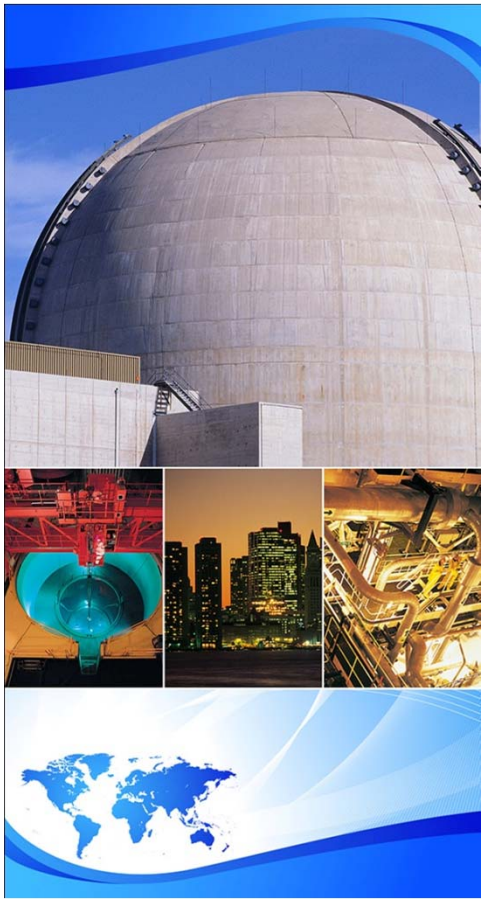


EPRI/NRC-RES FIRE PRA METHODOLOGY

Task 4 - Qualitative Screening
Task 7 - Quantitative Screening

Joint RES/EPRI Fire PRA Workshop 2012

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Qualitative / Quantitative Screening
Scope (per 6850/1011989)

- Task 4: Qualitative Screening
  - First chance to identify very low risk compartments

- Task 7: Quantitative Screening
  - Running the Fire PRA model to iteratively screen / maintain modeled sequences at different levels of detail

Qualitative Screening - Corresponding PRA Standard Element

- Primary match is to element QLS – Qualitative Screening
  - QLS Objectives (as stated in the PRA standard):

"*(a) The objective of the qualitative screening (QLS) element is to identify physical analysis units whose potential* fire risk contribution can be judged negligible without quantitative analysis.

(b) In this element, physical analysis units are examined only in the context of their individual contribution to fire risk. The potential risk contribution of all physical analysis units is reexamined in the multicompartment fire scenario analysis regardless of the physical analysis unit's disposition during qualitative screening."

Qualitative Screening – HLRs (per the PRA Standard)

- **HLR-QLS-A: The Fire PRA shall identify those physical analysis units that screen out as individual risk contributors without quantitative analysis (4 SRs).**
- **HLR-QLS-B: The Fire PRA shall document the results of the qualitative screening analysis in a manner that facilitates Fire PRA applications, upgrades, and peer review (3 SRs).**

Task 4: Qualitative Screening
Objectives and Scope

- The objective of Task 4 is to identify those fire compartments that can be shown to have a negligible risk contribution <u>without</u> quantitative analysis
  - This is where you exclude the office building inside the protected area
- Task 4 *only* considers fire compartments as individual contributors
  - Multi-compartment scenarios are covered in Task 11(b)
  - Compartments that screen out qualitatively need to be re-considered as potential Exposing Compartments in the multi-compartment analysis (but not as the Exposed Compartment)

Task 4: Qualitative Screening
Required Input and Task Output

- To complete Task 4 you need the following input:
  - List of fire compartments from Task 1
  - List of Fire PRA equipment from Task 2 including location mapping results
  - List of Fire PRA cables from Task 3 including location mapping results

- Task Output: A list of fire compartments that will be screened out (no further analysis) based on qualitative criteria
  - Unscreened fire compartments are used in Task 6 and further screened in Task 7

Task 4: Qualitative Screening
A Note….

- Qualitative Screening is OPTIONAL!
  - You may choose to retain any number of potentially low-risk fire compartments (from one to all) without formally conducting the Qualitative Screening Assessment for the compartment
    - However, to eliminate a compartment, you must exercise the screening process for the compartment
  - *Example 1*: Many areas will never pass qualitative screening, so simply keep them
  - *Example 2*: If you are dealing with an application with limited scope (e.g. NFPA 805 Change Evaluation) a formalized Qualitative Screening may be pointless

Task 4: Qualitative Screening
Screening Criteria (per 6850/1011989)

- A Fire Compartment may be screened out** if:
  - No Fire PRA equipment or cables are located in the compartment, and
  - No fire that remains confined to the compartment could lead to:
    - An automatic plant trip, or
    - A manual trip *as specified by plant procedures*, or
    - A *near-term* manual shutdown due to violation of plant Technical Specifications*

    *In the case of tech spec shutdown, consideration of the time window <u>is</u> appropriate
      - No firm time window is specified in the procedure – rule of thumb: consistent with the time window of the fire itself
      - Analyst must choose and justify the maximum time window considered

(**Note: screened compartments are re-considered as fire source compartments in the multi-compartment analysis - Task 11c)

Corresponding PRA Standard SRs: QLS-A1, A2

Mapping HLRs & SRs for the QLS technical element to NUREG/CR-6850, EPRI TR 1011989

Technical Element	HLR	SR	6850/1011989 section that covers SR	Comments
QLS	A	**The Fire PRA shall identify those physical analysis units that screen out as individual risk contributors without quantitative analysis**		
		1	4.5	
		2	4.5	
		3	4.5	
		4	n/a	Additional screening not covered in 6850/1011989
	B	**The Fire PRA shall document the results of the qualitative screening analysis in a manner that facilitates Fire PRA applications, upgrades, and peer review**		
		1	n/a	Documentation is discussed in Section 16.5 of 6850/101198
		2	n/a	Documentation is discussed in Section 16.5 of 6850/101198
		3	n/a	Documentation is discussed in Section 16.5 of 6850/101198

Task 7: Quantitative Screening
General Objectives (per 6850/1011989)

Purpose: allow (i.e., optional) screening of fire compartments and scenarios based on contribution to fire risk. Screening is primarily compartment-based (Tasks 7A/B). Scenario-based screening (Tasks 7C/D) is a further refinement (optional).

- Screening criteria not the same as acceptance criteria for regulatory applications (e.g., R.G. 1.174)
- Screening does not mean "throw away" – screened compartments/scenarios will be quantified (recognized to be conservative) and carried through to Task 14 as a measure of the residual fire risk

Quantitative Screening - Corresponding PRA Standard Element

- Primary match is to element QNS – Quantitative Screening
  - QNS Objective (as stated in the PRA standard):

"The objective of the quantitative screening (QNS) element is to screen physical analysis units from further (e.g., more detailed quantitative) consideration based on preliminary estimates of fire risk contribution and using established quantitative screening criteria."

Quantitative Screening – HLRs (per the PRA Standard)

- **HLR-QNS-A: If quantitative screening is performed, the Fire PRA shall establish quantitative screening criteria to ensure that the estimated cumulative impact of screened physical analysis units on CDF and LERF is small (1 SR).**
- **HLR-QNS-B: If quantitative screening is performed, the Fire PRA shall identify those physical analysis units that screen out as individual risk contributors (2 SRs).**
- **HLR-QNS-C: VERIFY that the cumulative impact of screened physical analysis units on CDF and LERF is small (1 SR).**
- **HLR-QNS-D: The Fire PRA shall document the results of quantitative screening in a manner that facilitates Fire PRA applications, upgrades, and peer review (2 SRs).**

Task 7: Quantitative Screening
Inputs/Outputs

- Inputs from other tasks for compartment-based screening (7A/B):
  - Fire ignition frequencies from Task 6,
  - Task 5 (Fire-Induced Risk Model),
  - Task 12 (Post-Fire HRA Screening), and
  - Task 8 (Scoping Fire Modeling) (7B only)

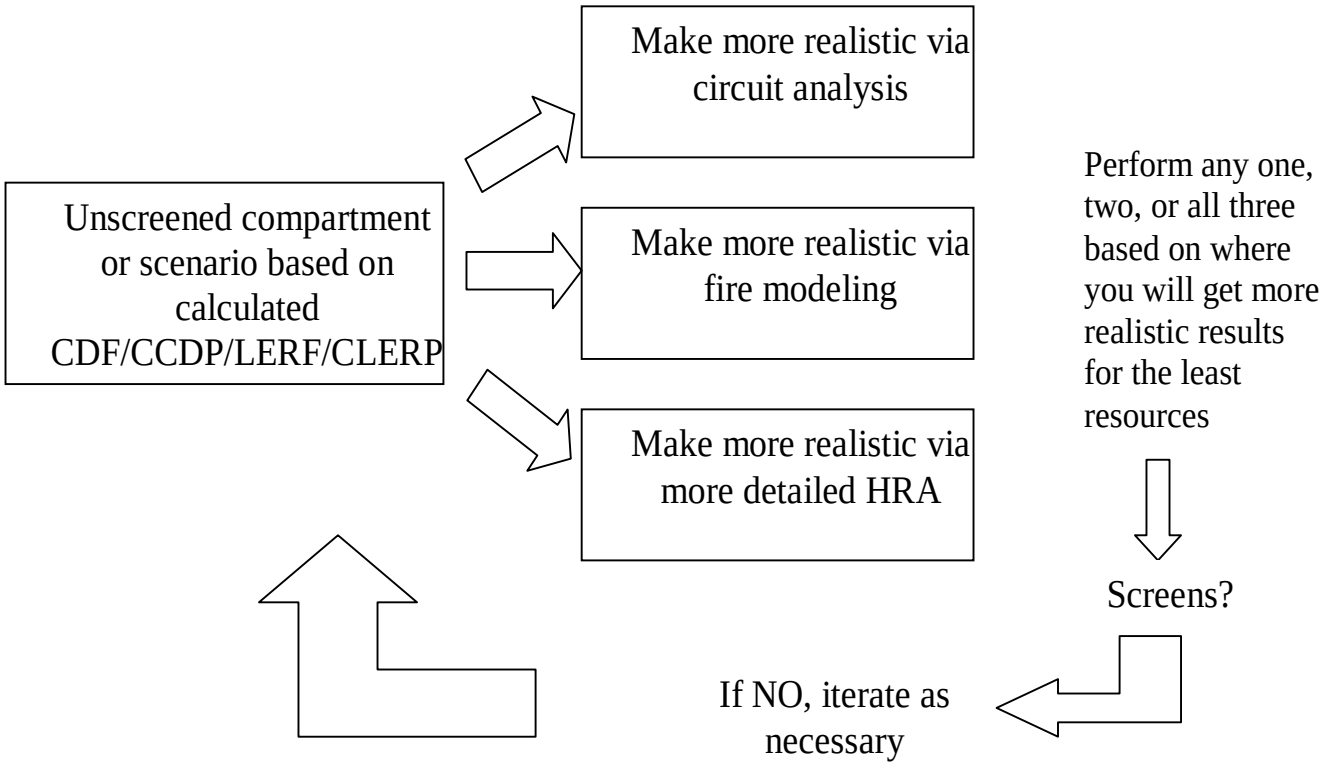
Task 7: Quantitative Screening
Inputs/Outputs (cont'd)

- Inputs from other tasks for scenario-based screening (7C/D) include inputs listed above plus:
  - Task 9 (Detailed Circuit Failure Analysis) and/or
  - Task 11 (Detailed Fire Modeling) and/or
  - Task 12 (Detailed Post-Fire HRA), and
  - Task 10 (Circuit Failure Mode Likelihood Analysis) (7D only)

Task 7: Quantitative Screening
Inputs/Outputs (cont'd)

- Outputs to other tasks:
  - Unscreened fire compartments from Task 7A go to Task 8 (Scoping Fire Modeling),
  - Unscreened fire compartments from Task 7B go to Task 9 (Detailed Circuit Failure Analysis) and/or Task 11 (Detailed Fire Modeling) and/or Task 12 (Detailed Post-Fire HRA),
  - Unscreened fire scenarios from Task 7C/D go to Task 14 (Fire Risk Quantification) for best-estimate risk calculation

Task 7: Quantitative Screening
Overview of the Process



Task 7: Quantitative Screening
Steps in Procedure

Three major steps in the procedure:

- Step 1: Quantify CDF/CCDP model
- Step 2: Quantify LERF/CLERP model
- Step 3: Quantitative screening

Task 7: Quantitative Screening
Steps in Procedure/Details

Step 1: Quantify CDF/CCDP models.

- Step 1.1: Quantify CCDP model
  - Fire-induced initiators are set to TRUE (1.0) for each fire compartment, CCDP calculated for each compartment
  - This step can be bypassed, if desired, by using fire frequencies in the model directly and calculating CDF

Task 7: Quantitative Screening
Steps in Procedure/Details

Step 1: Quantify CDF/CCDP models.

- Step 1.2: Quantify CDF
  - Compartment fire-induced initiator frequencies combined with compartment CCDPs from Step 1.1 to obtain compartment CDFs
- Step 1.3: Quantify ICDP (optional)
  - ICDP includes unavailability of equipment removed from service routinely
  - Recommend this be done if will use PRA for configuration management

Task 7: Quantitative Screening
Steps in Procedure/Details

Step 2: Develop LERF/CLERP models.

- Exactly analogous to Step 1 but now for LERF, CLERP
- Like ICDP, ILERP is optional

Task 7: Quantitative Screening
Establishing Quantitative Screening Criteria

- This is an area that has evolved beyond 6850/1011989
- 6850/1011989 *cumulative* screening criteria are based in part on screening against a fraction of the internal events risk results
  - Published PRA standard echoes 6850/1011989 (SR QNS-C1)
- Regulatory Guide 1.200 took exception to SR QNS-C1
  - NRC staff position: "screening criteria … should relate to the total CDF and LERF for the fire risk, not the internal events risk."
  - That is, screening should be within the hazard group (e.g., fire)
- An update to the PRA standard is pending and will *likely* revise QNS-C1 to reflect NRC staff position
- Bottom line: If you plan to use your fire PRA in regulatory applications, pay attention to RG 1.200 and watch for the PRA standard update

Task 7: Quantitative Screening
Screening Criteria for Single Fire Compartment

Step 3: Quantitative screening, Table 7.2 from NUREG/CR-6850

Quantification Type	CDF and LERF Compartment Screening Criteria	ICDP and ILERP Compartment Screening Criteria (Optional)
Fire Compartment CDF	CDF < 1.0E-7/yr	
Fire Compartment CDF With Intact Trains/Systems Unavailable		ICDP < 1.0E-7
Fire Compartment LERF	LERF < 1.0E-8/yr	
Fire Compartment LERF With Intact Trains/Systems Unavailable		ILERP < 1.0E-8

Note: The standard and RG 1.200 do not establish screening criteria for individual fire compartments – only cumulative criteria (see next slide…)

Task 7: Quantitative Screening
Screening Criteria For All Screened Compartments

Quantification Type	6850/1011989 Screening Criteria	NRC Staff Position per RG 1.200 for Cat II	NRC Staff Position per RG 1.200 for Cat III
Sum of CDF for all screened-out fire compartments	< 10% of internal event average CDF	the sum of the CDF contribution for all screened fire compartments is **<10%** of the estimated total CDF for **fire** events	the sum of the CDF contribution for all screened fire compartments is **<1%** of the estimated total CDF for **fire** events
Sum of LERF for all screened-out fire compartments	< 10% of internal event average LERF	the sum of the LERF contributions for all screened fire compartments is **<10%** of the estimated total LERF for **fire** events	the sum of the LERF contributions for all screened fire compartments is **<1%** of the estimated total LERF for **fire** events
Sum of ICDP for all screened-out fire compartments	< 1.0E-6	n/a	n/a
Sum of ILERP for all screened-out fire compartments	< 1.0E-7	n/a	n/a

Sample Problem Demonstration for Task 7

- On-line demonstration of Task 7

- Question and Answer Session

Mapping HLRs & SRs for the QNS technical element to NUREG/CR-6850, EPRI TR 1011989

Technical Element	HLR	SR	6850/1011989 section that covers SR	Comments
QNS	A	**If quantitative screening is performed, the Fire PRA shall establish quantitative screening criteria to ensure that the estimated cumulative impact of screened physical analysis units on CDF and LERF is small**		
		1	7.5.3	Specific screening criteria are identified in 6850/1011989
	B	**If quantitative screening is performed, the Fire PRA shall identify those physical analysis units that screen out as individual risk contributors**		
		1	7.5.1, 7.5.2	
		2	7.5.1, 7.5.2	
	C	**Verify that the cumulative impact of screened physical analysis units on CDF and LERF is small**		
		1	7.5.3	Specific screening criteria are identified in 6850/1011989
	D	**The Fire PRA shall document the results of quantitative screening in a manner that facilitates Fire PRA applications, upgrades, and peer review**		
		1	n/a	Documentation is discussed in Section 16.5 of 6850/101198
		2	n/a	Documentation is discussed in Section 16.5 of 6850/101198