Nuclear Services / Engineering Services

Low Power and Shutdown Probabilistic Risk Assessment Modeling for Pressurized Water Reactor Plants

Background

The increased focus on probabilistic risk assessments (PRAs) and risk-informed applications by the U.S. Nuclear Regulatory Commission (NRC) has led utilities to expand their PRA model update efforts. Their efforts have initially focused on updating the Level 1 and Level 2 PRA models for the internally initiated events. Subsequently, the utilities developed PRA models for other hazards such as fire and seismic events. In parallel, the nuclear industry has developed consensus standards to address PRA scope and technical adequacy. Through Regulatory Guide 1.200 (Revision 2), the U.S. NRC has endorsed the American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) consensus standard ASME/ANS RA-Sa-2009 for nuclear power plant PRAs. This standard includes a set of minimal requirements for modeling internal events, internal flooding, fires, seismic events and other external hazards PRAs. PRA models are used to evaluate core damage frequency (CDF) and large early-release frequency (LERF) in support of risk-informed applications. When utilities use a PRA for risk-informed applications, the PRA is generally required to meet the ASME/ANS RA-Sa-2009 standard supporting requirements at Capability Category II level.

Maintenance Rule requires licensees to manage plant risk resulting from maintenance activities during low power and shutdown (LPSD) operations. Currently, the U.S. NRC finds a qualitative risk assessment of LPSD operations assuring defense-in-depth for planned plant configurations during shutdown to be acceptable to meet this requirement. However, the U.S. NRC is now requiring licensees to carry out quantitative risk assessment for all LPSD configurations using LPSD PRAs to support risk-informed applications that could impact risks associated with LPSD operations.

In 2014, an industry consensus PRA standard, ANS/ASME-58.22, “Requirements for Low Power and Shutdown Risk Assessment,” which addresses plant configurations during LPSD operations, was developed and issued by the standards organizations for trial use and pilot application. A southern region boiling water reactor (BWR) plant is expected to adopt this standard for trial use. In parallel, a western region pressurized water reactor (PWR) plant has piloted an earlier version of the LPSD PRA standard. Following a 36-month trial use, the LPSD PRA standard will be revised to reflect lessons learned from pilot applications and subsequently reviewed by the U.S. NRC for approval.

After U.S. NRC approval, LPSD PRAs will be required for supporting licensees’ risk-informed applications. LPSD PRAs also can be used to address findings from the significant determination process of events that occurred during LPSD operations.

Description

The scope of the LPSD PRA modeling can be tailored to meet utilities’ overall goals and objectives for PRA model enhancements and risk-informed applications.

Using plant-specific features and characteristics, Westinghouse will identify the plant operational states (POS) that plants may encounter as they transition from full-power operation to refueling, and then back to full-power operation. For each identified POS, Westinghouse will develop accident sequence event trees that model the event initiators, mitigating systems and operator actions. Westinghouse also will develop system-level models based on success criteria and availability. Data analysis is performed to support the LPSD PRA model, taking into consideration equipment requirements during LPSD configurations and state-of-the-art methods for quantifying human failure events. Quantification is performed to characterize plant risk during LPSD in terms of CDF and LERF,

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and the associated key assumptions and sources of uncertainties are identified. Subsequently, uncertainty analysis is also carried out.

Benefits

Westinghouse has the expertise and capability to perform LPSD PRAs to meet customer needs and the requirements of the LPSD PRA standard.

Utilities can use an LPSD PRA model to improve plant safety, address regulatory requirements and justify changes in plant operations. Such benefits can be realized in several areas including:

- Carrying out maintenance activities that require management of plant risk during LPSD operations
- Shifting maintenance activities to a plant-operating mode of lower risk based on risk-informed assessments
- Developing plant outage plans with acceptable risk profiles to potentially shorten refueling shutdowns
- Assessing strategies to deal with emergent issues in all plant operating modes
- Developing strategies to respond to unfavorable regulatory findings resulting from the Significant Determination Process during LPSD operation

Experience

Westinghouse has the following experience to offer utilities:

- We have a team of 60-plus PRA engineers who can help utilities perform the LPSD PRA for their PWR plants.
- Westinghouse has performed LPSD PRA evaluations for the Advanced BWR design.
- Westinghouse has performed LPSD risk studies in support of the **AP1000**® design certification efforts.
- We can develop strategies to meet customer needs for reducing refueling outage durations without adversely impacting plant risk.
- Westinghouse has performed thermal-hydraulic analyses to establish system success criteria and operator response timing for assessing plant risk during LPSD operations. In addition to our in-house capability in performing thermal-hydraulic analyses, we have access to the severe accident analysis capability of our subsidiary, Fauske and Associates.
- Westinghouse actively participates in industry organizations that are currently developing consensus industry standards to address the technical scope and adequacy of PRAs to be used for assessing plant risk during LPSD operation.
- Westinghouse's involvements have kept the organization on the leading edge of LPSD PRA methods and industry positions so that customers can be informed of ongoing industry activities related to LPSD events.
- We have developed full-scope internal events and internal flood PRAs as well as external event PRAs for many PWR plants currently operating in the world.
- Westinghouse's PRA experts have carried out peer reviews of numerous PWR plant PRAs to evaluate conformance to the supporting requirements of the ASME/ANS PRA standard.

Westinghouse offers either a team-oriented implementation with the participation of the utility's PRA team or a complete implementation. In either case, we provide an integrated, plant-specific model and associated documentation that can support various utility applications.

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