00				7.4E-03					
2	Aux Bldg El. 0 Ft	Control/Aux/Reactor Building							4.3E-01			3.3E-01			
3	Cable Spreading Room	Control/Aux/Reactor Building													
4A	RHR Pump Room	Control/Aux/Reactor Building							4.3E-01			1.7E-01			
4B	AFW Pump Room	Control/Aux/Reactor Building										3.3E-01			
5	Battery Room A	Plant Wide Components	3.3E-01												
6	Battery Room B	Plant Wide Components	3.3E-01												
9	SWG Access Room	Plant Wide Components								2.2E-01					
10	Switchgear Room A	Plant Wide Components						3.3E-01		1.8E-01	2.5E-01		5.0E-01		
11	Switchgear Room B	Plant Wide Components						3.3E-01		1.8E-01	2.5E-01		5.0E-01		
14	Stairway	Plant Wide Components													
7	Containment	Containment		1.0E+00					1.4E-01						
8A	DG-A Room	Plant Wide Components			5.0E-01										
8B	DG-B Room	Plant Wide Components			5.0E-01										
12	Turbine Bldg El. 0 Ft	Plant Wide Components	3.3E-01				1.0E+00	3.3E-01		4.2E-01	5.0E-01	1.7E-01		1.0E+00	
15	Battery Room 1	Plant Wide Components													
13	Yard	Plant Wide Components													1.0E+00
14	Intake Structure	Plant Wide Components													

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Workshop Problem Set 06-11

Transient Ignition Source Weighting Factors: An NPP is composed of three compartments with the following characteristics:

A. Enter the influencing factors for each compartment and category:

	Influencing Factor			Cable Run (self-ignited cable fires)
Compartment	Maintenance	Occupancy	Storage	
Compartment 1	10	1	10	1,000
Compartment 2	3	1	3	--
Compartment 3	1	10	10	10,000
Total	14	12	23	11,000

B. Calculate the ignition source weighting factors for each compartment

Compartment	General Transients	Transients fires caused by welding and cutting	Cable fires caused by welding and cutting	Cable Run (self-ignited cable fires)
Compartment 1	43%	10/14	50%	9.1%
Compartment 2	14%	3/14	--	--
Compartment 3	43%	1/14	50%	90.9%
Total	100.0%	100.0%	100.0%	100.0%

C. Calculate the ignition frequencies for each compartment

	General Transients	Transients fires caused by welding and cutting	Cable fires caused by welding and cutting	Cable Run (self-ignited cable fires)
Total Location Frequency (/ry)	*3.90E-03*	*9.70E-03*	*1.60E-03*	*4.40E-03*
Compartment 1	1.67E-03	6.93E-03	8.0E-04	4.00E-04
Compartment 2	5.57E-04	2.08E-03	--	--
Compartment 3	1.67E-03	6.93E-04	8.0E-04	4.00E-03

Workshop Problems on Task 8: Scoping Fire Modeling

This handout includes workshop problems on the different steps of Task 8: Scoping Fire Modeling. Problems are grouped by steps.

Step 1: Preparation for Walkdown

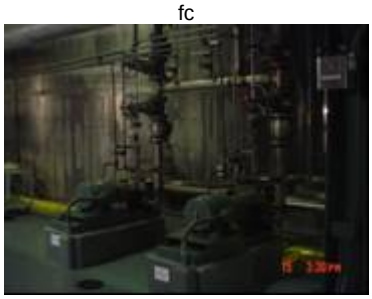
Step 1 has three sub-steps: 1) Estimate heat release rate for fixed ignition source screening, 2) Target and intervening combustibles damage or ignition criteria, and 3) Develop a zone of influence.

Workshop problem 08-01:

Step 1.1: Estimate heat release rate for fixed ignition source screening: Assign a heat release rate to the ignition sources depicted in the pictures of the following Table 08-01. For this exercise, assume that the plant has a mix of qualified and unqualified cables. The heat release rates are listed in Table E-1 of NUREG/CR-6850.

Table 08-01: Inputs for Workshop problems 1

Ignition Source	Table E-1 Case	98th Percentile HRR	Justification
Dry transformer	*7*	*69 kW*	*Table 8-1 in NUREG/CR-6850 suggests the use of the "Electric Motors" heat release rate probability distribution for dry transformers*
Fire protection panel	*4*	*464 kW*	*Fire protection panels have usually moderate to high combustible loading (including relays circuit cards etc.). It is therefore assumed that the fire may be able to propagate to more than one cable bundle.*
Ventilation sub-system	*7*	*69 kW*	*Table 8-1 in NUREG/CR-6850 suggests the use of the "Electric Motors" heat release rate probability distribution for ventilation sub-systems*

Ignition Source	Table E-1 Case	98th Percentile HRR	Justification
fc  Pumps	*6*	*211 kW*	*Table 8-1 in NUREG/CR-6850 suggests not to screen pumps due to the need of evaluating oil fires. Table E-1 suggests a heat release rate of 211 kW for electrical fires only.*

Workshop Problem Set 08-02:

Step 1.2: Target and intervening combustible damage and ignition criteria: Assign damage criteria to the ignition sources depicted in Table 08-01. For this exercise, assume that the plant has a mix of thermoset and thermoplastic cable. Generic damage criteria are listed in Table H-1 of NUREG/CR-6850.

Table 08-02: Inputs for workshop problem 2

Target/Intervening Combustible	Damage Criteria	Justification
Cables in a ladder back tray	*6 kW/m^2 (0.5 BTU/ft2s) or 205°C (400°F)*	*From Table H-1 in NUREG/CR-6850. Page H-2 of NUREG/CR-6850 suggests using the "weakest link" for determining damage criteria. Therefore the damage criteria for thermoplastic cable were selected.*
Cables in a solid tray	*6 kW/m^2 (0.5 BTU/ft2s) or 205°C (400°F)*	*Page H-2 of NUREG/CR-6850 suggests using the "weakest link" for determining damage criteria. Therefore the damage criteria for thermoplastic cable were selected. Solid trays are treated as conduits in this task. See second bullet in page H-1 of NUREG/CR-6850.*
Theromset cable in a conduit	*11 kW/m2 (1.0 BTU/ft2s) or 330°C (625°F)*	*From Table H-1 in NUREG/CR-6850. See second bullet in page H-1 of NUREG/CR-6850.*
Motor operated valve (MOV).	*6 kW/m^2 (0.5 BTU/ft2s) or 205°C (400°F)*	*See section H.2 in NUREG/CR-6850. Cables connecting the MOV are assumed thermoplastic in this example.*
Cabinet with a solid state device	*3 kW/m^2 (0.25 BTU/ft2s) or 65°C (150°F)*	*See section H.2 in NUREG/CR-6850.*

Workshop Problem Set 08-03

Step 1.3: Develop zone of influence: Calculate the heat release rate required for generating target damage for the following ignition source/target combination and determine if the ignition source can be screened. Use the engineering calculations described in NUREG-1805 for determining the heat release rate value.

- Target in the hot gas layer:
  - A cable tray target is located near the ceiling in a room approximately 21' by 7' and has a normally closed door on each end. The room is approximately 20' high. The inside walls of the MCC room are reinforced concrete. There is one MCC cabinet in the room. The MCC cabinet has unqualified cable.

The MQH room temperature correlation described in Section 2.6 of NUREG-1805 was selected for calculating the hot gas layer temperature in the room. Input values for the MQH model are listed in Table 08-03. Notice that a heat release rate of 600 kW generates room temperatures of approximately 205 ^{o}C. This calculation assumes a 20-min fire duration and one open door in the room.

Table 08-03: MQH room temperature correlation analysis

MCC Room	
Length [ft]:	*21*
Width [ft]:	*7*
Height [ft]:	*20*
MQH Temperature Correlation	
Inputs	
Ambient temperature [C]	*20*
Duration [sec]	*1200*
Opening area [m2]	*2*
Height of opening [m]	*2*
Room length [m]	*6*
Room width [m]	*2*
Room height [m]	*6*
Thermal conductivity [kW/mK]	*0.0014*
Density [kg/m3]	*2000*
Specific heat [kJ/kg]	*0.88*
Wall thickness [m]	*0.6*
HRR [kW]	*600*
Results	
Room Temp [C]	***205***

- Target subjected to flame impingement or fire plume temperatures:
  - A vertical cable tray is located 5’ ft from a floor based ventilation subsystem.

The Heskestad’ flame height and plume temperature correlations described in Chapter 3 and 9 of NUREG-1805 respectively were selected for calculating flame height and room temperature. Input values for the models are listed in Table 08-04 and Table 08-05. Notice that a heat release rate of 250 kW generates a flame height of 5’. In the case of the plume temperature correlation, a heat release rate of 165 kW generates damage temperatures of approximately 205 ^{o}C at the location of the target.

Table 08-04: Heskestad flame height correlation

Heskdestad's Flame Height Correlation		
Inputs		
Fire diameter [m]	*0.6*	
HRR [kW]	*250*	
Results	*[m]*	*[ft]*
Flame height [m]	***1.5***	***5.0***

Table 08-05: Heskestad plume temperature correlation

Heskestad Plume Temperature Correlation	
Inputs	
Ambient temperature [C]	*20*
Fire location factor	*1*
HRR [kW]	*165*
Fire elevation [m]	*0*
Target Elevation [m]	*1.5*
Radiation Fraction	*0.40*
Fire Diameter [m]	*1*
Results	
Plume Temp [C]	***202***

- Target subjected to flame radiation:
  - A conduit is located 3 ft from a battery charger with qualified cable.

The point source flame radiation model described in section 5.3 of NUREG-1805 was selected for calculating the incident heat flux at the location of the target. Input values for the point source model are listed in
Table 08-06. Notice that a heat release rate of 160 kW generates incident heat fluxes of 5 kW/m^2.

Table 08-06: Point source flame radiation model

Point Source Flame Radiation Model	
Inputs	
Fire heat release rate [kW]	*160*
Radiation fraction	*0.40*
Distance from flames [m]	*1*
Results	
Heat flux [kW/m2]	***5.1***

Workshop Problem Set 08-04

***Step 2: Plant Walkdown*:** Inspect the ignition source and target combination in the pictures included in Table 08-07 and determine the appropriate zone of influence calculation necessary.

Table 08-07: Inputs for Workshop problems 1

Ignition Source	Ignition Source/Target	Zone of Influence	Distance
	Fire protection panel/Conduits above	*Targets in the conduits will be affected by flame or plume conditions. Depending on the fire size and the characteristics of the room, the target may also be affected by hot gas layer temperatures.*	*~4'*
	Electrical cabinets/Conduit	*Targets in the conduits will be affected by flame or plume conditions. Depending on the fire size and the characteristics of the room, the target may also be affected by hot gas layer temperatures.*	*~3'*
	Ventilation Subsystem/Ventilation Subsystem	*Adjacent ventilation subsystem will be affected by flame radiation. Depending on the fire size and the characteristics of the room, the target may also be affected by hot gas layer temperatures.*	*~2'*

Ignition Source	Ignition Source/Target	Zone of Influence	Distance
	Ventilation Subsystem/MOV's	*MOV's and associated cables will be affected by flame radiation from a fire in the ventilation subsystem. Depending on the fire size and the characteristics of the room, the target may also be affected by hot gas layer temperatures.*	*~3'*
	Electrical cabinet/Cable tray	*Targets in the cable tray will be affected by flame or plume conditions. Depending on the fire size and the characteristics of the room, the target may also be affected by hot gas layer temperatures.*	*~4'*
	Transformer/Cable tray	*Targets in the cable tray will be affected by flame or plume conditions. Depending on the fire size and the characteristics of the room, the target may also be affected by hot gas layer temperatures.*	*~5'*
	Pump/Pump	*Adjacent pump will be affected by flame radiation. Depending on the fire size and the characteristics of the room, the target may also be affected by hot gas layer temperatures.*	*~4'*

Step 3: Verification of Screened Ignition Sources

No workshop problem for Step 3.

Workshop Problem Set 08-05

Step 4: Calculation of Severity Factors: Calculate the severity factors for the ignition source and target combinations listed in Workshop Problem 08-03. Use the results of Workshop Problem Set 08-03 as inputs to this exercise.

- Target in the hot gas layer
  - *Ignition source: MCC cabinet with unqualified cable*
  - *Heat release rate probability distribution: Case 4, Gamma distribution with* $\alpha = 2.6$ & $\beta = 67.8$.
  - *Critical heat release rate: 600 kW*
  - *Severity factor: Using a Microsoft Excel function,*
    SF = 1-GAMMADIST(600,2.6,67.8,TRUE) ≈ 0.004

- Target subjected to flame impingement or plume temperatures
  - *Ignition source: Ventilation subsystem*
  - *Heat release rate probability distribution: Case 7, Gamma distribution with* $\alpha = 2.0$ & $\beta = 11.7$.
  - *Critical heat release rate: 250 kW or 165 kW*
  - *Severity factor: Using a Microsoft Excel function,*
    SF = 1-GAMMADIST(250,2,11.7,TRUE) ≈ 1.2E-8 or
    SF =1-GAMMADIST(165,2,11.7,TRUE) ≈ 1.1E-5

- Target subjected to flame radiation
  - *Ignition source: Battery charger with qualified cable*
  - *Heat release rate probability distribution: Case 2, Gamma distribution with* $\alpha = 0.7$ & $\beta = 216$.
  - *Critical heat release rate: 160 kW*
  - *Severity factor: Using a Microsoft Excel function,*
    SF =1-GAMMADIST(160,0.7,216,TRUE) ≈ 0.83

It should be noted that this problem can also be solved using the discretized Gamma distribution tables in Appendix E of NUREG/CR-6850. Consider the target subjected to flame radiation, which was assigned the following Case 2 gamma distribution for heat release rate:

Bin	Heat Release Rate – kW (Btu/s)			Severity Factor (P_i)
	Lower	Upper	Point Value	
1	0 (0)	90 (85)	34 (32.7)	0.506
2	90 (85)	179 (170)	130 (123)	0.202
3	179 (170)	269 (255)	221 (209)	0.113
4	269 (255)	359 (340)	310 (294)	0.067
5	359 (340)	448 (425)	400 (379)	0.041
6	448 (425)	538 (510)	490 (464)	0.026
7	538 (510)	628 (595)	579 (549)	0.016
8	628 (595)	717 (680)	669 (634)	0.010
9	717 (680)	807 (765)	759 (719)	0.006
10	807 (765)	897 (850)	848 (804)	0.004
11	897 (850)	986 (935)	938 (889)	0.003
12	986 (935)	1076 (1020)	1028 (974)	0.002
13	1076 (1020)	1166 (1105)	1118 (1060)	0.001
14	1166 (1105)	1255 (1190)	1208 (1145)	0.001
15	1255 (1190)	Infinity	1462 (1386)	0.001

Figure 1: Table E-3 from NUREG/CR-6850

The severity factor is the sum of the severity factor column after the "Point Value" 160 kW (highlighted values in Figure 1).

Workshop Problem Set 08-06

Step 5: Calculation of Revised Compartment Fire Frequency: Determine a revised compartment ignition frequency for switchgear room A assuming the walkdown results listed in Table 08-08.

Table 08-08: Summary of Task 8 calculations

Equipment Description	Count	Fire Condition	Measured Distance (ft)	Table E-1 Case	Critical HRR (Table E-1)	Room Area (ft2)	Room Height (ft)	Calculated HRR (kW)	Room Temp (F)	Screened	Severity Factor	Count Task 8
Train A 4160 V Bus	8	flame or plume	1.7	9	Do Not Screen	1350	20	7	N/A	No	**1.00**	**8.00**
Train A 480 V Load Center	6	flame radiation	4.9	9	Do Not Screen	1350	20	401	N/A	No	**1.00**	**6.00**
Train A Station Service Transformer	1	flame radiation	4.5	9	Do Not Screen	1350	20	336	N/A	No	**1.00**	**1.00**
Train A Battery Charger	1	flame or plume	2.9	4	464	1350	20	25	264	No	**0.98**	**0.98**
Train A 125 VDC Bus	8	flame or plume	0.7	4	464	1350	20	1	264	No	**1.00**	**8.00**
Train A 125 VDC Panel	1	flame radiation	2.8	4	464	1350	20	129	264	No	**0.60**	**0.60**
Train A Inverter	1	flame radiation	2.0	4	464	1350	20	64	264	No	**0.88**	**0.88**

Table 08-09: Comparison of switchgear room A ignition frequency

Task 6	Switchgear Room A	**≈ 1.5E-02**
Task 8	Switchgear Room A	**≈ 1.5E-02**

Workshop Problems on Task 11a: Detailed Fire Modeling

This handout includes workshop problems on the different steps of Task 11: Detailed Fire Modeling. Problems are grouped according to the steps defined in NUREG/CR-6850. Detailed fire modeling will be conducted in the switchgear access room (Room 9) located in elevation 20 ft of the auxiliary building.

Workshop Problem Set 11a-01

***Step 1a: Identify and Characterize Compartments*:** Review the following information necessary for fire modeling purposes.

- Room size: For the purpose of this exercise, assume the size of the room is 45' by 22' by 20' high.
- Wall boundaries: The surfaces, floor, ceiling, and walls are reinforced concrete. All the surfaces are 2' thick.
- Doors: The room has three doorways: 1) a double door connecting to switchgear room A, 2) a double door connecting to switchgear room B, and 3) a single door connecting to the stairwell. The size of a single door is 6.5' by 3'.
- Mechanical Ventilation: The switchgear access room has a mechanical ventilation system with a balance 5 air changes per hour.

Workshop Problem Set 11a-02

***Step 2a: Identify and Characterize fire Detection and Suppression Features and Systems*:** Review the following information necessary for fire modeling purposes.

- Prompt detection: Prompt detection is not credited since there is no incipient fire detection system in the room and no continuous fire watch.
- Prompt suppression: Prompt suppression is not credited since there is no continuous fire watch in the room.
- Fixed fire detection system/s (type, and sensor location): An automatic fire detection system is credited since the room is equipped with an automatic fire detection system. The location of the relevant detectors is specified in the corresponding scenario descriptions later in this document.
- Fixed fire suppression system/s (type and nozzle location): An automatic CO_2 system is credited since the room is equipped with an automatic CO_2 system. Upon smoke detection alarm, a timer starts providing 60 seconds delay for life safety purposes. The CO_2 is released after the delay time. The soak time is approximately 20 min.
- Fire brigade arrival time: The fire brigade arrival time is assumed to be 15 min.
- Delayed detection: Delayed detection is credited and assumed to be 15 minutes (consistent with the example in page P-14 of NUREG/CR-6850).

Workshop Problem Set 11a-03

Step 3a: Characterize Fire Ignition Sources: From the Task 6 (Fire Ignition Frequencies) calculation package, list the fixed ignition sources located in the switchgear access room (room 9) and assign a heat release rate probability distribution to each of them from Table G-1 of NUREG/CR-6850.

Solution: Table 1 lists the recommended answer to workshop problem 3.

Table 1: Summary of ignition source characteristics in the switchgear access room.

Equipment ID	Equipment Description	Case (Table E-1 of NUREG/CR-6850)	HRR Profile (Page G-6 in NUREG/CR-6850)
MCC-A1	Train A 480 V Motor Control Center	Case 3	t^2 grow to a peak of 211 kW in 12 min followed by steady burning for 8 additional minutes
MCC-B1	Train B 480 V Motor Control Center	Case 3	t^2 grow to a peak of 211 kW in 12 min followed by steady burning for 8 additional minutes
VITAL-A	Train A 120 VAC Vital Bus	Case 3	t^2 grow to a peak of 211 kW in 12 min followed by steady burning for 8 additional minutes
VITAL-B	Train B 120 VAC Vital Bus	Case 3	t^2 grow to a peak of 211 kW in 12 min followed by steady burning for 8 additional minutes
Transients	Regular solid transient ignition sources.	Case 8	t^2 grow to a peak of 317 kW in 12 min followed by steady burning for 8 additional minutes

Step 4a: Identify Secondary Combustibles: No workshop problem is associated with this step. The following discussion provides an example of how to identify and characterize secondary combustibles.

Sample Analysis for Step 4a:
For the purpose of this example, let's assume that there is one cable tray stack above each cabinet in the room. Each stack has two trays. The first tray is 1' above each cabinet. The second tray in the stack is 1.5' above the first tray. The trays are ladder-back. A pictorial representation of the secondary combustibles in provided in Figure 1.

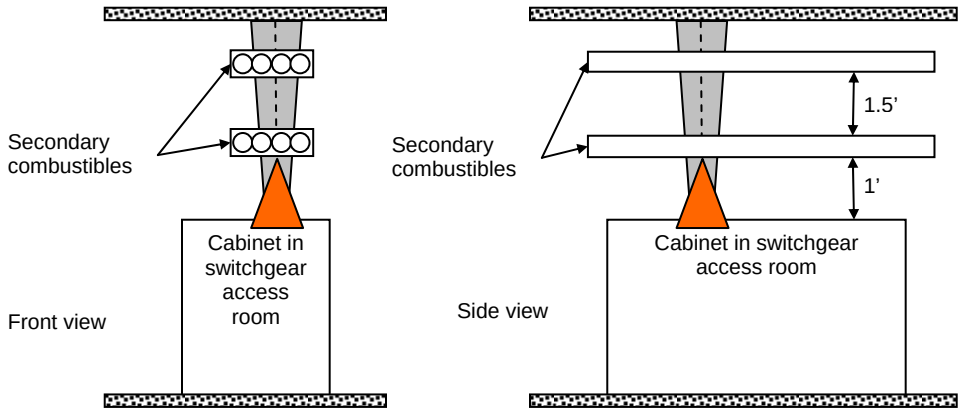


Figure 1: Pictorial representation of the secondary combustibles. Drawing not to scale.

From Table 1, the cabinets in the switchgear access room will have a peak heat release rate of 211 kW. Heskestad's flame height correlation (Chapter 3 of NUREG 1805) suggests a flame height of approximately 4.6' above the ignition source. Therefore, the cable tray stack above the cabinet is expected to ignite and contributing to the fire intensity. Table 2 lists the Heskestad's flame height correlation analysis.

Table 2: Heskestad's flame height correlation analysis.

Heskdestad's Flame Height Correlation	
Inputs	
Fire diameter [m]	0.6
HRR [kW]	211
Results	
Flame height [m]	**1.4**
Flame height [ft]	**4.6**

Step 5a: Identify and Characterize Target Sets: No workshop problem is associated with this step. The following discussion provides an example of how to identify and characterize target sets. In practice, this step requires highlighting of cable tray and conduit targets in room layout drawings based on cable routing analysis and plant walkdowns.

<u>Sample Analysis for Step 5a:</u>
For the purpose of this exercise, let's assume that there are two target sets in the room: 1) HCBT-35A and HCBT-37B, and 2) VCBT-20A, and VCBT-20B. These trays are identified in Figure 2. The trays have both thermo-set and thermo-plastic cables. Specifically, a fire damaging either the two horizontal trays or the two vertical trays will generate the postulated plant condition.

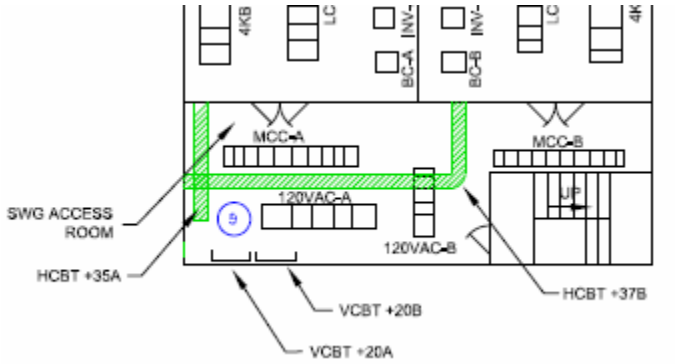


Figure 2: Cable tray locations in the switchgear access room

Tray locations:

- HCBT 35A: This horizontal tray comes into the switchgear access room from switchgear room A. The tray is the second tray in an elevated stack. The lowest tray in the stack is at elevation 33' (13' from the floor). The target tray, HCBT 35A, is at elevation 35' (15' ft from the floor and 2' above the lowest tray in the stack).

- HCBT 37B: This horizontal tray comes in the south direction into the switchgear access room from switchgear room B and turns west. The tray is the first tray in an elevated stack. It is located at elevation 37' (17' from the floor). At the point the cable tray crosses HCBT 35A, it is the third tray in the stack.

- VCBT 20A: This is a vertical cable tray in the south west corner of the room. The tray comes into the room through a floor penetration at elevation 20' and runs up to the ceiling.

- VCBT 20B: This is a vertical cable tray in the south west corner of the room. The tray comes into the room through a floor penetration at elevation 20' and runs up to the ceiling.

Workshop Problem 11a-04

Step 6a: Define the Fire Scenarios to be Analyzed: Define the fire scenarios to be analyzed in the switchgear access room using the information provided or collected in the first five steps.

Solution: The following tables and figures describe the fire scenarios defined for analysis. For the purpose of this exercise, only the scenarios that will be analyzed in detail in upcoming workshop problems have been defined in detail.

- Fixed ignition source fire scenarios: Fixed ignition source fire scenarios are postulated in the two closest cabinets to the target trays.

Table 3: Summary of scenario 1.

Scenario 1: A fire in the MCC-A cabinet affecting the two horizontal cable tray targets. The targets could be affected by hot gas layer temperatures, flame radiation or horizontal flame spread.	
Ignition Source	MCC-A cabinet. The fire is postulated 1' below the top of the cabinet. The cabinet is 7' high.
Secondary combustibles	Cable tray stack above the electrical cabinet.
Target	HCBT-35A, HCBT-37B. The pinch point is located 2' horizontally from the cabinet (closest distance from fire to pinch point).
Credited detection	Automatic fire detection system
Credited suppression	Automatic CO2 system and fire brigade

Figure 3 provides a pictorial representation of this scenario.

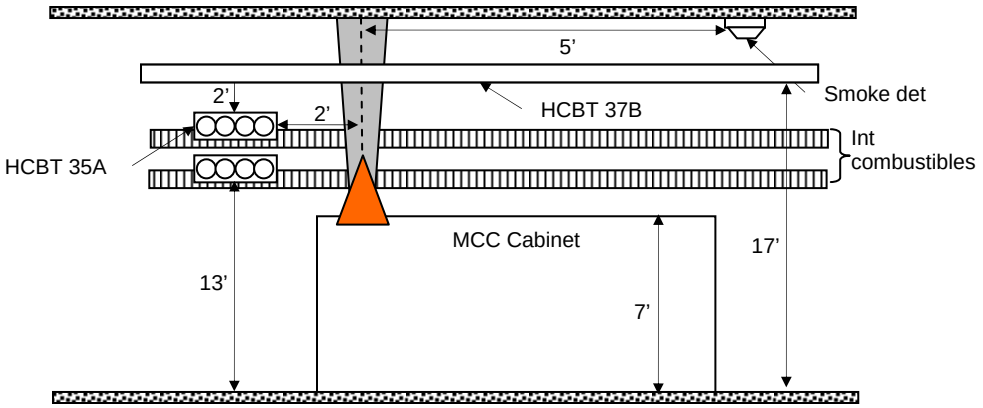


Figure 3: Pictorial representation of fire scenario 1. Drawing not to scale.

Table 4: Summary of scenario 2.

Scenario 2: A fire in the 120VAC-A cabinet affecting the two horizontal cable tray targets. The targets could be affected by hot gas layer temperatures, direct flame radiation, or horizontal flame spread.	
Ignition Source	120VAC-A cabinet
Secondary combustibles	Cable tray stack above the electrical cabinet.
Target	HCBT-35A, HCBT-37B
Credited detection	Automatic fire detection system
Credited suppression	Automatic CO2 system and fire brigade

Table 5: Summary of scenario 3.

Scenario 3: A fire in the 120VAC-A cabinet affecting the vertical cable tray targets. The targets could be affected by hot gas layer temperatures, direct flame radiation, or horizontal flame spread..	
Ignition Source	120VAC-A cabinet
Secondary combustibles	
Target	HCBT-35A, HCBT-37B
Credited detection	Automatic fire detection system
Credited suppression	Automatic CO2 system and fire brigade

Finally, Figure 4 illustrates the location of the postulated fires.

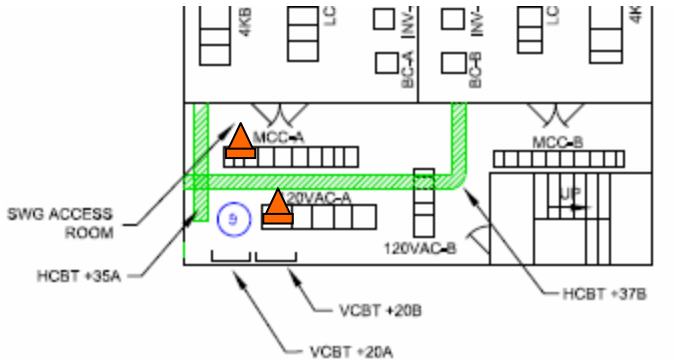


Figure 4: Pictorial representation of the location of the postulated fire scenarios.

- Transient ignition source fire scenarios: Only regular solid transient fire scenarios at floor level are postulated in this room. Since the room does not contain any mechanical equipment requiring lubrication or oil, fires resulting from combustible liquid spills are not postulated.

Table 6: Summary of scenario 4.

Scenario 4: A transient fire at floor level affecting the two horizontal cable tray targets. The targets could be affected by hot gas layer temperatures, flame impingement or fire plume temperatures.	
Ignition Source	Floor based transient fire
Secondary combustibles	
Target	VCBT-20A, VCBT-20B
Credited detection	Automatic fire detection system
Credited suppression	Automatic CO2 system and fire brigade

Figure 5 provides a pictorial representation of this scenario.

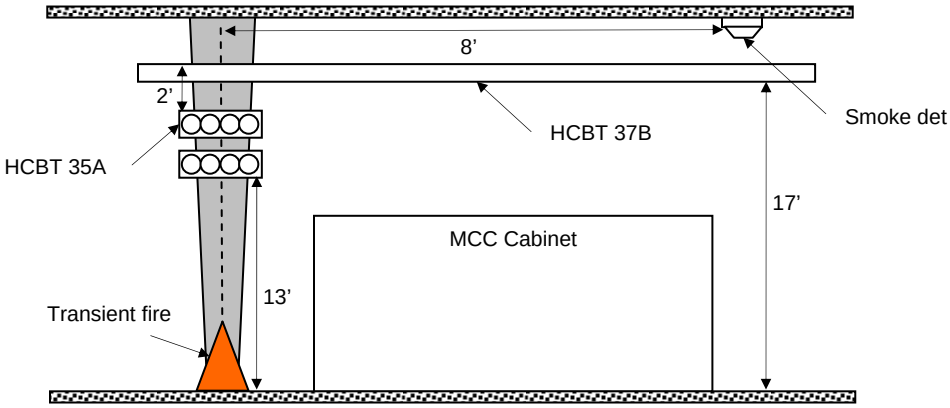


Figure 5: Pictorial representation of fire scenario 4. Drawing not to scale.

Table 7: Summary of scenario 5.

Scenario 5: A transient fire at floor level affecting the two vertical cable tray targets. The targets could be affected by hot gas layer temperatures, flame impingement or direct flame radiation.	
Ignition Source	Floor based transient fire
Secondary combustibles	
Target	VCBT-20A, VCBT-20B
Credited detection	Automatic fire detection system
Credited suppression	Automatic CO2 system and fire brigade

Figure 6 illustrate the location of the postulated transient fires.

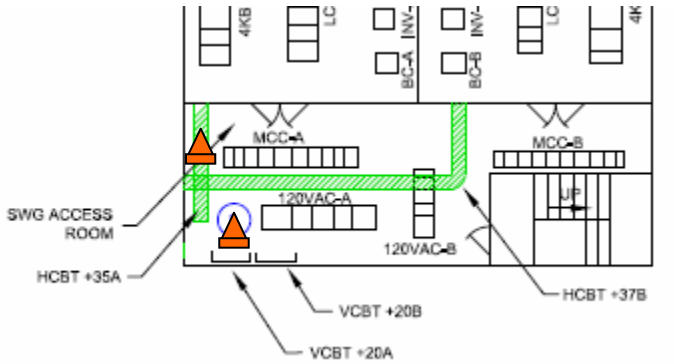


Figure 6: Pictorial representation of the location of the postulated fire scenarios.

- Additional scenarios that should be considered include self-ignited cable fires and junction box fires since this room has unqualified cable.

Step 7a: Conduct Fire Growth and Propagation Analysis: For the purpose of this workshop, only two of the fire scenarios listed in the previous section are analyzed in detail: Scenario 1, and Scenario 4.

Workshop Problem 11a-05:

Determine if a fire in the ignition sources associate with scenarios 1 and 4 can produce room wide damage in the switchgear access room. If the ignition sources alone are not expected to generate room wide damage, determine the amount of secondary combustibles necessary to achieve it.

Solution:

A 1.1 MW fire is necessary for generating room wide damage in the aux switchgear access room. Using the MQH Room Temperature correlation (NUREG 1805), a 1.1 MW fire may generate a room temperature of 205 ^{o}C, which is the assumed damage temperature (Appendix H of NUREG/CR-6850) for thermoplastic cables in the aux control room. The aux control room has approximately 1000 ft^2 floor and 20 ft high ceiling. All room surfaces are concrete. The calculation assumes one single open door and a 20 min fire duration. Table 8 lists the inputs and output of the MQH room temperature analysis.

Table 8: Summary of room temperature analyses using the MQH model.

MQH Temperature Correlation			**MQH Temperature Correlation**			**MQH Temperature Correlation**	
Single cabinet cubicle fire			Transient fire			Limiting fire size	
Inputs			**Inputs**			**Inputs**	
Ambient temperature [C]	20		Ambient temperature [C]	20		Ambient temperature [C]	20
Duration [sec]	1200		Duration [sec]	1200		Duration [sec]	1200
Opening area [m2]	2		Opening area [m2]	2		Opening area [m2]	2
Height of opening [m]	2		Height of opening [m]	2		Height of opening [m]	2
Room length [m]	14		Room length [m]	14		Room length [m]	14
Room width [m]	7		Room width [m]	7		Room width [m]	7
Room height [m]	6		Room height [m]	6		Room height [m]	6
Thermal cond [kW/mK]	0.0014		Thermal cond [kW/mK]	0.0014		Thermal cond [kW/mK]	0.0014
Density [kg/m3]	2000		Density [kg/m3]	2000		Density [kg/m3]	2000
Specific heat [kJ/kg]	0.88		Specific heat [kJ/kg]	0.88		Specific heat [kJ/kg]	0.88
Wall thickness [m]	0.6		Wall thickness [m]	0.6		Wall thickness [m]	0.6
HRR [kW]	211		HRR [kW]	317		HRR [kW]	1100
Results			**Results**			**Results**	
Room Temp [C]	**82**		Room Temp [C]	**102**		Room Temp [C]	**205**

Both an electrical cabinet and a transient fire are postulated at floor level in the switchgear access room. Appendix G of NUREG/CR-6850 suggests that the 98th percentile heat release rates for these fires are 211 kW and 317 kW (see also Table 1). These fire intensities are lower than the critical value of 1.1 MW calculated earlier required for room wide damage. Consequently, fire propagation to nearby cable trays or secondary combustibles (if available) is necessary to reach the critical fire intensity.

The cable tray heat release rate model described in Chapter 7 of NUREG-1805 suggests a heat release rate of 265 kW for a 1 m^2 for a bench scale HRR of 589 kW/m^2 (PE/PVC material). With this approximation:

- If the fire starts in an electrical cabinet, approximately 5 trays will need to burn to produce a 1.9 MW fire assuming a 1 m^2 of tray on fire: $(1100 - 211)/265 \approx 4$ (assuming a tray length of approximately 3').

- If the fire starts as a transient fire, approximately 6 trays will need to burn to produce a 1.9 MW fire assuming a 1 m^2 of tray on fire: $(1100 - 317)/265 \approx 3$ (assuming a tray length of approximately 3').

In the case of self ignited or junction box fires, a total of $1100/265 \approx 5$ trays will need to be on fire in order to generate room wide damage.

This analysis will serve as basis for decision making in selecting and analyzing fire scenarios in the aux control room. In this particular room, it appears that there are not enough trays above the cabinets or transients where the fire is postulated to generate room wide damage without significant horizontal flame spread and if suppression activities fail before fire propagates upward to at least five or six trays.

Workshop Problem 11a-06

Determine the time to target damage, time to smoke detection, time to automatic suppression and the fire brigade arrival time for scenario 1.

Solution:

- Time to target damage: Time to target damage is assumed to be: 1) the time required for the fire to heat up the cable trays to its damage temperature by direct flame radiation, or 2) the time to room heat up to cable damage temperature. In either case, the fire growth profile will be an important factor in this analysis.

  Heat release rate profile for the ignition source: Table 1, the heat release rate profile for this ignition source is t^2 grow to a peak of 211 kW in 12 min followed by steady burning for 8 additional minutes. This is the profile recommended in NUREG/CR-6850 for this electrical cabinet, page G-6.

  Heat release rate from secondary combustibles: Recall that the secondary combustibles (cable tray stack above the panel) is expected to contribute to the fire intensity. Consequently, the heat release rate profile should include such contribution. Appendix R of NUREG/CR-6850 describes the following model for fire propagation in cable trays: the first tray above the ignition source will ignited at the calculated time using fire modeling tools. The second tray will ignite 4 minutes after the first one. Evaluating the flame height and plume temperature using the corresponding correlations from Heskestad (Chapters 3 & 9 in NUREG 1805), both models suggest ignition of the first tray in approximately 3 to 5 min. Therefore, ignition of the second tray is expected in approximately 9 min after ignition. Table 9 lists the solution of the correlations as a function of time. Notice that between times 4 and 5 min, the flame height reaches 1' (the location of the first tray above the cabinet). At this time however, the plume temperature has exceeded the cable damage temperature.

Table 9: Summary of Heskestad's flame height and plume temperature analysis as a function of time.

Time (min)	HRR (kW)	Flame height (ft)	Plume Temp (F)
0	0	0.0	68
1	1	0.0	123
2	6	0.0	226
3	13	0.2	380
4	23	0.7	596
5	37	1.2	895
6	53	1.8	1305
7	72	2.3	1871
8	94	2.7	2663
9	119	3.2	3794
10	147	3.7	5458
12	211	4.6	12138
14	211	4.6	12138
16	211	4.6	12138

Considering that the cables above the cabinet are expected to ignite, the contribution from the cable tray fire should be included in the analysis. The heat release rate profile listed in Table 10 is obtained using the cable tray heat release rate model described in Chapter 7 of NUREG-1805 with a bench scale HRR of 589 kW/m^2 (PE/PVC material). Notice that the total heat release rate profile includes the contribution from both, the cabinet fire and the cable tray fire. .

Table 10: Summary of heat release rate profile and room temperature analysis as a function of time.

Tray width [m]:	0.6					
Tray sep [m]:	0.46					
Bench Scale HRR [kW/m^2]	589					
Ignition Source	**Length [m]**	**Fire Duration [min]**	**HRR [kW] for cable trays**	**HRR for electrical cab [kW]**	**Total HRR [kW]**	**Room Temp [F]**
Electrical cabinet		0		0	0	Ambient
Tray 1	0.6	5	95	37	132	134
Tray 2	1.03	9	164	119	283	187
		10		147	311	197
		12		211	375	219
		14		211	375	223
		16		211	375	226
		18		211	375	229
		20		211	375	232

In the case of room heat up, Table 10 suggests that the fire will not generate hot gas layer temperatures capable of producing room wide damage. These temperatures were calculated using the MQH model for room temperature. The results are also consistent with the analysis in workshop problem 5.

In the case of direct flame radiation, the pinch point is located approximately 2' from the fire. The point source flame radiation model (see Chapter 5 of NUREG 1805), suggest a damaging incident heat flux 2' from the ignition source from a fire intensity of 60 kW. This intensity is lower than the peak calculated earlier and listed in Table 10. A 60 kW fire is expected somewhere in between 5 and 9 min due to the fire quickly propagating to cable trays above. The point source flame radiation analysis is documented in Table 11. This heat flux result bounds the flame spread analysis since the fire at the ignition source location is capable of impacting the target.

Table 11: Summary of point source flame radiation model analysis

Point Source Flame Radiation Model	
Inputs	
Fire heat release rate [kW]	60
Radiation fraction	0.40
Distance from flames [m]	0.6
Results	
Heat flux [kW/m2]	**5.3**

- Time to smoke detection:

  The time to smoke detection is assumed to be 1 min. The technical basis for this assumption is as follows: The time to smoke detection listed in Table 12 below are calculated using the model described in Chapter 11 of NUREG 1805. Notice that for vertical and horizontal distances from the ignition source in the order of 6 meters, calculated times to detection are in the order of seconds, which suggests that the 1 min assumption is conservative. The time to detection calculations were conducted conservatively assuming a low heat release rate of 25 kW. It should be noted that these activation times are not considering any incipient stage of the fire development, e.g., smoldering.

Table 12: Time to detector activation

Seconds		Horizontal Radial Distance (m)					
		1	**2**	**3**	**4**	**5**	**6**
Vertical Height Above Fire (m)	**1**	0.5	1.3	2.4	3.9	5.7	7.9
	2	0.8	1.3	2.1	3.2	4.5	6.0
	3	1.2	1.6	2.2	3.1	4.2	5.4
	4	1.6	2.0	2.5	3.3	4.2	5.3
	5	2.1	2.4	2.9	3.6	4.4	5.4
	6	2.6	2.9	3.4	4.0	4.7	5.6

- Time to automatic suppression: Assuming a smoke detection signal in 1 min, and considering the delay time of 60 for the automatic CO_2 system, the time for automatic suppression is estimated as 2 min.

- Time to fire brigade arrival: The time to fire brigade arrival at the room is estimated as 15 min from brigade drill records.

Workshop Problem 11a-07

Determine the time to target damage, time to smoke detection, time to automatic suppression and the fire brigade arrival time for scenario 4.

Solution:

- Time to target damage: Time to target damage is assumed to be: 1) the time required for the fire to heat up the cable trays to its damage temperature from fire plume exposure, or 2) the time to room heat up to cable damage temperature, whichever is less. In either case, the fire growth profile will be an important factor in this analysis.

Heat release rate profile for the ignition source: From Table 1, the heat release rate profile for this ignition source is t^2 growth to a peak of 317 kW in 12 min followed by steady burning for 8 additional minutes. This is the profile recommended in page G-6 of NUREG/CR-6850 for this electrical cabinet. Similar to the flame height and plume temperature analysis in workshop problem 6, Table 13 lists the corresponding results for the transient fire. The results suggest that the fire will not affect cable trays located 13' above the floor since the plume temperature does not reach 405 ^{o}F.

Table 13: Summary of Heskestad's flame height and plume temperature analysis as a function of time.

Time (min)	HRR (kW)	Flame height (ft)	Plume Temp (F) (at 13' above the floor)
0	0	0.0	68
1	2	0.0	72
2	9	0.0	79
3	20	0.5	88
4	35	1.2	98
5	55	1.8	110
6	79	2.4	123
7	108	3.0	137
8	141	3.6	152
9	178	4.1	168
10	220	4.7	186
12	317	5.7	226
14	317	5.7	226
16	317	5.7	226

- Time to smoke detection: Time to smoke detection is assumed to be 1 min based on the results presented in Table 12.

- Time to automatic suppression: Assuming a smoke detection signal in 1 min, and considering the delay time of 60 for the automatic CO_2 system, the time for automatic suppression is estimated as 2 min.

- Time to fire brigade arrival: The time to fire brigade arrival at the room is estimated as 15 min from brigade drill records.

Workshop Problem 11a-08

Let's assume that MCC-A1, which is the ignition source in scenario 1 it's a 4160V switchgear. In this case, a high energy arcing fault event should be also postulated and evaluated. Determine if the cable tray targets will be within the zone of influence of a high energy arcing fault.

Solution: The two horizontal trays, HCBT-35A and HCBT-37B are located 6' vertically and 2' horizontally from the cabinet. According to the criteria listed in pages M-13 and M-14 or NUREG-CR/6850, the target trays will be outside the zone of influence. However, the stack of cable trays above the cabinet (the secondary combustibles) will be within the zone of influence, and therefore, will ignite at time zero. The time to target damage calculated in workshop problem 6 will be affected due to different ignition time of secondary combustibles.

Step 8a: Conduct Fire Detection and Suppression Analysis*:* The detection and suppression is reflected in the risk analysis with the non-suppression probability, which is calculated using a Detection/Suppression event tree approach discussed in Appendix P of NUREG/CR-6850, Detection and Suppression Analysis. Recall that the switchgear access room is equipped with a smoke detection system, and an automatic CO_2 system. The CO_2 system has a 60 second warning alarm delay. In addition to these fixed systems, the fire brigade can also provide manual suppression activities.

Considering the above fire protection features, the suppression strategy in the switchgear access room can be summarized as:

1. Indication of smoke detection in control room
2. Control room sends an operator to the switchgear access room to confirm the fire
3. If fire is confirmed, the operator first determines if the automatic CO_2 system operated.
4. If further suppression activities are warranted after any of the automatic systems, manual suppression by the fire brigade may be used.

Workshop Problem Set 11a-09

Develop a detection suppression event tree for the fire protection strategy defined above.

Solution:

The above strategy is reflected in the event tree depicted in Figure 7 (similar to the one described in Appendix P of NUREG/CR-6850). The event tree is then applied to each of the fire scenarios producing a non-suppression probability for each. The non-suppression probability results from the summation of the failure to suppress branches in the event tree. The event tree includes the events listed in Table 14:

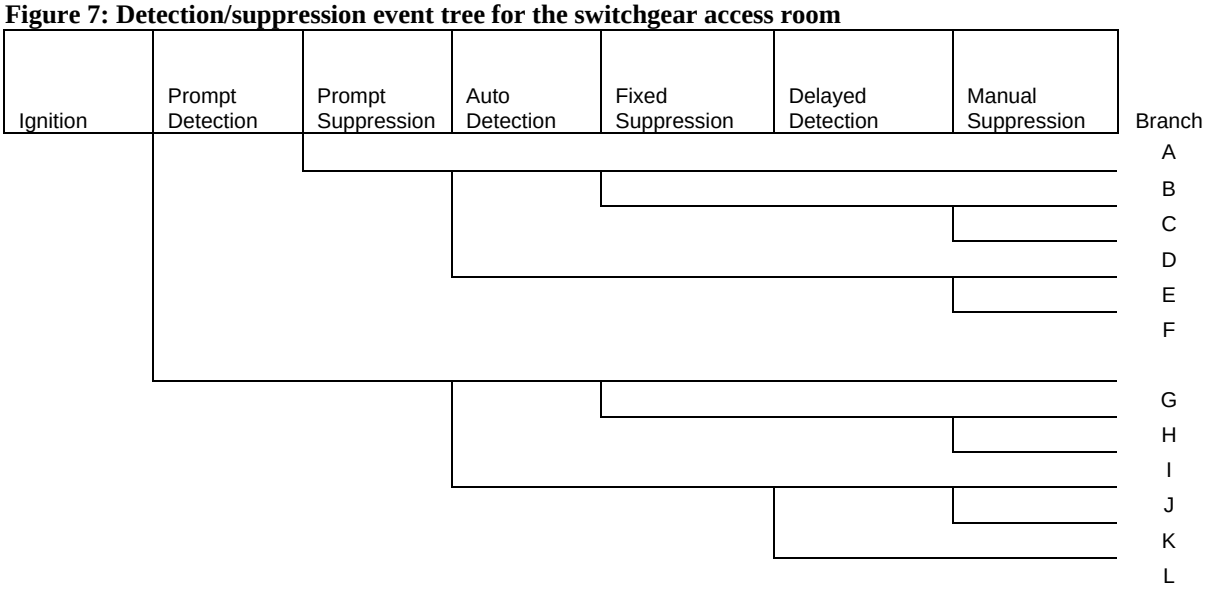
Table 14:Events included in the detection suppression event tree

Sequence	Detection	Suppression
A	Prompt detection	Prompt suppression
B	Prompt detection	Automatic suppression
C	Prompt detection	Fire brigade
D	Prompt detection	Fire brigade failure
E	Prompt detection	Fire brigade
F	Prompt detection	Fire brigade failure
G	Automatic detection	Automatic suppression
H	Automatic detection	Fire brigade
I	Automatic detection	Fire brigade failure
J	Delayed detection	Fire brigade
K	Delayed detection	Fire brigade failure

Sequence	Detection	Suppression
L	Delayed detection failure	

Prompt detection and prompt suppression are not credited in the analysis since the switchgear access room has no continuous fire watch or is equipped with an incipient fire detection system. Automatic detection is credited since the room has a fire detection system. Fixed automatic suppression is also credited since the room has an automatic CO_2 system. Delayed detection is not credited since time to ignition of the first tray occurs in approximately 7 to 10 min, which is less than the recommended 15 min for delayed detection in NUREG/CR-6850. Finally, manual suppression by the fire brigade could be credited but will not have any impact since the CO_2 release is expected to occur first and the room must remain close during the CO_2 soak time.

Figure 7: Detection/suppression event tree for the switchgear access room



Workshop Problem 11a-10

Step 9a: Calculate Conditional Non-Suppression Probability and Severity Factor: Determine the severity factor and the non-suppression probability for scenario 1.

Solution:
This scenario consists of a fire propagating to cable trays above. From Table 9, a heat release rate of approximately 13 to 23 kW (based on plume results) is necessary for a fire to affect the cables above. For the purpose of this example, a value of 15 kW is selected. Per Table 1, the ignition source is assigned a Case 3 probability distribution for heat release rate from Table E-1 in NUREG/CR-6850. This is a Gamma distribution with α = 1.6 and β = 41.5. The severity factor values for heat release rates greater than 15 kW is (using the gamma distribution function in Microsoft Excel):

SF = 1-GAMMADIST(15,1.6,41.5,TRUE) = 0.89

This is interpreted as the probability of a fire spreading to the cable trays above.

Solving the event tree depicted in Figure 7 for a damage time of 5 min, the non suppression probability is ≈ 0.1. The solution of the event tree is presented in Figure 8. The general inputs to the event tree are listed in Table 15. Additional inputs to the event tree, developed from the fire modeling analysis described in the previous step are listed in

Table 16.

Table 15: General inputs to detection/suppression event tree

Prompt Detection:	FALSE
Auto Det:	TRUE
Prompt Suppression:	FALSE
Fixed Suppression:	TRUE
Fixed Supp Type:	Automatic
Supp Agent:	CO2
Delay time (Min):	1
Brigade Arrival (min):	15
Target Damage (min):	5
Det reliability:	0.95
Supp system reliability:	0.95
Traditional Sprinklers:	FALSE
HEP:	1
Supp Curve (Table P-3):	Electrical Fires

Table 16: Fire modeling inputs to detection/suppression event tree

Time to (Min)	
Ignition:	0
Prompt Det:	0
Prompt Supp:	0
Auto Det:	1
Fixed Supp:	2
Delayed Det:	15
Target Damage (min):	5

Figure 8: Solution of the detection/suppression event tree

Ignition	Prompt Detection	Prompt Suppression	Auto Detection	Fixed Suppression	Delayed Detection	Manual Suppression	Branch	Branch Probability
	0	0.00					A	--
		1.00	0.95	0.95			B	--
				0.05		0.00	C	0.0E+00
						1.00	D	--
			0.05			0.00	E	--
						1.00	F	0.0E+00
	1		0.95	0.95			G	--
				0.05		0.00	H	--
						1.00	I	4.8E-02
			0.05		0	0.00	J	--
						1.00	K	0.0E+00
					1		L	5.0E-02
							P_{NS}	0.098

Workshop Problem 11a-11

***Step 10a: Calculate Scenario Frequency*:** Using the ignition frequency calculated in Task 6 for the ignition sources in the switchgear access room, and the severity factor and non-suppression probability calculated in the previous step for scenario 1, determine the frequency for fire scenario 1.

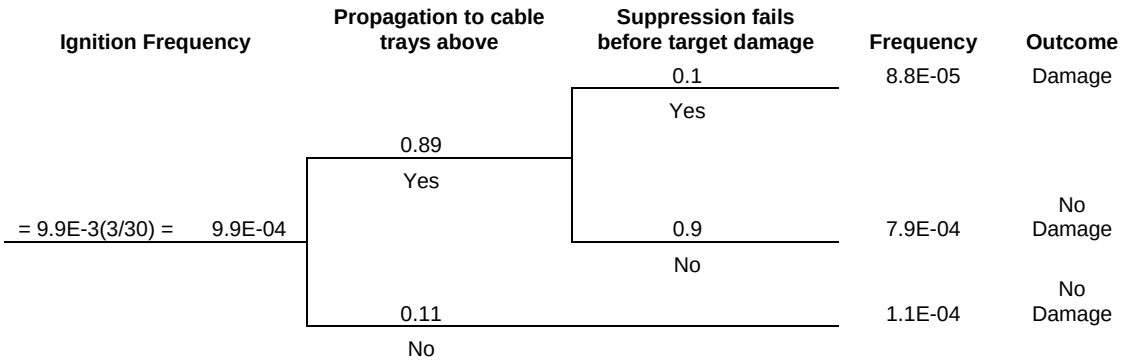
Solution:

Recall that this scenario consists of a fire propagating to a cable tray stack above and generating target damage due to direct flame radiation. This sequence of events is captured in the event tree depicted in Figure 9.

- The first event is the ignition frequency calculated in Task 6 of the Fire PRA as documented in NUREG/CR-6850.
- The second event refers to the fire propagating to the cable tray stack above. The probability of propagating is given by the severity factor calculated in Step 9.
- The third event is defined by the probability of suppressing the fire before target damage, as calculated earlier in Step 9.

Only one outcome in the event tree refers to cable damage before suppression. The frequency of this outcome is 8.8E-5.

Figure 9: Event tree depicting the sequence of events leading to target damage



Workshop Problems for Task 11b: Detailed Fire Modeling in the Main Control Room

Workshop Problem Set 11b-02 (Solution)

Step 2.b: Estimate Control Room Fire Frequency: Using the information provided in this Sample Package, and the above formula copied from NUREG/CR 6850, estimate the frequency of fire for the SNPP MCR.

$W_{L, MCR}$ = 1 per ___N/A_____
There is only one unit and one MCR for the unit.

λ_{MCB} = 2.5E-03 per reactor year
From Table 6-1 of NUREG/CR 6850, bin # 4

$W_{PWC, Elec. Cab, MCR.}$ = 7.4E-03 per ___N/A_____
From Results of Task 6 Problem Set 06-09

$\lambda_{PWC, Elec. Cab.}$ = 4.5E-02 per reactor year
From Table 6-1 of NUREG/CR 6850, bin # 15

$W_{transients, MCR}$ = 0.64 per ___N/A_____
From Task 6 Calculations

$\lambda_{transient}$ = 3.9E-03 per reactor year
From Table 6-1 of NUREG/CR 6850, bin # 7

$W_{welding, MCR}$ = 0.2 per ___N/A_____
From Task 6 Calculations

$\lambda_{welding}$ = 9.7E-03 per reactor year
From Table 6-1 of NUREG/CR 6850, bin # 6

$W_{Cable,MCR:}$ = 0.35 per ___N/A_____
From Task 6 Calculations

λ_{cable} = 1.6E-03 per reactor year
From Table 6-1 of NUREG/CR 6850, bin # 5

λ_{MCR} = 1 x (2.5E-03 + 7.4E-03 x 4.5E-02 + 0.64 x 3.9E-03 + 0.2 x 9.7E-03 + 0.35 x 1.6E-03 =

= 2.5E-03 + 3.3E-04 + 2.5E-03 + 1.9E-03 + 5.6E-04 = 7.79E-03 per reactor year

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Workshop Problem Set 11b-05 (Solution)

Step 5.b: Identify and characterize target sets: Identify at least five target sets for the Main Control Room by inspecting drawings DWG A-07 and A-09 and other information provided in this Sample Package.

Target Set ID	Items in the target set	Basis for selecting target set
MCR-01	Control room habitability	Of potential scenarios involving control room abandonment without any damage to the Main Control Board, a fire in the kitchen could be severe enough forcing the operators out.
MCR-02	Service water controls CCW Controls	Service water and CCW are controlled from a small part of the Main Control Board. A fire within CB-7 may fail both systems. Loss of Service Water alone, may have a significant CCDP.
MCR-03	HPI-A High pressure safety injection pump A HPI-B High pressure safety injection pump B RHR-B RHR pump AOV-2 (SOV-2) Letdown isolation valve AOV-3 (SOV-3) Charging pump injection valve MOV-1 HPI valve MOV-2 VCT isolation valve MOV-3 Cont. sump recirc valve MOV-4 Cont. sump recirc valve MOV-5 RWST isolation valve MOV-6 RWST isolation valve MOV-7 RHR inboard suction valve MOV-8 RHR outboard suction valve MOV-9 HPI valve LI-1 RWST level LI-2 RWST level LI-3 Cont. sump level LI-4 Cont. sump level TI-1 Letdown heat exchanger outlet temp	CB-5 contains a large number of safety related component controls. A fire limited to this part of the panel, affecting the equipment controlled from this panel may have a significant CCDP.

Target Set ID	Items in the target set	Basis for selecting target set
MCR-04	AFW-A Motor driven AFW pump A AFW-C Motor driven AFW pump C MOV-10 AFW discharge valve MOV-11 AFW discharge valve MOV-14 AFW turbine steam line isolation valve MOV-15 AFW steam inlet throttle valve MOV-16 AFW test line isolation valve MOV-17 AFW test line isolation valve MOV-18 AFW C Pump Discharge MOV-19 AFW test line isolation valve A-1 AFW motor high temp	CB-3 contains all post shutdown secondary cooling equipment controls. A fire limited to this part of the panel, affecting the equipment controlled from this panel may have a significant CCDP.
MCR-05	HPI-A High pressure safety injection pump A HPI-B High pressure safety injection pump B AOV-2 (SOV-2) Letdown isolation valve MOV-2 VCT isolation valve LI-3 Cont. sump level LI-4 Cont. sump level AFW-A Motor driven AFW pump A AFW-C Motor driven AFW pump C MOV-14 AFW turbine steam line isolation valve MOV-15 AFW steam inlet throttle valve	The shortest distance between the controls of the HPI and AFW systems that can render the pumps from both system inoperable is the distance from MOV-15 control switch to HPI-A control switch. Loss of both systems may have a significant CCDP.

Workshop Problem Set 11b-06 (Solution)

Steps 6.b: Identify and Characterize Ignition Sources:

Steps 7.b: Define Fire Scenarios: For the target sets provided in the solution of the preceding problem set, identify the corresponding ignition sources and fire scenarios.

Target Set ID	Ignition Sources	Fire Scenarios
MCR-01	1. Water heater in the kitchen	MCR-01.1. An electrical short in the water heater leads to a fire in the kitchen that becomes severe enough to lead to control room abandonment.
	2. Microwave oven in the kitchen	MCR-01.2. An electrical short in the microwave oven or a food item fire inside the oven leads to a fire in the kitchen that becomes severe enough to lead to control room abandonment.
MCR-02	1. Main Control Board – Fire in CB-7	MCR-02.1. A fire inside Main Control Board due to internal causes. The fire initiates inside CB-7. Operator response in putting the fire is not fast enough to prevent damage to CB-7 contents. But the fire is controlled before it propagates to other parts of the panel.
	2. Transient fire	MCR-02.2 A transient fire inside Main Control Room, but outside the Main Control Board, occurs near CB-7 such that only CB-7 is affected either because of the location of the fire or fire fighting efforts.
	3. Transient fire due welding and cutting	MCR-02.3. A transient fire due to welding and cutting inside Main Control Room, but outside the Main Control Board, occurs near CB-7 such that only CB-7 is affected either because of the location of the fire or fire fighting efforts.
	4. Cable fire due welding and cutting.	MCR-02.4. A cable fire occurs due to welding and cutting inside Main Control Board occurs near CB-7 such that only CB-7 is affected because fire fighting efforts limit the reach of the fire.
MCR-03	1. Main Control Board – Fire in CB-5	MCR-03.1. A fire inside Main Control Board due to internal causes. The fire initiates inside CB-5. Operator response in putting out the fire is not fast enough to prevent damage to CB-5 contents. But the fire is controlled before it propagates to other parts of the panel.
	2. Transient fire	MCR-03.2. A transient fire inside Main Control Room, but outside the Main Control Board, occurs near CB-5 such that only CB-5 is affected either because of the location of the fire or fire fighting efforts.
	3. Transient fire due welding and cutting	MCR-03.3. A transient fire due to welding and cutting inside Main Control Room, but outside the Main Control Board, occurs near CB-5 such that only CB-5 is affected either because of the location of the fire or fire fighting efforts.

Target Set ID	Ignition Sources	Fire Scenarios
	4. Cable fire due welding and cutting.	MCR-03.4. A cable fire occurs due to welding and cutting inside Main Control Board occurs in CB-5 such that only CB-5 is affected because fire fighting efforts limit the reach of the fire.
MCR-04	1. Main Control Board – Fire in CB-3	MCR-04.1. A fire inside Main Control Board due to internal causes. The fire initiates inside CB-3. Operator response in putting the fire is not fast enough to prevent damage to CB-3 contents. But the fire is controlled before it propagates to other parts of the panel.
	2. Transient fire	MCR-04.2. A transient fire inside Main Control Room, but outside the Main Control Board, occurs near CB-3 such that only CB-3 is affected either because of the location of the fire or fire fighting efforts.
	3. Transient fire due welding and cutting	MCR-04.3. A transient fire due to welding and cutting inside Main Control Room, but outside the Main Control Board, occurs near CB-3 such that only CB-3 is affected either because of the location of the fire or fire fighting efforts.
	4. Cable fire due welding and cutting.	MCR-04.4. A cable fire occurs due to welding and cutting inside Main Control Board occurs in CB-3 such that only CB-3 is affected because fire fighting efforts limit the reach of the fire.
MCR-05	1. Main Control Board – Fire starting either in CB-3 or in CB-5	MCR-05.1. A fire inside Main Control Board due to internal causes. The fire initiates inside CB-3 or CB-5. Operator response in putting the fire is not fast enough to prevent damage to the postulated target set. But the fire is controlled before it propagates to other parts of the panel.
	2. Transient fire	MCR-05.2. A transient fire inside Main Control Room, but outside the Main Control Board, occurs near CB-3 and CB-5 such that only the postulated target set is affected either because of the location of the fire or fire fighting efforts.
	3. Transient fire due welding and cutting	MCR-05.3. A transient fire due to welding and cutting inside Main Control Room, but outside the Main Control Board, occurs near CB-3 and CB-5 such that only the postulated target set is affected either because of the location of the fire or fire fighting efforts.
	4. Cable fire due welding and cutting.	MCR-05.4. A cable fire occurs due to welding and cutting inside Main Control Board occurs in CB-3 or CB-5 such that only the postulated target set is affected because fire fighting efforts limit the reach of the fire.

Workshop Problem Set 11b-07 (Solution)

Step 8b: Conduct Fire Growth and Propagation Analyiss

Step 9b: Detection and Suppression Analysis and Severity Factor: Using the information provided in the solution to Problem Sets 11b-05 and 06 and Figure L-1, conduct fire propagation, detection and suppression analysis for the following fire scenarios and calculate scenario frequency:

<u>MCR-03.1</u>

The farthest distance between the postulated control devices on the board is 4 ft.

d = 4 ft = 1.2 m

Assumed non-qualified cables since a portion of the cables are non-qualified. From Figure L-1 it is concluded:

$[SFxP_{NS}]_{MCR\text{-}03.1}$ = 3.0E-03

$\lambda_{MCR\text{-}03.1}$ = 2.5E-03 x 3.0E-03 = 7.5E-06 per reactor year

<u>MCR-04.1</u>

The farthest distance between the postulated control devices on the board is 2 ft.

d = 2 ft = 0.6 m

Assumed non-qualified cables since a portion of the cables are not qualified. From Figure L-1 it is concluded:

$[SFxP_{NS}]_{MCR\text{-}04.1}$ = 5.0E-03

$\lambda_{MCR\text{-}04.1}$ = 2.5E-03 x 5.0E-03 = 1.25E-05 per reactor year