ISSUE STATEMENT

Fire can represent a contributor to the risk of a severe accident at a nuclear power plant. Effective decision-making related to managing risk relies on a realistic understanding of all risk contributors. The methods and tools currently used to assess fire risks, however, are not as refined as they could be. Their use can introduce biases that can mask some risk contributors and other findings related to fire risk. Improvements are needed to the data, methods, and tools for performing probabilistic risk assessment (PRA) for fire to provide more realistic estimates of the risk it poses and a better understanding of the contributors to that risk to support better decision-making.

DRIVERS

Several factors drive the need for more comprehensive and improved fire PRA methods.

Support of Regulatory Interactions

Safety authorities in many countries require (or are considering requiring) that fire PRAs be conducted as part of the process of understanding the risks posed by operating nuclear power plants. In the United States, a movement toward risk-informed and performance-based regulation has led the nuclear power industry to conduct new fire PRAs for many plants. The current methods and tools for fire PRA are in need of refinement so that their use results in making better decisions related to these applications.

The extent to which risk-informed regulation has been implemented outside the United States varies widely, but many countries are considering programs similar to those in the United States, or are including fire within the scope of their periodic safety reviews.

Effective Use of Resources for Risk Management

End users of risk technology need to make effective use of finite resources in developing and applying the fire PRA. Improving the ability to evaluate the risk posed by fire aids in assuring that the results lead to appropriate, cost-effective safety improvements and operational decisions. Improvements to fire PRA methods and tools can also reduce the resources required to perform the analyses.

Public Perception

Fire risk assessments performed using current methods, tools, and data can overstate risk, in some cases by a large factor. Results from such risk assessments can, therefore, be of limited value in supporting efforts to make informed decisions; the potential exists to divert resources from more important issues.

RESULTS IMPLEMENTATION

EPRI will, in conjunction with other stakeholders, refine the methods, tools, data, and guidelines needed to support realistic assessments of the risks associated with fire. These efforts will produce new databases and practical guidance for performing fire PRAs. The improvements will allow plant owners to perform fire PRAs that yield a more realistic understanding of risk with far less effort than is the case with the current methods and tools. This, in turn, will support more effective decision-making.

PROJECT PLAN

Research activities to address fire risk have been identified through interactions with various stakeholders. These activities are being coordinated with those undertaken by other stakeholders, including regulators and member utilities. The research activities are organized in four areas:

Initiation, Detection, and Suppression

Research is needed to improve the characterization of fire initiation frequencies. An effort to develop a more comprehensive fire events database was completed in 2013. The updated fire events database compiles information about experiences relating to fires in the operating history of nuclear power plants through 2009. The data collected was evaluated to assess new frequencies for ignition and better treatment of detection and suppression. The database has also been configured to facilitate maintenance and to allow new experience to be incorporated on an ongoing basis. Follow-on research will explore possible improvements, such as the use of component-based fire frequencies to replace plant-wide fire frequencies.
Damage Assessment
Current PRAs apply assumptions and correlations that appear to over-predict the amount of heat released from a fire and the rate at which a fire of a particular type will grow. These predictions, in turn, cause risk assessments to reflect greater damage to equipment than may be realistic based on evidence from operating experience. Research into the most important of the physical aspects of fire development will continue to be performed to ensure that the assessment of potential fire damage to equipment can be properly characterized in the PRA in a way that comports better with observed events. Most recently, for example, a new characterization of the damage potential associated with fires in electrical cabinets has been completed.

Development and Quantification of PRA Models
Multi-year research efforts in post-fire human reliability analysis and plant response that might result from damage to electrical cables (both ac and dc) have led to increased understanding and improved modeling of these areas in fire PRAs. Additional research in characterizing uncertainty, modeling of main control room fires, and refining other aspects of plant response to fires is underway. The refined understanding of the potential for damage from the previous research area, coupled with better methods for incorporating this understanding into the PRA models, will result in more realistic risk estimates.

Implementation Activities
Important activities necessary to implement the improved technical treatment of fire risks include updating relevant portions of the international ASME/ANS PRA Standard to reflect what is learned through new fire research; providing training in the proper use of methods for fire PRA; and participating in peer review of new methods, tools and data as they are developed.

RISKS
Fire PRAs developed using current technology require the expenditure of significantly more effort than would be required with improved methods, data and tools. In addition, PRAs developed using current methods could overstate the risk of fire, potentially leading to erroneous conclusions regarding measures to improve safety or address regulatory concerns.

There is a small chance that the new data and methods will not significantly improve the ability to assess the risk associated with fires. It is also possible that the improved methods could highlight plant improvements that are expensive to implement. Finally, it is possible that the improvements to fire PRA will not be completed in a timely manner. Priority application of available resources to support this research helps to reduce this likelihood.
RECORD OF REVISION

This record of revision will provide a high level summary of the major changes in the document and identify the Roadmap Owner.

<table>
<thead>
<tr>
<th>REVISION</th>
<th>DESCRIPTION OF CHANGE</th>
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| 0        | Original Issue: August 2011  
Roadmap Owner: Richard Wachowiak |
| 1        | Revision Issued: August 2012  
Roadmap Owner: Richard Wachowiak  
Changes: Updated flowchart: Added milestones for Fire Events Database, Fire Frequencies, and Human Reliability Analysis reports. Updated task dependencies to better reflect the actual flow of information. Increased the timeframe of the roadmap to depict that the activity will undergo continuous improvement following the initial generation of work envisioned when the roadmap was conceived. |
| 2        | Revision Issued: August 2013  
Roadmap Owner: Ashley Lindeman  
Changes: Updated terminology in the flow chart document to reflect current usage. Milestone 1 marked as completed. Added milestones 4-6. Updated fire testing plans for NRC. |
| 3        | Revision Issued: August 2014  
Roadmap Owner: Ashley Lindeman  
Changes: Revised roadmap event relating to “Update frequencies long term”. Changed timeline for “Continue Evolution of Methods”. In “Improved PRA Modeling of Fire Effects” replaced “update guidance for HRA” with “Main Control Room Abandonment”. Lastly, revised the timelines to reflect NRC testing schedule. |
| 4        | Revision Issued: January 2015  
Roadmap Owner: Ashley Lindeman  
Changes: Marked milestones 2 and 5 complete. Extended duration of “revised fire modeling methods” to reflect slower progress than expected. |
| 5        | Revision Issued: August 2015  
Roadmap Owner: Ashley Lindeman  
Changes: Extended roadmap timeframe through 2017 and extended major activities to reflect current pace of research. Minor updates to align milestones with actual/anticipated dates. For example, Milestone #5 was marked complete in mid-2013, when the publication occurred end of 2014. Added Milestone #9 (component based/enhanced fire frequencies). |
| 6        | Revision Issued: December 2015  
Roadmap Owner: Ashley Lindeman  
Changes: Marked milestone 7, Electrical Cabinet Heat Release Rate as complete. |
| 7        | Revision Issued: August 2016  
Roadmap Owner: Ashley Lindeman  
Changes: Pushed out milestones 4 and 8 to align with actual / anticipated dates. Following this revision, this roadmap is being retired. Internal fire is addressed through a broad scope of research activities. The EPRI Nuclear Sector’s more recent prioritization process, which is organized by research focus areas (RFAs), is a more useful tool for presenting broad research areas. Together with the project overview forms and new, more consistent project plans, the RFAs provide sufficient detail and the needed perspective on the strategic horizon to inform advisors and obtain effective feedback. In the future, a separate roadmap may be initiated to track more specific areas within Internal Fire PRA, based on the need to reflect cross-organizational collaboration in a given technical area, as roadmaps are a particularly effective tool for displaying and communicating these interrelationships. |
Probabilistic Risk Assessment for Internal Fire Events

Utilities
- Reporting of Fire-Relevant Operating Experience
  - Report fire incidents
  - Report fire incidents long-term

Risk and Safety Management APC
- Reassessment of Initiator Frequencies
  - Update Fire Events Database
    - Calculate new fire frequencies
  - Improve calculation methods

- Improved Modeling of Fire Damage
  - Improve fire modeling methods
  - Revised fire modeling methods

- Improved PRA Modeling of Fire Effects
  - Develop methods to incorporate improved models
  - Continuous improvement of fire PRA methods

- Guidance for human reliability analysis

- Nuclear Regulatory Commission – Physical Fire Testing
  - DC circuit testing
    - Testing of incipient detection
  - Cabinet HRR Testing
  - High-energy arc fault testing
  - Other testing as required to improve methods, tools, and data

INPO
- Tracking of Industry Operating Experience
  - Collect data on fire experience long-term

Implementaiton Activities for Fire PRA
- Provide input to revisions to PRA Standard and peer review guidance
- Provide and improve training in fire PRA
- Improve process to provide comprehensive update of methods, tools, and data

Milestones
1. Issue Fire Events Database
2. Issue updated Fire Frequency report
3. Issue Fire PRA Human Reliability Analysis report
4. Issue Fire PRA Uncertainty
5. Issue updated Suppression data
6. Issue revised transient methodology
7. Electrical Cabinet HRR Revision
8. HRA Guidance for MCR abandonment
9. Enhanced component based fire frequencies