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Implementation of Performance-Based Fire Protection at Operating US Nuclear Power Plants

Jack Grobe and Steven Laur
Office of Nuclear Reactor Regulation

Presented by
William H. Ruland
Acting Deputy Director for Engineering
May 5, 2011

International Congress on Advances in Nuclear Power Plants 2011

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Topics

- Introduction
- Risk-Informed, Performance-Based Regulation
  - Definitions
  - Application to Fire Protection
- Implementing NFPA 805
  - Process
  - Insights from two Pilot Plants
- Conclusion

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Background

- NRC Regulation: 10 CFR 50.48(c) “National Fire Protection Association Standard NFPA 805”
  - Issued June 16, 2004
  - Incorporates NFPA 805, “Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants”
  - Performance-based fire protection program is a voluntary alternative to deterministic fire protection regulations
- NFPA 805 is a national consensus standard.

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Background (cont.)

General Design Criteria for Nuclear Power Plants

- *Criterion 3--Fire protection*. Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions
- Noncombustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room
- Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety
- Firefighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.

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Performance-Based

A performance-based approach is one that establishes performance and results as the primary basis for decision-making and incorporates the following attributes:

1. Measurable or calculable parameters exist to monitor the system, including facility performance;
2. Objective criteria to assess performance are established based on risk insights, deterministic analyses, and/or performance history;
3. Plant operators have the flexibility to determine how to meet established performance criteria in ways that will encourage and reward improved outcomes; and
4. A framework exists in which the failure to meet a performance criteria, while undesirable, will not in and of itself constitute or result in an immediate safety concern.

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Risk-Informed

A risk-informed approach is a philosophy that considers risk insights together with other factors to establish performance requirements commensurate with their importance to public health and safety.

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Risk-Informed

- NRC principles of risk-informed regulation:
  1. Comply with regulations
  2. Be consistent with defense-in-depth philosophy
  3. Maintain sufficient safety margins
  4. Ensure any risk increases are small and consistent with Commission's Safety Goal Policy Statement
  5. Use performance measures to monitor the change

- Fire protection defense-in-depth (NFPA 805):
  - Prevent fires from starting
  - Rapidly detect any fires and extinguish promptly
  - Protect essential plant systems to allow safe shutdown if a fire is not promptly extinguished

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Fire PRA

- NFPA 805 requires that the fire Probabilistic Risk Assessment:
  - Evaluate core damage frequency and large early release frequency
  - Address the risk contribution associated with all potentially risk-significant fire scenarios
  - Use acceptable approaches, methods, and data
  - Be based on the as-built and as-operated and maintained plant
- The PRA must be of sufficient technical adequacy to support the application
- NRC relies on industry peer review to the PRA standard* to demonstrate technical adequacy of base fire PRA
- The licensee should describe the specific modeling of each cause and effect relationship associated with the application

* Addendum A to the American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) RA-Sa 2009, "Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications" as endorsed by NRC Regulatory Guide 1.200

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NFPA 805 Features

- Requirements are applied during all plant operating modes
- Establishes fundamental fire protection program elements and design requirements
- Allows the nuclear safety performance criteria to be satisfied deterministically or using performance-based approach
- Requires monitoring program of fire protection systems and features
- Licensees can self approve certain changes to fire protection program using performance-based methods

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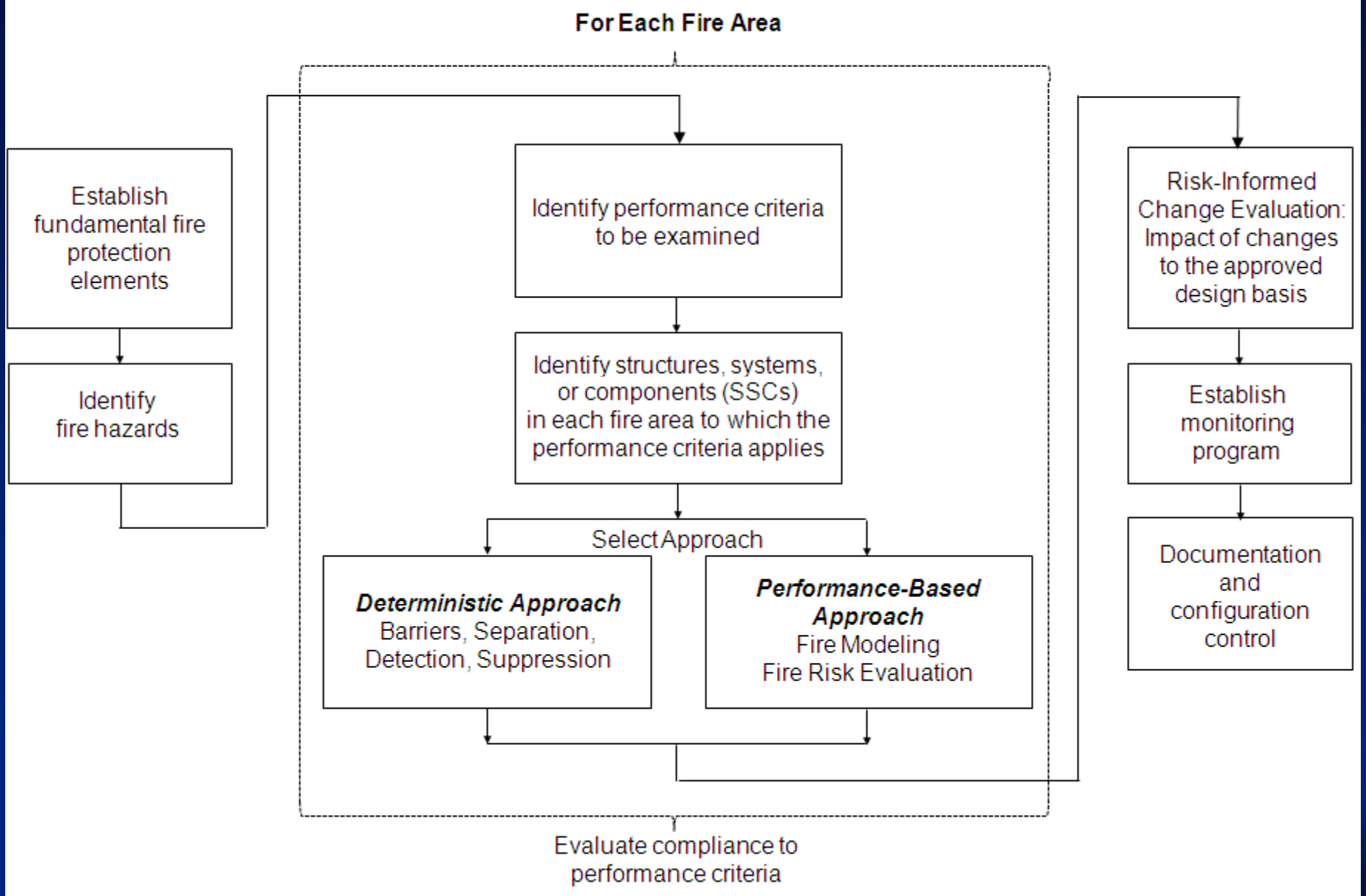
Implementing NFPA 805



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Implementing NFPA 805

- 48 of the 104 operating U.S. nuclear units have committed to implement a risk-informed performance-based fire protection program
- 2 licensees (4 operating nuclear units) volunteered to pilot implementation of NFPA 805 at their plants
- The pilot plants now have performance-based fire protection programs
- Lessons learned through the pilot process have been shared with the industry
- Subsequent license amendment requests will incorporate these lessons, resulting in more efficient NRC review and approval

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Insights from Pilot Process

- Pilot approach - extremely beneficial
- Frequent meetings key to resolving technical and process issues
- Frequently asked question process was useful
- Fire PRA methods are adequate to support performance-based fire protection
- Transition to performance-based fire protection is costly ($7 to $16 million per unit)
- Performance-based fire protection program can be successfully implemented and can result in improvements to plant safety

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Pilot Plant Safety Improvements

- Moved/wrapped/upgraded electrical cables
- Improved electrical raceway fire barrier systems
- Added incipient detection to instrumentation cabinets
- Provided new or additional fire detectors
- Installed additional controls on alternate shutdown panel
- Added new pumps to provide key functions (protect RCP seals; provide make-up water to the steam generators)
- Improved fire plans and procedures

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Incipient Detection

- "Very Early Warning Fire Detection System“
- Air sampling type fire detection that utilizes “cloud chamber” technology
- Can detect a fire while still in the smoldering incipient stage
- Installed in specific plant electrical cabinets based on risk insights
- System has "alert" and "alarm" setpoints
- Monitored in the main control room

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New Plant Equipment

- New diesel generator and dedicated charging pump
  - Alternate RCP seal injection
  - Can power essential battery chargers
- Install “protected service water” system
  - Three functions:
    - Additional power source for the High Pressure Injection
    - Additional power source for Safe Shutdown Facility
    - Additional water source to support secondary side heat removal

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Conclusion

- Two U.S. licensees (4 units) have implemented performance-based fire protection programs
- A performance-based fire protection program based on NFPA 805 can be successfully implemented and can:
  - Provide a clear fire protection licensing basis
  - Result in improvements to plant safety

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References

- NFPA 805, “Performance-Based Standard for Fire Protection for Light-Water Reactor Electric Generating Plants,” 2001 Edition, National Fire Protection Association, Quincy, MA.
- Title 10 of the Code of Federal Regulations, Section 50.48, “Fire Protection,” U.S. Nuclear Regulatory Commission, Washington, DC.
- Criterion 3, “Fire Protection,” of Appendix A, “General Design Criteria for Nuclear Power Plants,” to Title 10 of the Code of Federal Regulations, Part 50, “Domestic Licensing of Production and Utilization Facilities,” U.S. Nuclear Regulatory Commission, Washington, DC.
- Appendix R, “Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979,” to Title 10 of the Code of Federal Regulations, Part 50, “Domestic Licensing of Production and Utilization Facilities,” U.S. Nuclear Regulatory Commission, Washington, DC.
- “Voluntary Fire Protection Requirements for Light Water Reactors; Adoption of NFPA 805 as a Risk-Informed, Performance-Based Alternative,” Federal Register, Volume 69, Number 115, pp. 33536–33550, Washington, DC (June 16, 2004).

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References (cont.)

- Staff Requirements - SECY-98-144 - White Paper on Risk-Informed and Performance-Based Regulation," U.S. Nuclear Regulatory Commission, Washington, DC (March 1, 1999). (Agencywide Documents Access and Management System (ADAMS) Accession No. ML003753601)
- Regulatory Guide 1.205, "Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants," Revision 1, U.S. Nuclear Regulatory Commission, Washington, DC (December 2009). (ADAMS Accession No. ML092730314)
- NUREG/CR 6850/EPRI 1011989, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," Volume 1: "Summary and Overview," Volume 2: "Detailed Methodology," U.S. Nuclear Regulatory Commission, Washington, DC (September 2005). (ADAMS Accession Nos. ML050940183 and ML050940189)
- Transcript, "Commission Briefing On Fire Protection Lessons Learned From Shearon Harris," U.S. Nuclear Regulatory Commission, Washington, DC, pp. 7, 20 (November 3, 2009). (ADAMS Accession No. ML093100574)

1. Publicly available NRC published documents such as Regulations and Regulatory Guides are available electronically through the Electronic Reading Room on the NRC's public Web site at: http://www.nrc.gov/reading-rm/doc-collections/. Copies are also available for inspection or copying for a fee from the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail PDR.Resource@nrc.gov.

2. Copies of the non-NRC documents above may be obtained directly from the publishing organization.