EPRI/NRC-RES FIRE PRA METHODOLOGY

Task 3 - Fire PRA Cable Selection

Dan Funk – Kleinsorg Group
Gabriel Taylor – U.S. NRC
Office of Nuclear Regulatory Research

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FIRE PRA CABLE SELECTION
Purpose & Scope (per 6850/1011989)

- Identify circuits/cables associated with Fire PRA components
- Determine routing/location of the identified cables
- Use component-to-cable-to-location relationships to determine what components could be affected for postulated Fire Scenarios

  Note: A Fire Scenario can involve a Fire Area, Room/Compartment, Raceway, or Other Specific Location

- Identify Fire PRA power supplies

FIRE PRA CABLE SELECTION
Corresponding PRA Standard Element

- Primary match is to element CS – Cable Selection
  - CS Objectives (as stated in the PRA standard):

    "[T]o ensure that

    (a) all cables needed to support proper operation of equipment selected per technical element ES (see 4-2.2) are identified and assessed for relevance to the Fire PRA plant response model

    (b) the plant location information for selected cables is sufficient to support the Fire PRA and its intended applications."

FIRE PRA CABLE SELECTION
HLRs (per the PRA Standard)

- HLR-CS-A: The Fire PRA shall identify *and* locate the plant cables whose failure could adversely affect credited equipment or functions included in the Fire PRA plant response model, as determined by the equipment selection process (HLR-ES-A, HLR-ES-B, and HLR-ES-C). (11 SRs)
- HLR-CS-B: The Fire PRA shall
  - *(a)* perform a review for additional circuits that are either required to support a credited circuit (i.e., per HLR-CS-A) or whose failure could adversely affect a credited circuit
  - *(b)* identify any additional equipment and cables related to these additional circuits in a manner consistent with the other equipment and cable selection requirements of this Standard. (1 SR)
- HLR-CS-C: The Fire PRA shall document the cable selection and location process and results in a manner that facilitates Fire PRA applications, upgrades, and peer review. (4 SRs)

FIRE PRA CABLE SELECTION

NEI 00-01, Rev. 2, Section 3.3 – Safe Shutdown Cable Selection and Location

- NEI 00-01, Rev. 2, "Guidance for Post-Fire Safe Shutdown Circuit Analysis," May 2009.
- Generally follows the Task 3 methodology of NUREG/CR-6850, EPRI TR 1011989.
- Figure 3-4 in NEI 00-01 provides a flowchart illustrating the steps involved in selecting the cables necessary for performing a post-fire safe shutdown analysis:

  Step 1 – Define safe shutdown equipment.

  Step 2 – Identify circuits (power, control, instrumentation) required for the operation of each safe shutdown equipment.

  Step 3 – Identify equipment whose spurious operation or mal-operation could affect safe shutdown.

FIRE PRA CABLE SELECTION

NEI 00-01, Rev. 2, Section 3.3 – Safe Shutdown Cable Selection and Location (continued)

Step 4 – Identify interlocked circuits and cables whose failure may cause spurious actuations.

Step 5 – *Decision:* Is power required for equipment operation?

Step 6 – If power is required, identify closest upstream power supply and verify that it is on the safe shutdown list.

Step 7 – Assign cables to equipment.

Step 8 – Identify routing of cables.

Step 9 – Identify location of cables by fire area.

FIRE PRA CABLE SELECTION
Introduction (per 6850/1011989)

- Conducted for all Fire PRA Components

  Note: Exceptions do exist

- Cable selection is a **Deterministic** process
- Selected cables are associated to components based on specified functionality
  - Basic circuit analysis (Task 9A) incorporated into Task 3 work to prevent overwhelming the PRA model with inconsequential cable failures
  - Final product is a listing of defined Basic Events (component and credited function) that could be impacted by a fire in a given location (Fire Area, Compartment, etc.) or for a specific Fire Scenario

FIRE PRA CABLE SELECTION
Introduction (continued)

- Cable Selection procedure is subdivided into six (6) distinct steps

  Step 1: Compile and Evaluate Prerequisite Information and Data

  Step 2: Select Fire PRA Circuits/Cables

  Step 3: Identify and Select Fire PRA Power Supplies

  Step 4: Perform Associated Circuits Review

  Step 5: Determine Cable Routing and Plant Locations

  Step 6: Generate Fire PRA Cable List and Target Equipment Location Reports

FIRE PRA CABLE SELECTION
Task Interfaces - Input

- Plant Boundary Partitions (Task 1)
- Fire PRA Component List (Task 2)
- Fire PRA Database (Support Task B)
- Appendix R Circuit Analysis
- Plant Cable & Raceway Database
- Plant Drawings

FIRE PRA CABLE SELECTION
Task Interfaces - Output

- Fire PRA Cable List
- Fire PRA Power Supply List
- Associated Circuits Review
- Component Analysis Packages
- Target Equipment Loss Reports (potential equipment functional losses broken down by location or fire scenario)

FIRE PRA CABLE SELECTION
Step 1 – Prerequisite Information

- Confirm Plant Partitioning is compatible
  - Do partitions align with cable location data?
  - What data is available and what is missing?
- Confirm PRA Equipment List is final
  - Input into a formal and controlled database
  - For NFPA-805 transition projects a joint "consistency" review of NSP task and PRA component selection task is highly recommended

    NOTE: Consistency checks are recommended for all Fire PRAs
  - *Critical that electrical analysts understand what the Basic Events really mean*

  (Corresponds to NEI 00-01, Rev. 2, Step 1)
- Evaluate Database Requirements
  - What currently exists?
  - What is needed to support work?
  - How is data to be managed and controlled?
  - This is a "Biggie"

FIRE PRA CABLE SELECTION
Step 2 – Select Fire PRA Cables

- Analysis Cases
  - Appendix R Component with *same* functional requirements
    - Must consider which (if any) automatic features are included in the existing analysis
    - Aligning existing analyses to Fire PRA Basic Events is not straightforward
  - Appendix R Component with *different* functional requirements
  - Non-Appendix R Component *with* cable location data
  - Non-Appendix R Component *without* cable location data

- Analysis Sub-Steps
  - *Step 2.1:* Analysis Strategy
  - *Step 2.2:* Plant Specific Rules
  - *Step 2.3:* Select Cables

- Corresponding PRA Standard SRs: CS-A1, A3
- Corresponding NEI 00-01, Rev. 2, Steps: 2 & 4

FIRE PRA CABLE SELECTION
Step 2.1 – Analysis Strategy

- Coordinate with Systems Analysts to establish Functional Requirements and General Rules
  - Equipment functional states, basic events, initiators
  - Initial conditions and equipment lines (i.e., normal state)
  - Consistent conventions for equipment functions/state/position
  - Equipment-level dependencies and primary components
  - Multiple function components
  - "Super" components
- Evaluate Appendix R Component & Circuit Data
  - Ensure equipment list comparison was conducted during Task 2
  - Review in detail the comparison list – ask questions!!!
  - Essential that comparison includes detailed review/assessment of "desired functional state(s)"

FIRE PRA CABLE SELECTION
Step 2.1 – Analysis Strategy (continued)

- Goal – Efficient and accurate process to obtain required information
- Revisit past assumptions, conventions, and approach
- Potential trouble areas
  - How is off-site power going to be handled?
  - Instrument circuits – understand exactly what is credited
  - ESFAS, Load-Shed, EDG Sequencer, other automatic functions
  - Medium-voltage switchgear control power
- Extent that Circuit Analysis is to be conducted concurrently

  Note: This will be discussed as part of the Task 9 presentation
- Determine how analysis will be documented

FIRE PRA CABLE SELECTION
Step 2.2 – Plant Specific Cable Selection Rules

- Objective is Consistency
- Approach for Groups of Components
- Approach for Spurious Actuation Equipment
- Auxiliary Contacts – Critical Area for Completeness
- System-Wide Actuation Signals
- Bus or Breaker?
- Subcomponents & Primary Components
- Identification of Permanent Damage Scenarios
- Procedure - Develop Circuit Analysis Procedure/Guidelines

FIRE PRA CABLE SELECTION
Step 2.2 – Ready to Start?

- Develop Written Project Procedure/Guidelines
  - Consistency, Consistency, Consistency
  - Checking Process?
  - Data Entry
  - Problem Resolution

- Training for Analysts
  - Prior circuit analysis experience is a prerequisite for key team members
  - Familiarity with plant drawings and circuits is highly beneficial
  - A junior engineer with no prior circuit analysis experience will not be able to work independently

FIRE PRA CABLE SELECTION
Step 2.3 – Select Cables

- *Case 1:* Incorporate Existing Appendix R Analysis
  - Confirm adequacy of existing analyses IAW plan
  - Careful consideration of automatic functions
  - Exact alignment for credited functionality

- *Case 2:* New Functional State/Component w/ Cable Routing Data
  - Collect drawings and/or past analysis information
  - Identify/select cables IAW plant specific procedure/guidelines
  - Conduct circuit analysis to the extent decided upon
  - Formally document cable selection IAW established procedures/guidelines

FIRE PRA CABLE SELECTION
Step 2.3 – Select Cables (continued)

- *Case 3:* New Component w/o Cable Routing Data Available
  - Same as Case 2, plus…
  - Determine cable routing and associate with plant locations, including cable end points

- Analysis Work Packages
  - Retrieve from past Appendix R Analysis
  - Highly recommended for new components
  - Major time saver for future work

Note: More on Work Packages later in this presentation…

FIRE PRA CABLE SELECTION
Step 3 – Select Fire PRA Power Supplies

- Identify Power Supplies as integral part of Cable Selection
  - Make sure to differentiate between “Required” and “Not Required” power supplies
  - Switchgear and instrument power supplies can be tricky
  - Useful to identify the applicable breaker/fuse
- Add Power Supplies to Fire PRA Component List
- Make sure Fire PRA model, equipment list, and circuit analysis are consistent
- Does Fire PRA model consider spurious circuit breaker operations?
  - Must understand how this is modeled to correctly select cables
- Corresponding PRA Standard SRs: CS-B1
- Corresponding NEI 00-01, Rev. 2, Steps: 5 & 6

FIRE PRA CABLE SELECTION
Step 4 – Associated Circuits Review

- Objective is to confirm existing studies are adequate
- View the process as a "Gap Analysis"
- Common Power Supply Circuits - Assess Plant Coordination Studies
- Common Enclosure Circuits - Assess Plant Electrical Protection
- Roll up results to Circuit Analysis or Model as appropriate

  Note: Ensure switchgear internal fusing supports analysis assumptions

- Corresponding PRA Standard SRs: CS-A6, CS-B1
- Corresponding NEI 00-01, Rev. 2: Step 3 and Sections 3.5.2.4 & 3.5.2.5 (circuit analysis and evaluation)

FIRE PRA CABLE SELECTION
Step 5 – Determine Cable Routing and Locations

- Correlate Cables-to-Raceways-to-Locations
- Conceptually Straightforward
- Logistically Challenging
  - Labor intensive
  - Manual review of layout drawings
  - Plant walkdowns often required
- Determine Cable Protective Features
  - Fire wraps
  - Embedded conduit

- Corresponding PRA Standard SRs: CS-A10
- Corresponding NEI 00-01, Rev. 2, Steps: 7, 8, & 9

FIRE PRA CABLE SELECTION
Step 6 – Target Equipment Loss Reports

- Data Entered into Fire PRA Database
- Sorts and Queries to Generate Target Equipment Loss Reports

Perspective – Cable selection process should be viewed as providing "Design Input" to the Fire PRA. It does not, however, provide any risk-based results. In its simplest form it provides a list of equipment that could be affected by a fire at a specified location or for a specific fire scenario.

- Corresponding PRA Standard SRs: CS-C1, C2, C4

FIRE PRA CABLE SELECTION
Work Packages

- A work package for each Fire PRA component consists of a compilation of drawings and documents that provide the basis of the circuit analysis results for that component
- Contents typically include
  - One-line diagram(s) (highlighted to show the component's power supply)
  - Elementary diagram(s) (marked up to show cable associations)
  - Block diagram(s) (highlighted)
  - Loop diagram(s) (if applicable)
  - Component circuit analysis worksheets
  - Other descriptive/supporting information

FIRE PRA CABLE SELECTION
Questions

Any Questions?

FIRE PRA CABLE SELECTION

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

Technical Element	HLR	SR	6850/1011989 Sections that cover SR	Comments
CS	A	The Fire PRA shall identify and locate the plant cables whose failure could adversely affect credited equipment or functions included in the Fire PRA plant response model, as determined by the equipment selection process (HLR-ES-A, HLR-ES-B, and HLR-ES-C).		
		1	3.5.2	
		2	9.5.2	Covered in "Detailed Circuit Failure Analysis" chapter
		3	3.5.2, 9.5.2	Also covered in "Detailed Circuit Failure Analysis" chapter
		4	3.5.3	
		5	9.5.2	Covered in "Detailed Circuit Failure Analysis" chapter
		6	3.5.4, 9.5.2	Also covered in "Detailed Circuit Failure Analysis" chapter
		7	9.5.2	Covered in "Detailed Circuit Failure Analysis" chapter
		8	9.5.2	Covered in "Detailed Circuit Failure Analysis" chapter
		9	9.5.2	Covered in "Detailed Circuit Failure Analysis" chapter
		10	3.5.5	
		11	3.5.5	
	B	The Fire PRA shall (a) perform a review for additional circuits that are either required to support a credited circuit (i.e., per HLR-CS-A) or whose failure could adversely affect a credited circuit (b) identify any additional equipment and cables related to these additional circuits in a manner consistent with the other equipment and cable selection requirements of this Standard		
		1	3.5.3, 3.5.4	
	C	The Fire PRA shall document the cable selection and location process and results in a manner that facilitates Fire PRA applications, upgrades, and peer review.		
		1	3.5.6	
		2	3.5.6	
		3	3.5.6	
		4	3.5.6	

FIRE PRA CABLE SELECTION

Mapping NEI 00-01, Rev. 2, Safe Shutdown Cable Selection to NUREG/CR-6850, EPRI TR 1011989

NEI 00-01, Rev. 2, Section	NEI 00-01, Figure 3-4 Step	6850/1011989 Sections that cover step	Comments
3.3 - Safe Shutdown Cable Selection and Location	1	3.5.1	
	2	3.5.2	
	3	3.5.4	
	4	3.5.2	
	5	3.5.3	
	6	3.5.3	
	7	3.5.5	
	8	3.5.5	
	9	3.5.5	