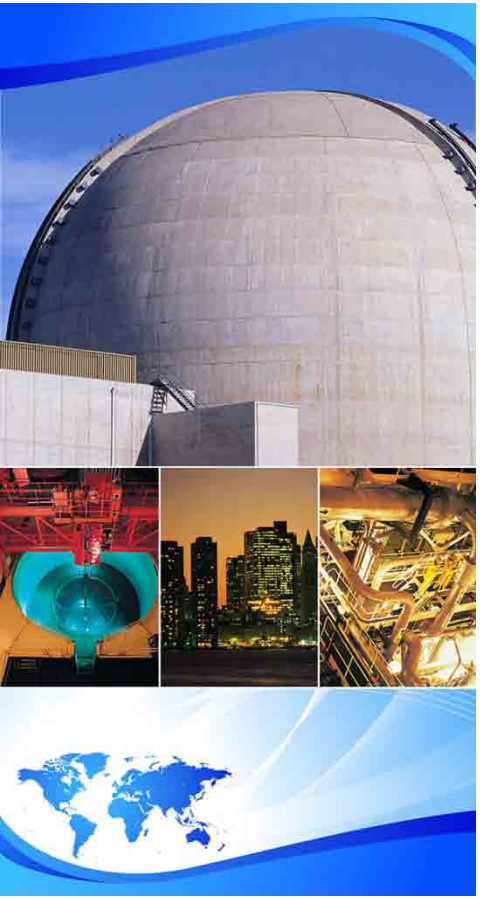


EPRI/NRC-RES FIRE PRA METHODOLOGY: Task 12 – Fire HRA

Qualitative Analysis

Joint NRC-RES/EPRI Fire PRA Workshop 2012

Bethesda, MD

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

Outline of the Presentation

1. Overview of the EPRI/NRC-RES Fire HRA Guidelines
2. Identification and definition of fire human failure events
3. **Qualitative analysis**
4. Quantitative analysis
   a) Screening
   b) Scoping
   c) EPRI approach (detailed)
   d) ATHEANA (detailed)
5. Recovery analysis
6. Dependency analysis
7. Uncertainty analysis

Fire HRA Module Training Objectives

1: Be able to name the **steps in the process** for conducting a fire HRA.

2: Be able to list the **different categories** of fire HRA human failure events (HFEs).

3: Demonstrate a knowledge of ASME/ANS PRA Standard **high level requirements** for fire PRA.

4: Be able to identify **context and performance shaping factors** (PSFs) used in the analysis of fire human failure events.

5: Be able to list the **quantification methods** available for developing human error probabilities (HEPs).

6: Understand the concept and importance of addressing **dependencies** between fire HRA events.

Outline of the Qualitative Analysis Module

- Introduction
- Applicable PRA Standard High Level Requirements
- Elements of or tools for performing qualitative analysis per NUREG-1921/EPRI 1023001*
- Operator performance influencing factors and special topics in NUREG-1921

* For brevity, NUREG-1921 is used for the remainder of the presentation

Qualitative Analysis - Introduction

- Qualitative analysis is an essential part of HRA
  - Not always explicitly defined as a separate step
  - But, provides a foundation for **all** steps in the HRA process
- The objective of HRA qualitative analysis is to:
  - Understand the PRA context for each HFE
  - Understand actual "as-built, as-operated" response of operator and plant
  - Translate this understanding into factors, data, and elements used in HRA quantification methods
- Qualitative analysis tasks are performed constantly and iteratively throughout the HRA

Qualitative Analysis - Introduction (continued)

- For fire PRA, HRA qualitative analysis includes*:
  1. Review and refine (if needed) the fire-specific context (e.g., evaluate applicability of internal events HFEs)
  2. General information collection
  3. Review of historical experience
  4. Review and refine (if needed) plant operations input
  5. Assess feasibility of operator actions for new (or existing) HFEs in fire context
  6. Identify performance shaping factors (PSFs) and other contextual factors specific to fire HRA/PRA

* New or redefined qualitative analysis tasks specific to fire context are in blue font

Qualitative Analysis – Introduction (continued)

- Qualitative analysis results support all HRA products:
  - Identification and definition of HFEs
  - Selection of appropriate quantification methods
  - Quantification of HFE probabilities
  - Documentation of HRA overall
- Regardless of the HRA quantification method, qualitative information is needed
- All PSFs addressed in Part 2 of the PRA Standard (high-level requirements HR-F and HR-G) need to be considered, but may or may not be explicitly used during quantification

Applicable HLRs (from the PRA Standard*)
Qualitative Analysis

Relevant HLRs from Internal-Events Section (Part 2) of PRA Standard*

- HLR-AS-A: The accident sequence analysis shall describe the plant-specific scenarios that can lead to core damage following each modeled initiating event. These scenarios shall address system responses and operator actions, including recovery actions that support the key safety functions necessary to prevent core damage (11 SRs)
- HLR-HR-E: A systematic review of the relevant procedures shall be used to identify the set of operator responses required for each of the accident sequences (4 SRs)
- HLR-HR-F: Human failure events shall be defined that represent the impact of not properly performing the required responses, in a manner consistent with the structure and level of detail of the accident sequences (2 SRs)

* ASME/ANS RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008, Standard for Level 1/Large Early Release Frequency PRA for Nuclear Power Plant Applications"

Applicable HLRs (per the PRA Standard)
Qualitative Analysis (Continued)

Internal Events (non-fire) HLRs (cont'd)

- HLR-HR-G: The assessment of the probabilities of the post-initiator HFEs shall be performed using a well-defined and self-consistent process that addresses the plant-specific and scenario-specific influences on human performance, and addresses potential dependencies between human failure events in the same accident sequence. (8 SRs)

Relevant HLRs from Fire Section (Part 4) of PRA Standard

- HLR-HRA-B: The Fire PRA shall include events where appropriate in the Fire PRA that represent the impacts of incorrect human responses associated with the identified human actions (2 SRs; consistent with HLR-HR-F)
- HLR-HRA-C: The Fire PRA shall quantify HEPs associated with the incorrect responses accounting for the plant-specific and scenario-specific influences on human performance, particularly including the effects of fires (1 SR)

Tools for Performing Qualitative Analysis in NUREG-1921

- Information collection and interpretation
- Feasibility assessment
- Development of HFE narrative
- Review of relevant historical experience
- Reviews with plant operations

Tools for Performing Qualitative Analysis – Information collection and interpretation

- Qualitative analysis consists of:
  - Collection and review of "objective" information, e.g.,
    - PRA logic model and its events
    - Data on timing of cues and time available for actions
  - Development of assumptions and assessments of gathered information to explain operator behavior (i.e., interpretation)
  - Development of inputs for HRA quantification methods, e.g.,
    - Performance shaping factors
    - Timing information
    - Other contextual information

Tools … – Information collection and interpretation (continued)

- For fire HRA, three general sources of information:
  1. PRA information needed to understand HFE context, e.g.,
     - PRA model (fire-induced initiating events, event trees, etc.)
     - Success criteria and timing information (from T-H analyses)
     - Other deterministic analysis (e.g., circuit analysis, fire growth)
  2. Plant information needed to understand "as-built, as-operated" plant response and required operator response, e.g.,
     - Procedures (EOPs, fire response procedures, alarm procedures)
     - Alarms and instrumentation that serve as cues for operator actions
     - Plant layout and locations for local operator actions
     - Plant staffing and roles
  3. HRA-specific information, e.g.,
     - Internal events HRA (qualitative analysis and quantification)
     - Interview notes from discussions and talk-throughs
     - Simulator observations, walk-through data, job performance measures

Tools … – Information collection and interpretation (continued)

- The amount of effort and detail needed from qualitative HRA tasks varies with the fire PRA context
- In turn, the fire PRA context typically varies in detail with NUREG/CR-6850 [EPRI 1011989] Task
  - Task 7a – Screening HEPs often use qualitative information developed during the Identification and Definition HRA task
  - Task 12 – Scoping HRA often uses qualitative information (context and PSF) associated with the scoping HRA trees
  - Task 14 – For risk significant HFEs, perform detailed HRA using qualitative context and PSFs associated with the detailed quantification method

Corresponding PRA Standard SRs: Part 2, HR-F2 and Part 4, HRA–B2

Tools for Performing Qualitative Analysis - Feasibility assessment

- Feasibility assessments evaluate whether actions associated with HFEs are “feasible,” i.e.,
  - capable of being done or carried out
  - per NUREG-1852, a feasible operator manual action is one “that is analyzed and demonstrated as being able to be performed within an available time so as to avoid a defined undesirable outcome”
- Feasibility assessments are needed in fire HRA/PRA for operator actions associated with:
  - All new HFEs (especially for those actions outside the control room)
  - HFEs from existing internal events PRA that are significantly changed in fire context
- Why?
  - Actions often have not been demonstrated, either at all or in fire contexts
  - Actions usually have not been validated by decades of simulator training exercises and vendor testing (as have most actions represented in EOPs and internal events PRAs)

Tools … - Feasibility Assessment

- The evaluation of feasibility is continuous throughout all fire HRA tasks, i.e.,
  - considered part of **Qualitative Analysis** step
  - begins at the **Identification and Definition** HRA step
  - continues through **Quantification** step
- Feasibility assessments may need to be re-visited as further information becomes necessary and available
- Once feasibility assessments are "complete" in HRA quantification, some of the same factors considered in **feasibility** are re-considered from the **reliability** (or failure probability) perspective

Corresponding PRA Standard SRs: Part 2, HR-G3 to HR-G5; Part 4, HRA-C1

Tools … - Feasibility Assessment

- Feasibility assessment factors:
  - Sufficient time
  - Sufficient manpower
  - Primary cues available/sufficient
  - Proceduralized and trained
  - Accessible location
  - Equipment and tools available and accessible
  - Relevant components are operable
- Any one of these factors could provide sufficient information to determine whether an operator action is not feasible, but all factors need to be sufficient for an action to be feasible.
- NUREG-1921, Section 4.3.4 provides substantial guidance on performing feasibility assessments

Tools … - Feasibility Assessment

- Example guidance for feasibility assessment factors:
  - Sufficient time (and more time may be needed than for internal events HRA due to fire effects) (Sections 4.3.4.1 and 4.6.2)
    - Timeline used to model operator performance
    - Sources of timing information (e.g., job performance measures [JPMs], training exercises, Appendix R feasibility demonstrations)
  - Sufficient manpower (both inside and outside control room)
  - Primary cues available/sufficient (e.g., is there a fire impact?)
  - Proceduralized and trained (plus certain *skill-of-the-craft* actions)
  - Accessible location (both travel path and action location; effects of environmental and security measures must be considered)
  - Equipment and tools available and accessible, e.g.,
    - Keys for locked doors
    - Radios, ladders, flashlights, protective clothing, SCBAs

Tools … - Initial Feasibility Assessments

- In Identification and Definition HRA step (see Section 3.5), feasibility assessment is a "Go/No Go" check
  - Ensures that fire PRA is not crediting an operator action that may not be possible
  - If operator action is not feasible, HEP should be set to 1.0
- At this stage, the answers to the following questions <u>may be</u> known:
  - Is there sufficient time to complete action?
  - Are there sufficient cues available for diagnosis?
  - Is the location for the action accessible?
  - Is there enough staff available to complete the action?
  - Has the fire impacted equipment such that the action cannot be performed?
- This initial feasibility assessment is likely to be represented in screening quantification

Tools… - Feasibility Assessments for Scoping and Detailed Fire HRA quantification

- At later stages in fire HRA/PRA, additional information (fire modeling or fire PRA model sequence information) will be available, allowing feasibility assessments to be revised
- Feasibility assessments during scoping and detailed HRA quantification typically examine further details regarding the action, context, scenario and timing
- Especially to support detailed HRA quantification, feasibility assessments are best evaluated through, e.g.,
  - reliable existing information
  - structured interviews
  - if possible, walkthroughs with operations and training personnel
  - photo-documentation of locations to be accessed, equipment to be actuated and tools to be used

Tools for Performing Qualitative Analysis - Development of HFE narrative

- Best way to communicate what is understood about an HFE and its associated PRA scenario is:
  - HFE narrative (or “operational story”)
  - An HFE narrative integrates and relates elements of PRA context to other information (e.g., PSFs) as a way to understand plant response and how it relates to operator response
- Elements of HFE narrative for fire HRA:
  - Fire-induced initiating event
  - Accident sequence (including preceding failures and successes)
  - Timing information
  - Accident-specific procedural guidance
  - Cues for operator action and other associated indications
  - Preceding operator errors or successes
  - Operator action success criteria
  - Physical environment

Tools for Performing Qualitative Analysis - Review of relevant historical experience

- Performed to gain a better understanding of plant and operator response following an event
- Includes both plant-specific and industry-wide incidents (e.g., NRC Information Notices) with focus on contexts in which accidents and operator failures occur
- Usually focuses on a specific type or class of initiating event (e.g., fire or small LOCA)
- May reveal potential influences on operator performance (e.g., plant conditions and associated gaps in procedures or training) and challenging conditions or situations the operators might encounter
- Is particularly relevant to detailed HRA (when more specifics on context are needed) but useful earlier in HRA (e.g., screening), too

Tools for Performing Qualitative Analysis - Reviews with plant operations

- Typically, several interviews of plant operations personnel are needed to confirm an understanding of plant and operator response
- Early in HRA, first interview(s) used to confirm general understanding (e.g., staffing, procedural hierarchy, communication protocols, how fire procedures are implemented, interactions with fire brigade)
- Later, additional interviews used to review and confirm understanding and modeling of HFEs, e.g.,
  - Specific procedural usage for each action
  - Scenario and plant specific timing information
  - Expected operator response and travel path for specific scenario
- Interviews and plant-specific data collection include plant walk-throughs, talk-throughs, and simulator observations

Tools … - Reviews with plant operations (continued)

- Tips on conducting talk-throughs:
  - Operators, trainers, and other knowledgeable plant staff should be involved to extent possible
  - Thorough task breakdown is needed to make actions and locations clear
  - Applicable procedures and key indicators need to be identified
  - Feasibility factors (listed previously) should be discussed
  - Thoroughly discuss actions and likely impacts on operator performance
  - Expert elicitation process in ATHEANA User's Guide (NUREG-1880) can be used to assist in developing timing estimates
- Tips on conducting walk-throughs:
  - Set up walk-through to be as realistic as possible
  - Be aware of execution of actions and influencing factors that cannot be represented (e.g., heat or smoke from fire, locations or travel paths that are not accessible while at power)
  - Be aware of factors that can influence timing of actions and range of possible performance times (even if only one demonstration is made)

Qualitative Analysis – Operator performance influencing factors and special topics

- Operator performance influencing factors:
  - Performance shaping factors for fire context
  - Other relevant contextual factors
- Special topics (and potential areas for additional, future development):
  - Treatment of main control room abandonment
  - Preemptive procedures
  - Operator responses to spurious operations

Performance Shaping Factors (PSFs)

PSFs are those factors which can impact operator performance (no new categories for fire), e.g.,

- Cues and indications
- Timing (time required and time available)
- Procedures and training
- Complexity
- Workload, stress, pressure
- Human-machine interface
- Environment
- Special equipment
- Crew communication, staffing and dynamics

Corresponding PRA Standard SRs: Part 2, HR-G3 to G5; Part 4, HRA–C1 Note 1

PSFs: Cues and Indications

- Cues are the prompts to initiate actions
  - Alarms, indications, and/or procedure steps
- Need to evaluate availability of cues given the fire impact
  - Verify (by cable tracing if necessary) that either

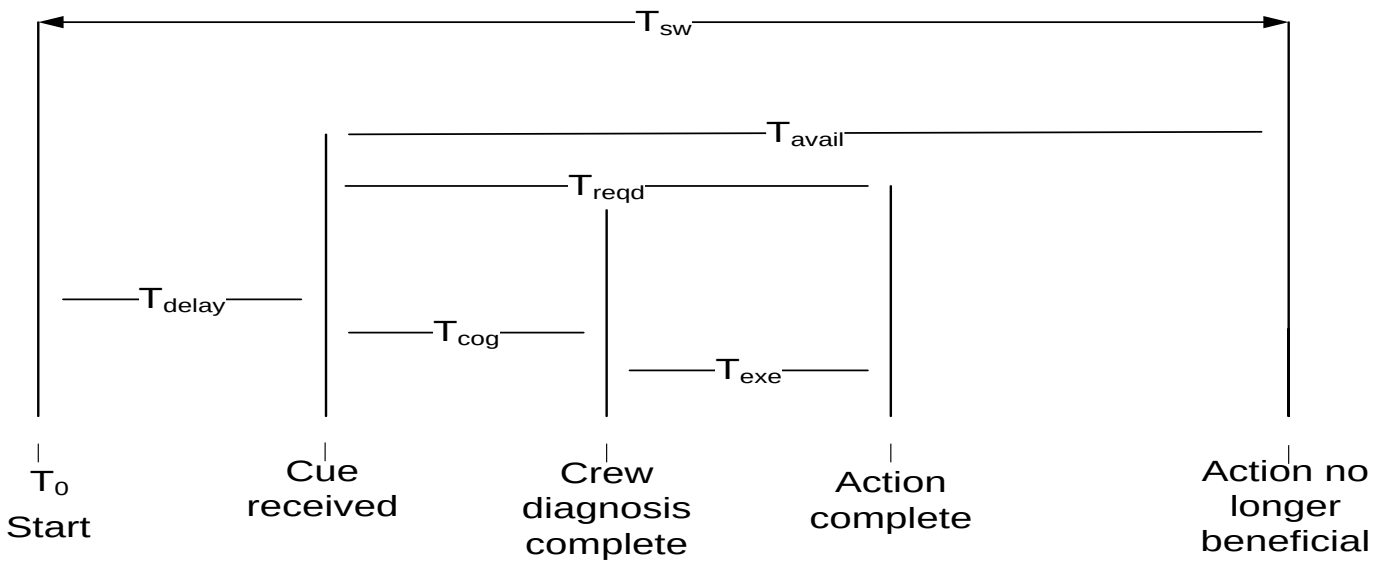
    (1) Instrumentation is not affected by fire, or

    (2) It is known that required instrumentation is sufficiently protected and is identified (e.g., procedurally) as such
  - If primary cues or indications are impacted, identify diverse cues and indications that could be credited
    - From the procedure
    - From discussions with plant operators
- If no cue credit can be given, need to quantify HFE with 1.0 or hard-wire operator failure given instrument failure in model

PSFs: Timing

- Obtain the following timing for each HFE
  - Total time available (thermal-hydraulic data), e.g.,
    - Time to damage (core damage or component damage)
    - This is usually assessed with a bounding calculation that can be applied in many situations
  - Time that plant response cue occurs relative to the initiating event (thermal-hydraulic data)
  - Time it takes operators to formulate a response (cognitive)
    - Detection, diagnosis and decision-making
    - Data from operator interviews, generic simulator data or observations
  - Time it takes to execute response, given a fire
    - Includes travel, equipment/tools, and manipulation
    - Data from operator interviews, JPMs, training records or observations

Time Line Depiction



- T_{sw} = System time window
- T_{delay} = Time of the Cue
- T_{avail} [available Time Window] = $[T_{sw} - T_{delay}]$
- T_{cog} = Given cue, the time for detection, diagnosis & decision-making
- T_{exe} = Given the decision, the time to execute the action (including travel & manip.)

PSFs: Procedures and Training

- Identify how operators implement fire procedures
  - Implemented in parallel or after completion of EOPs
  - Unlike EOPs, fire procedures might not be standardized or their use could be discretionary
  - Might require more judgment-based, rather than "automatic" decisions/actions, due to dynamic nature of fires
- Identify critical procedure steps for both cognition and execution
- Identify if and how often operators are trained on both fire procedures and EOPs

PSFs: Complexity

- For local and MCR abandonment actions, the crew may be required to visit various locations
  - As the number of locations increases, the complexity of the situation also increases
  - Multiple actions may require coordination among crew(s), which may increase complexity
  - The number and complexity of the actions and the availability of needed communication devices should be addressed

PSFs: Workload, Pressure and Stress

- For HRA methods that categorize stress into different levels, such as low, moderate and high, a further increase in the level of stress may be considered for fire HRA
- Example - the scenario may be unfamiliar, the procedures and training for the fire scenario may only be considered adequate, the time available to complete the action may be shortened due to fire, and/or the time required may be longer
  - The analyst may therefore decide that stress will have a significant impact on performance, where it may not have been as significant in the internal events HRA

PSFs: Human Machine Interface

- For control room abandonment actions, the adequacy of the remote shutdown and local panels needs to be verified
  - Remote shutdown panels are plant specific and design reviews and improvements have not always been completed
  - Remote shutdown panels are typically not designed for mitigation of all initiating events
  - Additionally, the operators may not be as familiar with the panel layout as they are in control room scenarios
- Local actions that require the use of equipment that has been damaged such that manipulation could be difficult or unlikely to succeed should not be credited in the PRA
  - For example, a hot short on a control cable has caused a valve to close and drive beyond its seat, possibly making it impossible to open manually

PSFs: Environment

- For local actions, there is the potential that the fire could impact ideal travel path to locations. Less direct routes and longer travel times need to be considered
- For control room actions, even if fire does not directly impact control room, environmental conditions outside the control room may still impact operator performance inside the control room (i.e. smoke entering CR from HVAC system)
- For main control room abandonment, actions may need to consider operators' use of SCBA gear
  - Consider effects of smoke, heat and toxic gas for main control room abandonment
    - NUREG/CR-6850 [EPRI 1011989] Section 11.5 provides guidance for impact of smoke

PSFs: Environmental Effects on Feasibility

- Radiation
  - Fire could damage equipment in a way that radiation exposure could be an issue in the location in which the action needs to be taken, causing the need to don personnel protection clothing (extra time)
- Smoke and toxic gas effects
- Increased noise levels from fire fighting activities, operation of suppression equipment, or personnel shouting instructions
- Water on the floor, possibly delaying the actions
- Obstruction from charged fire hoses or large wheeled portable extinguishers
- Heat stress which requires special equipment, limiting time in the area and other precautions; or too many people (getting in each others' way)

PSFs: Special Equipment

- Due to varying environmental conditions during a fire, the crew may require the use of special equipment such as:
  - Keys
  - Ladders
  - Hoses
  - Flashlights
  - Clothing to enter containment areas
- Tools need to be checked to ensure they can be located and accessed during a fire, and that they will likely be functional
- Lists/locations of tools may be cited in procedures
- Pre-job briefings may review use of special equipment

PSFs: Crew Communication, Staffing and Dynamics

- Per NUREG/CR-6850 [EPRI 1011989], most plants can be operated from the control room with two or three operators as the minimum, but a crew may consist of four or five licensed operators
  - thus assigning one to the fire brigade usually does not diminish the control room capability below what is required
- Crew credited for recovery in internal events may no longer be applicable for fire
- For MCR abandonment actions, verify that there are adequate control room members necessary to fulfill the needs of proper shutdown actions from remote shutdown panel (RSP)
- MCR abandonment actions as well as some local actions may require the use of SCBA and could impact communications

Other relevant context factors … that could impact MCR crew

- MCR staff actions can influence the time to respond; such as the time to
  - obtain the correct fire plan and procedures once the fire location is confirmed
  - inform the plant staff of the fire and call for fire brigade assembly and actions
  - alert and/or communicate with local staff responsible for completing various actions
  - provide any specific instructions to the responsible local staff for the actions

Other relevant context factors … that could impact local crew

- Timing considerations of local staff actions can influence the time to respond; such as the time to
  - collect procedures, establish communications, or obtain special tools
  - perform preparatory actions such as donning SCBA or personnel protective clothing
  - travel to the necessary locations
  - implement the desired actions; if more than one action, they may have to be coordinated or done sequentially
  - inform MCR staff and others that the actions have been successfully completed and the desired effect achieved

Other relevant context factors … crew to crew variability

- Physical size, strength and dexterity differences that may be important for performing the actions
- Cognitive differences (e.g., memory ability, analytic skills)
- Different emotional responses to the fire/smoke
- Different responses to wearing SCBA to accomplish a task (i.e., some people may be more uncomfortable than others with a mask over their faces, thus affecting action times)
- Differences in individual sensitivities to “real-time” pressure
- If the action has training, it is typically assumed that all crew members could complete the action, and crew to crew variability is treated as a sensitivity.

Qualitative Analysis Summary

- Regardless of the HRA quantification method, qualitative information is needed to support evaluation.
  - Provides the data "foundation" used in each Fire HRA process step
  - Objective information, called the FPRA context
  - Evaluated information, such as performance shaping factors (PSFs)
- All PSFs addressed in Part 2 of the ASME/ANS standard (high-level requirements HR-F and HR-G) need to be considered, but may or may not be explicitly used during quantification
- **Qualitative analysis includes**:
  1. Information collection and interpretation (especially for fire-specific context)
  2. Evaluation of HFE feasibility
  3. Development of HFE narrative (or operational story)
  4. Review of historical experience
  5. Review of plant operations
  6. Identification of PSFs and other contextual factors for fire-specific HRA/PRA

Qualitative Analysis – Special topics

- Treatment of main control room abandonment (Section 4.8)
  - NUREG-1921 assumes that MCR will be completely abandoned only if it is uninhabitable
  - NUREG-1921 does not provide detailed guidance on evaluating the decision to abandon the MCR
- Preemptive procedures (Section 4.9)
  - Discussion of issues is provided on preemptive procedures, especially those used by plants that use a self-induced station blackout (SISBO) strategy for addressing fire events
  - NUREG-1921 does not provide any further explicit guidance on modeling or quantifying actions associated with these strategies

Qualitative Analysis – Special topics (continued)

- Operator responses to spurious operations (Section 4.10)
  - NUREG-1921 written to Capability Category II with respect to spurious indications that could affect operator response
  - Section 2.5 discusses how fire PRA (overall) addresses issue of multiple spurious actuations
  - Section 4.10:
    - discusses how spurious indications or actuations of equipment that are not explicitly modeled by fire HRA/PRA could affect operator response
    - provides suggested strategies on how to represent such potential operator behavior through sensitivity studies or uncertainty analysis

EXAMPLES

1. FIRE SPECIFIC CONTEXT DEFINITION
2. CUES AND INDICATION CONFIRMATION
3. PROCEDURES AND TRAINING
4. TIMING

Example of Fire Specific Context Definition

Description: Locally open valve (8804A) for high pressure recirculation following a spurious PORV LOCA

1. Initial Conditions: Steady state, full power
2. Initiating Event:
   - Fire in Area 5A2
   - The fire starts in transformer and impacts targets in the plume and vertical trays adjacent to the flames
   - PORV spuriously opens resulting in small LOCA
3. Accident sequence (functional failures and successes):
   - Reactor trip, Turbine trip
   - No ATWS
   - No containment spray required
   - AFW successful
   - SI actuates due to open PORV
   - Cooldown and depressurization required
   - Switch over to recirculation required

Example of Fire Specific Context Definition
(Continued)

4. Preceding operator error or success in sequence:
   - Operators fail to detect spurious PORV opening prior to auto SI actuation
   - Operators controlled ECCS flow to match make-up flow with leakage rate
   - RHR pumps tripped
   - Cooldown and depressurization either failed or failed to be completed before RWST reaches 33%
5. Operator action success criterion:
   - Recognize 8804A cannot be opened from the control room due to fire damage
   - Locally open 8804A located at 73' RHR Access or 100’
6. Timing (Typically determined from MAAP)
   - Time to RWST 33% = 180 minutes
   - Time to RWST 0% = 300 minutes
   - Time required to perform local valve operation = 25 minutes

Example of Fire Specific Context Definition
(Continued)

7. Consequence of failure: Time to drain RWST
8. Availability of Cues and Indications:
   - RCS Pressure decreasing would be the primary cue operators would be focused on for diagnosing stuck open PORV; RCS pressure indicators are not failed by the fire
   - RWST Level indications are not impacted by fire
   - Monitor light boxes: The indicators at the switch would not be available to alert the operators that the valve failed to close but the monitor light boxes would be giving conflicting information and the operators tend to look at both the position switch and the monitor light boxes

Example of Cues and Indication Confirmation

Description: Locally open valve (8804A) for high pressure recirculation following a spurious PORV LOCA

- Operator interview insights
  - The operators stated that it would be obvious that 8804A failed to open when attempted from the control room. In addition to the position switches in the control room, the valve positions are also monitored on monitor light boxes. The cabling for the monitor light boxes are separate from the valve cabling
  - The operators stated that they are aware that switch-over to recirculation is imminent and they will have an operator preview E1.3 (step 13 of E-1 PREVIEW EOP E-1.3, TRANSFER TO COLD LEG RECIRCULATION). They anticipate that the preview will alert the operators to a failed valve.
- Review of cable tracing
  - The RWST level indicators are not failed by the fire
  - RCS pressure indicators are protected per Appendix R requirements and remain available during the fire
  - The indicator switch in the control room is failed by the fire

Procedures and Training Example

Description: Locally open valve (8804A) for high pressure recirculation following a spurious PORV LOCA

Procedures:

Cognitive: ES 1.3 (Transfer to Cold Leg Recirculation) Revision: 26

Step: 8.g. - Check for charging pump (pp or pps) amps, Charging injection flow and SI Pp flow if pps are in operation

Execution: ES 1.3 (Transfer to Cold Leg Recirculation) Revision: 26

Other: Fire Procedure Revision: 21A

Procedure Notes:

By the time switch over to cold leg recirc is required, the operators will also be looking at CP-M-10 (The fire procedure)

The procedure step in CP-M-10 reads:

Manually close 8804A Power will be isolated (by opening 480V MCC feeder breaker 52-1G-58 to preclude spurious operation of 8982A. If 8982A has opened, then locally close valve 8980 after opening its power breaker 52-1F-31

The operators are trained bi-annually on ES 1.3 but they are not specifically trained on ES 1.3 following a fire with various valve failures

Training – For Non Fire Scenario

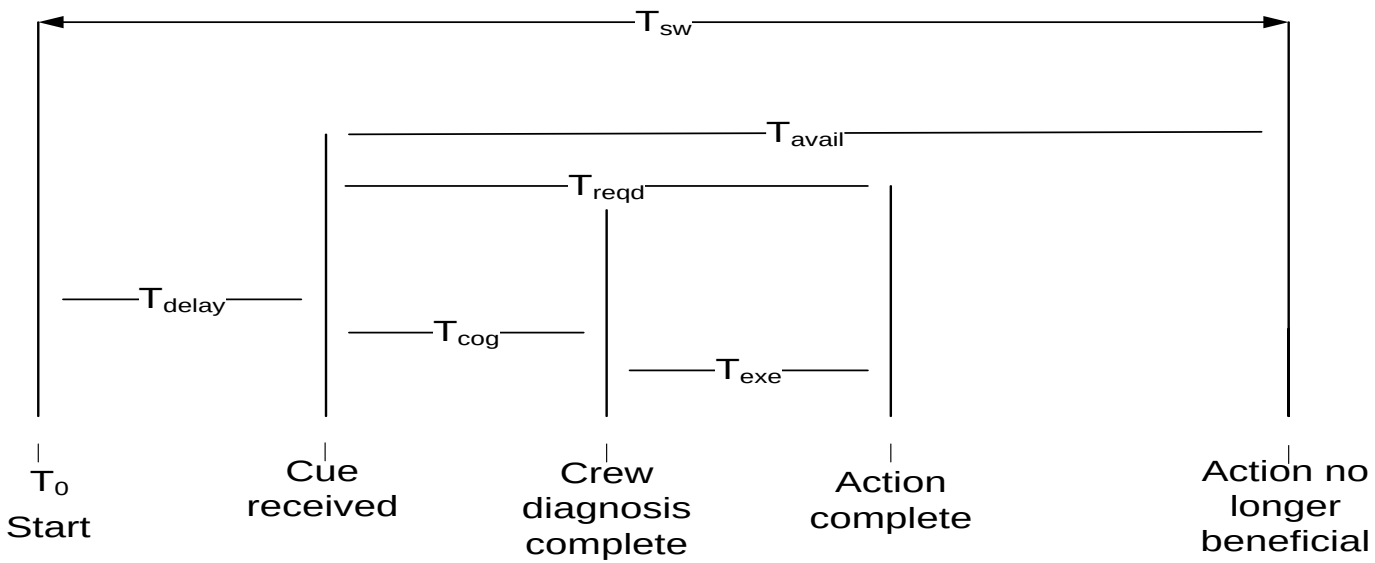
Classroom, Frequency: 0.5 per year

Simulator, Frequency: 0.5 per year

There is no fire specific training for this scenario.

Timing Example

Description: Locally open valve (8804A) for high pressure recirculation following a spurious PORV LOCA



- T_{sw} = 300 min = time to RWST depleted
- T_{delay} = 180 min = switchover to recirc. RWST <33%
- T_{avail} [available Time Window] = 300 -180 = 120 min
- T_{cog} = 2 min = Estimated time to attempt to close CR switch and realize that valve must be closed locally
- T_{exe} = 25 minutes, from operator interviews

Time Margin Calculation

$$\frac{120-(2+25)}{2+25} * 100 \sim 360\%$$

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Definition and Fire-Specific Context

- HFE Definition starts during Identification with:
  - Cues/alarm or other indications
  - Procedure
  - Staffing
  - Time available
- Feasibility evaluation initially done during Definition, then repeated/updated as HFE is developed
- Fire PRA Context typically varies with NUREG/CR-6850 [EPRI 1011989] Task
  - Task 7a – Screening HEPs often use qualitative info from Definition
  - Task 12 – Scoping HRA often uses qualitative info (context and PSF) associated with the scoping HRA trees
  - Task 14 – For risk significant HFEs, perform Detailed HRA using qualitative context and PSFs associated with the detailed quantification method

Corresponding PRA Standard SRs: Part 2, HR-F2 and Part 4, HRA–B2