

# Module II – Circuit Analysis

## Task 3: Fire PRA Cable Selection



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**Gabe Taylor – U.S. NRC**

**Daniel Funk – JENSEN HUGHES**

**Dane Lovelace – JENSEN HUGHES**

# FIRE PRA CABLE SELECTION

## *Purpose & Scope (per NUREG/CR-6850, EPRI 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
- Screen for Associated Circuits

# FIRE PRA CABLE SELECTION

## *Corresponding PRA Standard Element*

- What Standard?
  - ASME/ANS RA-Sb-2009, “Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications,” Addendum A to RA-S-2008, ASME, February 2009
  - Because the number and name rather impractical and non-intuitive, the common reference is “The PRA Standard”
  
- 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 3/9 methodology of NUREG/CR-6850, EPRI 1011989
- Updated Guidance in NEI 00-01, Rev. 4
  - Number of hot-shorts that must be postulated
  - Perspective on “Proper Polarity”
  - Latching vs Non-Latching
  - High Impact Components
  - Updates to Failure Mode Classification
  - Shorting Switches
  - Hot Short Duration – Deterministic Analysis
  - CT Open Circuit Secondary Fires

# FIRE PRA CABLE SELECTION

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

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.
- 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 NUREG/CR-6850, EPRI 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 during cutset reviews and quantification runs
  - Final output 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 (cont.)*

- 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
  - Generally managed by a database (e.g., FRANX)

# 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?
  - Are routing assumptions used?
- Confirm PRA Equipment List is Stable
  - Easier said than done...
  - Input into a formal and controlled database
  - For NFPA-805 transition projects a joint “consistency” review of NSCA and PRA component lists is highly recommended

*NOTE: Critical that electrical analysts understand the functional requirements for the PRA Model Basic Events*

(Corresponds to NEI 00-01, Rev. 2, Step 1)

- Evaluate Database Requirements and Controls are in Place
  - How is data to be managed and controlled?
  - This is a BIG DEAL

# FIRE PRA CABLE SELECTION

## Step 2 – Select Fire PRA Cables

### ■ Analysis Cases

- Appendix R SSA / NSCA 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
- New Component (Non-Appendix R/NSCA)

**IMPORTANT:** In Practice this Breakdown is Seldom Used – “Real World” cases are less well defined

### ■ 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
  - MUST WORK OUT THE DETAILS OF HOW PRA BASIC EVENTS ARE TO BE CORRELATED TO CIRCUIT ANALYSIS
  - Consistent conventions for equipment functions & positions
  - Equipment-level dependencies and primary components – must understand what is beneficial to PRA and what is a waste of time
  - Multiple function components (Consider carefully how to treat instruments)
  - “Super” or “Pseudo” 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 (cont.)

- 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
  - Digital control system circuits
- Extent that Circuit Analysis (Task 9) is to be conducted concurrently

*Note: This will be discussed as part of the Task 9 presentation*

# FIRE PRA CABLE SELECTION

## *Step 2.2 – Plant Specific Cable Selection Rules*

- Objective is Consistency and Accuracy
- Approach for Groups of Components
- Approach for Spurious Actuation Equipment
- Auxiliary Contacts – Critical Area for Completeness
- System-Wide Actuation Signals
- Digital Control System Conventions
- 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 or personnel that will work with minimal supervision
  - Familiarity with plant drawings and circuit types is a requirement
  - A junior engineer with no prior circuit analysis experience will not be able to work independently
- Consideration of Permanent Mechanical Damage



# 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 2A: New Functional State / New Component**
  - Collect drawings and/or past analysis information
  - Identify/select cables IAW plant specific procedure/guidelines
  - Conduct circuit analysis (Task 9A) to the extent decided upon
  - Formally document cable selection IAW established procedures/guidelines

# FIRE PRA CABLE SELECTION

## *Step 2.3 – Select Cables (cont.)*

- **Case 2B: New Functional State / New Component (no cable routing information)**
  - Same as Case 2A, plus...
  - Determine cable routing and associate with plant locations, including cable end points
- **Analysis Work Packages**
  - Retrieve from past Appendix R Analysis (if available)
  - 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
  - Decide how to handle alternate sources
- Add New Power Supplies to Fire PRA Component List
- Make sure Fire PRA model, equipment list, and circuit analysis are consistent with respect to power supplies
- 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
  - Be cautious of coordination studies that credit cable length
  - Understand implications of adding new non-vital equipment
- Common Enclosure Circuits - Assess Plant Electrical Protection
- Roll up results to Circuit Analysis or Model as appropriate
- Has emerged as difficult issue for Fire PRA – more discussion later
  
- 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
- Treatment and Documentation of “Assumed Locations”
- 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
- Mapping of Circuit Analysis to Model Basic Events is CRITICAL to accurate results
- 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

**Any Questions ??**

