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Improved Technical Approach in the U.S. NRC/EPRI Fire Risk Requantification Study



J.S. Hyslop, Senior Risk and Reliability Engineer
U. S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Email: JSH2@nrc.gov Phone: 301-415-6354



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RES Motivation

- Field test RES R&D program
- Perform pilot studies
 - Improve understanding of fire risk
 - Transfer technology



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Background

- Memorandum of Understanding between NRC-RES and EPRI
- Fire risk addendum
- One of several elements on fire risk addendum



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Objectives

- Develop and demonstrate state of art fire risk analysis methods
 - Consolidate existing research
 - Limited extension of state-of-art
 - Field test
- Identify strengths and weaknesses
- Update corresponding fire risk estimates
- Develop risk insights
- Transfer the technology



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Participants

- EPRI
- U.S. NRC
- Two volunteer pilot plants (PWR)
 - D.C. Cook, Millstone Unit 3
- Six non-pilot plant participants
- Further cooperation
 - One independent pilot plant – Diablo Canyon
- Pilot plant (BWR) recently added – Nine Mile Point



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Expected Use Of Products

- Guidance for risk-informed analyses (EPRI)
- Basis for review guidance that RES will develop for NFPA 805 related changes
- ANS fire risk standard



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FRA Areas Addressed

- Fire data and ignition frequency
- Fire modeling
- Fire protection systems and features
- Plant response
 - Systems analysis
 - Circuit analysis
 - Human reliability analysis



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Demonstration Studies

- Analyses performed jointly by NRC and EPRI using case examples from pilot plant FRA.
- Purpose:
 - Demonstrate that methods can be implemented
 - Acquire feedback
 - Technology transfer
- Demonstration studies in place of full update of plant FRA for initial pilots



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Advances

- Fire frequency
 - Prior condition:
 - Widespread use of severity factors to “correct” base fire frequencies
 - Room-based frequencies
 - New condition
 - Now limited to potentially challenging fires
 - Increased use of component fire frequency



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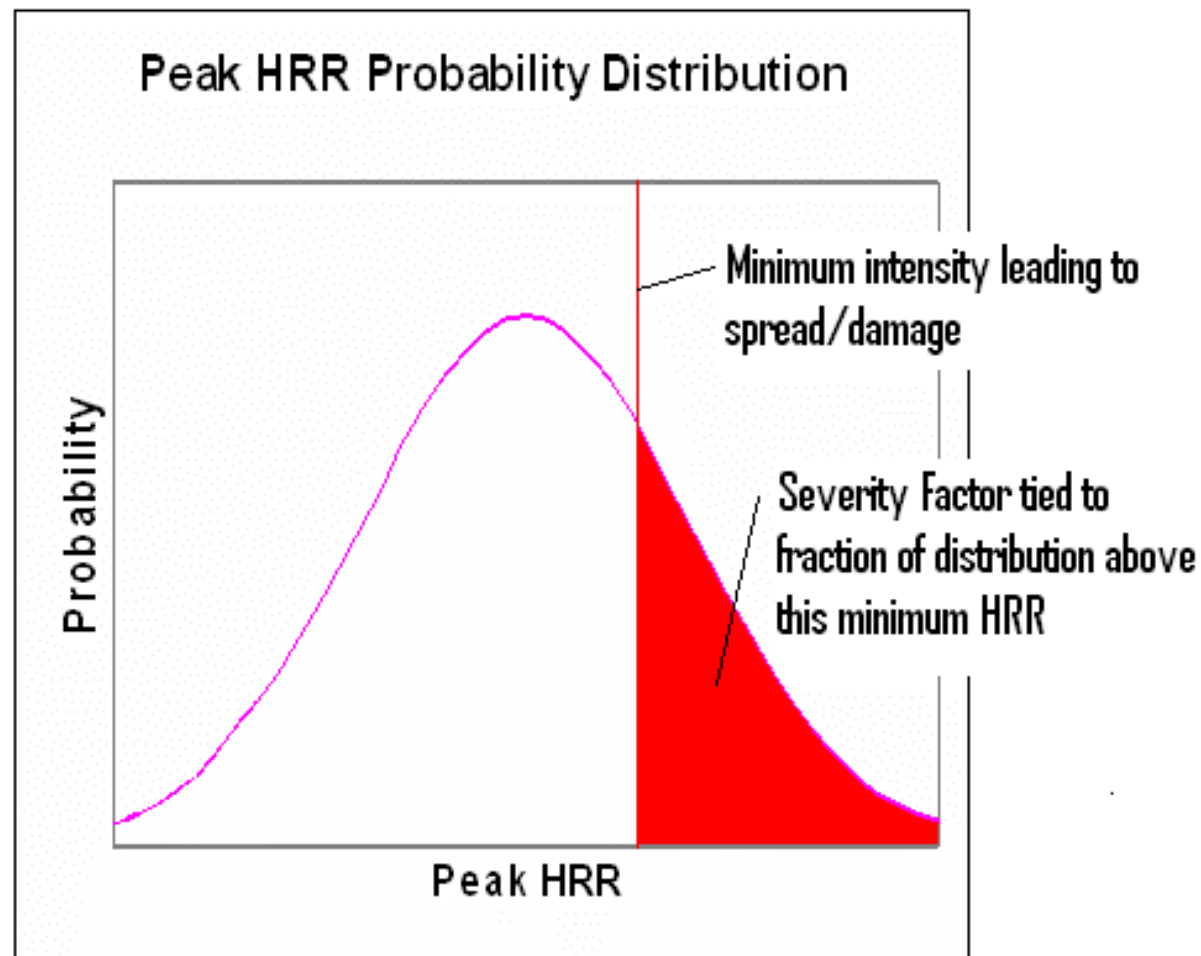
Advances (cont.)

- Distributions of peak heat release rate (HRR)
 - Prior condition: Each source had single HRR and severity factor
 - Distributions developed based upon available data and experience
 - For each major fire ignition source type
 - Includes low frequency/high intensity values
 - Severity factor tied explicitly to intensity
 - Treatment of fire frequency/severity factor avoids double count with suppression



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Conceptual HRR/severity factor





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Advances (cont.)

- Detection/manual suppression
 - A common approach: consideration of only fire brigade response time
 - Historical data approach
 - New approach ensures explicit treatment of long duration fires
 - Duration curves binned by component or location



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Advances (cont.)

- Plant safe shutdown response model
 - Resolve difference between emergency operating procedures and plant safe shutdown procedures
 - Ensures equipment out of service is captured
 - Refine treatment of spurious operations and fire-specific operator actions
- Human reliability analysis
 - Three levels of degradation
 - Fire specific factors included
 - Quantitative screening guidance



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Advances (cont.)

- Circuit analysis
 - Prior condition: Single value at best for probability of spurious operation
 - New approach: Probabilities dependent on circuit and cable characteristics (based upon NRC/EPRI testing and expert elicitation)
 - Challenge: Extend probability estimates beyond tested configurations



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Observations

- Past methods issues have been resolved
- Procedures allow flexibility for user to determine extent that state of art is necessary
- Implementing circuit analysis methods may take extensive resources
- Developing quantitative methods for human reliability analysis from a fire perspective remains a challenge



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Status

- Technical task procedures drafted
- Industry peer review completed
- Pilot application & testing of methodology
 - Limited testing of all procedures by EPRI/NRC at PWR
 - On-going use of methodology at another PWR
 - Full testing by EPRI/NRC at BWR planned in CY04-05
- Milestones
 - Draft report Aug 04
 - Publication Spring CY05
 - Joint EPRI/NRC Fire PRA Workshop CY05 (tentative)
 - Revision of publication TBD
based on BWR pilot (tentative)



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Final Remarks

- More comprehensive and accurate methods, tools, and data developed
- Path forward
 - Technology transfer
 - Development of ANS fire risk standard



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Procedures

- 1- Plant partitioning
- 2- Selection of critical equipment
- 3- Selection of circuits
- 4- Qualitative screening
- 5- Plant fire-induced risk model
- 6- Fire ignition frequency
- 7A- Quantitative screening 1
- 7B- Quantitative screening 2
- 8- Scoping fire modeling



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Procedures (cont.)

- 9- Detailed circuit failure analysis
- 10- Circuit failure mode and likelihood analysis
- 11- Detailed fire modeling
- 12- Post-fire HRA screening
- 12B- Post fire HRA – detailed and recovery
- 13- Seismic-fire interactions
- 14- Fire risk quantification
- 15- Uncertainty and sensitivity analysis
- 16- Fire PRA documentation



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Fire Model Verification and Validation

- Selected fire models
 - Five Rev. 1, FDTs (Empirical), CFAST, MAGIC (Zone), FDS (CFD)
 - Utilize ASTM standard 1355-97
- Fire model benchmark/validation
 - Multi-national blind benchmark exercises for cable tray fires and turbine hall fires
 - Longer term activities involve multi-compartment tests at DIVA (IRSN)