

Module III – Fire Analysis

Task 11: Detailed Fire Modeling, and the PRA Standard’s Fire Scenario Selection and Analysis Technical Element

**Joint EPRI/NRC-RES Fire PRA
Workshop
August 21-25, 2017**



Corresponding Technical Element

...and a note on structure

- Task 11 maps to FSS – Fire Scenario Selection and Analysis
 - FSS has 8 HLRs and a total of 50 SRs
 - FSS has more SRs than any other fire technical element
- We are going to quickly go over structure of FSS technical element, and then we will get into the various elements of Task 11 in more detail

Corresponding Technical Element

...and a note on structure (cont.)

- Task 11 has 3 subtasks and there are presentations for each:
 - 11a - Single compartment analysis
 - 11b - Main control room analysis
 - 11c - Multi-compartment analysis
- We will cover the FSS HLRs just once (here)
- SRs specific to a subtask will be cited as appropriate, but...
 - While there are SRs that are subtask specific:
 - e.g., FSS-B for MCR abandonment, FSS-G for multi-compartment scenarios...
 - Some SRs will apply to all subtasks:
 - e.g., define targets, characterize source, provide basis...

Corresponding Technical Element

...and a note on structure (cont.)

- This training also covers several 6850/1011989 “special models”
 - Detailed analysis tools for specific problems (methodology)
- Recall that the standard sets high-level scope and quality metrics, but does not prescribe methodology
- The special model presentations map to SRs where a direct link does exist:
 - e.g., define failure thresholds, characterize ignition source...
- SRs other than those we cite will likely apply:
 - e.g.: basis, validation, defining input variables, uncertainty...
- Note that 6850/1011989 provides a basis for the modeling tools it presents

Technical Element FSS

- FSS Objectives (per the PRA Standard):
 - To select the fire scenarios to be analyzed
 - To characterize the selected fire scenarios
 - To determine the likelihood and extent of risk-relevant fire damage for each selected fire scenario including
 - An evaluation of the fire generated conditions at the target location including fire spread to secondary combustibles
 - An evaluation of the thermal response of damage targets to such exposure
 - An evaluation of fire detection and suppression activities
 - To examine multi-compartment fire scenarios

FSS HLRs (per the PRA Standard)

- **HLR-FSS-A:** The Fire PRA shall select one or more combinations of an ignition source and damage target sets to represent the fire scenarios for each unscreened physical analysis unit upon which estimation of the risk contribution (CDF and LERF) of the physical analysis unit will be based. (6 SRs)
- **HLR-FSS-B:** The Fire PRA shall include an analysis of potential fire scenarios leading to the MCR abandonment. (2 SRs)
- **HLR-FSS-C:** The Fire PRA shall characterize the factors that will influence the timing and extent of fire damage for each combination of an ignition source and damage target sets selected per HLR-FSS-A. (8 SRs)

FSS HLRs (per the PRA Standard)

- HLR- FSS-D: The Fire PRA shall quantify the likelihood of risk-relevant consequences for each combination of an ignition source and damage target sets selected per HLR-FSS-A. (11 SRs)
- HLR-FSS-E: The parameter estimates used in fire modeling shall be based on relevant generic industry and plant-specific information. Where feasible, generic and plant-specific evidence shall be integrated using acceptable methods to obtain plant-specific parameter estimates. Each parameter estimate shall be accompanied by a characterization of the uncertainty. (4 SRs)

FSS HLRs (per the PRA Standard)

- **HLR-FSS-F:** The Fire PRA shall search for and analyze risk-relevant scenarios with the potential for causing fire-induced failure of exposed structural steel. (3 SRs)
- **HLR-FSS-G:** The Fire PRA shall evaluate the risk contribution of multi-compartment fire scenarios. (6 SRs)
- **HLR-FSS-H:** The Fire PRA shall document the results of the fire scenario and fire modeling analyses including supporting information for scenario selection, underlying assumptions, scenario descriptions, and the conclusions of the quantitative analysis, in a manner that facilitates Fire PRA applications, upgrades, and peer review. (10 SRs)

Mapping HLRs & SRs for the FSS Technical Element to NUREG/CR-6850, EPRI 1011989

Technical Element	HLR	SR	6850 Sections	Comments
FSS	A	The Fire PRA shall select one or more combinations of an ignition source and damage target sets to represent the fire scenarios for each unscreened physical analysis unit upon which estimation of the risk contribution (CDF and LERF) of the physical analysis unit will be based.		
		1	11.3.3, 11.5.1.3, 11.5.2.6	
		2	11.3.2, 11.5.1.5, 11.5.2.5	
		3	11.5.1.5	These sections of 6850/1011989 imply the requirements of these SRs.
		4	11.3.2, 11.5.1.5	
		5	11.5.1.6, 11.5.2.7	
		6	11.5.2.7	
	B	The Fire PRA shall include an analysis of potential fire scenarios leading to the MCR abandonment.		
		1	11.5.2.11	
		2	11.5.2.11, 11.5.3	

Mapping HLRs & SRs (continued)

Technical Element	HLR	SR	6850 Sections	Comments
FSS	C			The Fire PRA shall characterize the factors that will influence the timing and extent of fire damage for each combination of an ignition source and damage target sets selected per HLR-FSS-A.
		1	8.5.1, 11.3.3, 11.3.4, 11.5.1.3	Section 8 of 6850/1011989 partly address the requirements of this SR
		2	8.5.1, 11.3.3, 11.3.4, 11.5.1.3	
		3	11.3.3, 11.3.4, 11.5.1.3	These sections of 6850/1011989 imply the requirements of this SR.
		4	11.5.1.9, Appendices E and G	Section 11.3 of 6850/1011989 directs the reader to these Appendices where discussions relevant to the requirements of this SR are provided.
		5	8.5.1.2, Appendix H	
		6	11.5.1.7.6, Appendix H	
		7	n/a	Appendix P of 6850/1011989 implies the requirements of this SR but does not explicitly address it.
		8	11.5.1.7.3, Appendices M and Q	Referenced section and appendices of 6850/1011989 do not fully address the requirements of this SR.

Mapping HLRs & SRs (continued)

Technical Element	HLR	SR	6850 Sections	Comments
FSS	D			The Fire PRA shall quantify the likelihood of risk-relevant consequences for each combination of an ignition source and damage target sets selected per HLR-FSS-A.
		1	11.5.1.7.1	
		2	11.5.1.7.1	
		3	11.5.1.7.1	Several other sections and appendices of 6850/1011989 collectively address the requirements of this SR.
		4	11.5.1.7.1, Appendices E, F, G, H, M, N, O, R, S	
		5	Appendices E, G, P	
		6	11.5.1.7.1, Appendices H, M, N, O, P	
		7	11.5.1.8, Appendix P	
		8	11.5.1.8, Appendix P	
		9	11.5.1.5, 11.5.1.7.1, Appendix T	
		10	8.5.2, 11.4.3	Referenced sections of 6850/1011989 imply the requirements of this SR.
11	8.5.2, 11.4.3			

Mapping HLRs & SRs (continued)

Technical Element	HLR	SR	6850 Sections	Comments
FSS	E	The parameter estimates used in fire modeling shall be based on relevant generic industry and plant-specific information. Where feasible, generic and plant-specific evidence shall be integrated using acceptable methods to obtain plant-specific parameter estimates. Each parameter estimate shall be accompanied by a characterization of the uncertainty.		
		1	11.3, 11.5.1, Appendices G, H, L, N, O, R, and S	6850/1011989 does not discuss plant-specific fire modeling parameters. However, the discussions in the referenced sections and appendices imply the requirements of this SR.
		2		
		3	11.3, 11.5.1, Appendices E, G and P	
		4	n/a	The requirement in this SR is not explicitly addressed in 6850/1011989
	F	The Fire PRA shall search for and analyze risk-relevant scenarios with the potential for causing fire-induced failure of exposed structural steel.		
		1	n/a	Failure of exposed structural steel from fire impact is not explicitly discussed in 6850/1011989. Appendix Q addresses passive fire protection features but does not address exposed structural steel.
		2	n/a	
		3	n/a	

Mapping HLRs & SRs (continued)

Technical Element	HLR	SR	6850 Sections	Comments
FSS	G	The Fire PRA shall evaluate the risk contribution of multicompartment fire scenarios.		
		1	11.5.4.6	
		2	11.5.4	
		3	11.5.4	
		4	11.5.4.4	
		5	11.5.4.4	
		6	11.5.4.5, 11.5.4.6	
	H	The Fire PRA shall document the results of the fire scenario and fire modeling analyses including supporting information for scenario selection, underlying assumptions, scenario descriptions, and the conclusions of the quantitative analysis, in a manner that facilitates Fire PRA applications, upgrades, and peer review.		
		1	n/a	Documenting the analysis and the results is discussed in Chapter 16 and in several parts of Chapter 11 of 6850/1011989. The specific requirements of these SRs is generally not explicitly addressed.
		2	n/a	
		3	n/a	
		4	n/a	
		5	n/a	
		6	n/a	
		7	n/a	
		8	n/a	
		9	n/a	
10	n/a			