Application of the New Fire Protection SDP
(IMC 0609, Appendix F)

Robert Perch
Probabilistic Safety Assessment Branch
U.S. Nuclear Regulatory Commission

rlp@nrc.gov (301)415-1422

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Overview

- Summary of Changes
- Process Description Overview
- Phase 1 Process Details
- Phase 2 Process Details
- Tabletop Exercise Results
- Conclusions

What Has Not Changed

- Entry conditions (what is a finding?)
- Duration factor plays the same role
- Risk significance (color assignment) criteria
- Focus on credible scenarios
- Most of the original guidance on degradations is retained
- Use of the plant notebooks for post-fire safe shutdown
- Judgment of the analyst is still critical

What Has Changed

- Process is tied more directly to fire PRA
- More steps, but each step is more focused
- More aggressive efforts to identify findings that will screen to green as soon as information is sufficient to justify
- Much more supporting guidance
- The NRC Fire Dynamics Tools (FDT) are used to support fire damage timing analysis

What the Changes Should Mean

- More quickly identify findings that will screen to green
- If a finding is potentially greater than green, the Phase 2 analysis will be:
  - More systematic
  - More repeatable
  - More accurate
- Phase 2 analysis will now be complimentary to Phase 3 analysis
- Expectation of overall reduction in the analysis burden

Some Issues Remain Pending

- "Cross-cutting issues"
  - Broad performance issues for manual fire fighting
  - Some circuit analysis issues
- MCR fires and MCR abandonment guidance
- Complex manual actions
  - Worksheets are provided to assess manual actions but, due to simplified approach, won't give much credit to complex action sets
  - Complex actions sets may require additional analysis (e.g., Phase 3 analysis)

A Word About Complexity

- The new process looks complex, but it is fairly straight-forward
- The original approach faced all the same analytical challenges, but with less structure and guidance
- The systematic structure and supporting guidance should improve efficiency and effectiveness

Basic Characteristics of the FP SDP

- The new SDP structure is the same as that used in a general fire PRA
- FP SDP is a screening tool
- We calculate CDF using four basic factors:
  - Fire Frequency (F)
  - Severity Factor (SF)
  - Probability of Non-Suppression (PNS)
  - Conditional Core Damage Probability (CCDP)

For one fire scenario:

$$CDF_i = F_i * SF_i * PNS_i * CCDP_i$$

Basic Characteristics of the FP SDP (cont.)

- Appendix F to Inspection Manual Chapter 0609, Significance Determination Process
- Eight attachments
- Supplemental guidance/basis document for Appendix F contained within IMC 0308, Reactor Oversight Process (ROP) Basis Document, as Att 3, App F
- Phase 1 is mostly qualitative; Phase 2 is mostly quantitative

Phase 1 Objective and Basis

- Objective: Identify findings that can be categorized as green without detailed analysis

- Basis: Combines concepts of "qualitative screening" and very preliminary "quantitative screening" from fire PRA

Phase 2 Objective and Basis

- Objective: Estimate the risk change associated with a finding

- Basis: Simplified versions of current fire PRA methods – we borrow:
  - Structure
  - Assumptions
  - Numerical values
  - Analysis Tools
  - Quantification approach

Phase 1, Step 1.1

- Assign a finding category
  - Cold Shutdown
  - Fire Prevention and Administrative Controls
  - Fixed Fire Protection Systems
  - Fire Confinement
  - Localized Cable or Component Protection
  - Post-Fire Safe Shutdown
- Later decisions will depend on the assigned category
- Once assigned, category does not change

Phase 1, Step 1.2

- Assign a degradation rating
  - In general choices are: High – Moderate – Low
  - Exceptions:
    - No Moderate for Fire Prevention and Administrative Controls (either High or Low)
    - For Fire Confinement, and Localized Cable and Component Protection (fire barriers), Moderate is split into "Moderate A" and "Moderate B"
- Degradation rating criteria depend on finding category (from Step 1.1)
  - More detailed guidance in Attachment 2
- Once set, the degradation rating does not change

Phase 1, Step 1.3

- Initial Qualitative Screening
  - Based on a series of yes/no questions
  - Questions are phrased so that a "yes" will mean screen to green

- Two Tasks:
  - Task 1.3.1 applies to all findings
  - Task 1.3.2 applies to only Fire Confinement findings with Moderate degradation

Phase 1, Step 1.4

- Initial Quantitative Screening
- Uses two factors:
  - Duration factor (DF) – Task 1.4.1
  - Room fire frequency (F_{area}) – Task 1.4.2
- Screening check performed on the product of these two values – Task 1.4.3

Task 1.4.3 Screening Criteria

$$\Delta CDF_{1.4} \approx DF * F_{area}$$

Table A1.1 - Phase 1 Quantitative Screening Criteria		
Assigned Finding Category (from Step 1.1):	**$\Delta CDF_{1.4}$ Screening Criteria**	
	Moderate Degradation	**High Degradation**
Fire Prevention and Administrative Controls	N/A	1E-6
Fixed Fire Protection Systems	1E-5	
Fire Confinement	1E-5	
Localized Cable or Component Protection	1E-5	
Post-fire SSD	1E-6	

Phase 2, Step 2.1 - Independent SSD Path First Screening Assessment

- This step involves a course assessment of the designated post-fire safe shutdown path
  - Task 2.1.1 – Identify SSD path
  - Task 2.1.2 – SSD nominal unavailability
  - Task 2.1.3 – SSD path independence
  - Task 2.1.4 – Screening check

Step 2.2 – FDS Determination

- This step is a quick decision process to decide which FDSs need to be considered as fire scenarios are developed
  - Task 2.2.1 - Initial FDS assignment
  - Task 2.2.2 - FDS3 screening
- At the end of this step, either one, two, or three FDSs remain to be considered in the development of fire scenarios
- If one or more FDSs are dropped, they never come back

Step 2.3 – Fire Scenario Identification and Ignition Source Screenings

- Purpose of this step is to begin defining fire scenarios
  - Additional guidance - Attachment 3
- Focus is on identification of fire ignition sources to be retained for further analysis
  - Task 2.3.1 - Identify and count fire ignition sources
  - Task 2.3.2 - Characterize fire ignition sources
  - Task 2.3.3 - Identify nearest and most vulnerable ignition or damage target
  - Task 2.3.4 - Fire ignition source screening
  - Task 2.3.5 - Screening check

Step 2.4 - Fire Frequency for Unscreened Fire Sources

- In this step a new refined fire frequency for the fire area is calculated
  - Task 2.4.1 - Nominal fire frequency estimation
    - Additional guidance - Attachment 4
  - Task 2.4.2 - Findings quantified based on increased in fire frequency
  - Task 2.4.3 - Credit for compensatory measures that reduce fire frequency
  - Task 2.4.4 - Screening check

Step 2.5 - Definition of Specific Fire Scenarios and Independent SSD Path Second Assessment

- In this step the process of defining specific fire scenarios continues
  - Fire growth and damage scenarios are defined for each combination of a fire ignition source and FDS that we are retaining
- This step includes identification of scenario specific target sets
- Once fire growth and damage scenarios are defined, survival of the designated safe shutdown path is re-assessed in context of each fire ignition source

Step 2.5 - Definition of Specific Fire Scenarios and Independent SSD Path Second Assessment (cont.)

- Task 2.5.1 - Identify specific fire growth and damage scenarios (fixed ignition sources)
  - Additional guidance - Attachment 6
- Task 2.5.2 - Identify specific fire growth and damage scenarios (self-ignited cable fire, transients, hotwork)
  - Additional guidance - Attachment 5
- Task 2.5.3 - Identify specific plant damage state scenarios
- Task 2.5.4 - Assess fire scenario-specific SSD path independence
- Task 2.5.5 - Screening check

Step 2.6 – Fire Growth and Damage Scenario Time Analysis

- Analyze the fire growth and damage time for each fire scenario
  - Additional guidance - Attachment 7
- Separate "rules" for FDS1, 2, and 3
  - Task 2.6.1 – FDS1 scenarios
  - Task 2.6.2 – FDS2 scenarios
  - Task 2.6.3 – FDS3 scenarios
- FDS1 and FDS2 require use of Fire Dynamics tools (plume, radiant, hot gas layer)
- Fire spread rules also apply (Attachment 3)

Step 2.7 – Non-Suppression Probability Analysis

- This step estimates the probability that suppression fails in the time available before the target set is damaged
  - Additional guidance - Attachment 8
- Credit is given to both fixed fire suppression and manual fire suppression
- For the fire brigade, determination of the detection time is needed
  - Detection activates the human response including the fire fighting response

Step 2.7 – Non-Suppression Probability Analysis (cont.)

- Task 2.7.1 - Fire detection analysis
- Task 2.7.2 - Fixed fire suppression system analysis
- Task 2.7.3 - Plant personnel and manual fire brigade
- Task 2.7.4 - Probability of non-suppression
- Task 2.7.5 - Screening check

Step 2.8 – Plant Safe Shutdown Response Analysis

- In this step, the plant response, including required human recovery actions is analyzed
  - Task 2.8.1 – Select plant initiating event worksheets
  - Task 2.8.2 – Identify credited systems and functions
  - Task 2.8.3 – Identify ex-control room manual actions
  - Task 2.8.4 – Assess the failure probability of manual actions
  - Task 2.8.5 – Assess CCDP

Step 2.9 – Final Quantification

- In this step, a final quantification of the FDS scenarios of interest is calculated
- Specific CCDP for each individual scenario
- Run values through the risk equation
- Sum scenarios
- Assign a preliminary color

Tabletop Exercise Results

- Ran new process on several previous FP finding scenarios
  - Some limitations based on information now collected
  - Resulted in additional improvements to Phase 2 worksheets (Attachment 1 to Appendix F)
  - Resulted in additional clarification of some tasks and additional guidance in some areas
  - Improved tools for performing analysis
- Results generally matched or closer to Phase 3 analysis results

Conclusions

- NRC staff generally finds the new process an improvement over previous version
- Still some work to be done
  - Pre-filter for associated circuit issues
  - MCR fires and MCR abandonment guidance
  - Complex manual action