US-APWR Shutdown Risk Staff Review Insights

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NRO/DSRA/SPLA
February 18-19, 2009

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Agenda

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- Introduction
- Overview of shutdown PRA development process
- Shutdown success criteria
- Gravity injection strategy
- Steam generator heat removal strategy
- Equipment availability during shutdown
- Plans for Level 2 shutdown PRA
- Plans for gathering insights and assumptions in the DCD
- Future follow-up questions

Introduction

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- Regulatory Requirements
  - ★ 10 CFR 52.47(a)(27): Provide a description of the design-specific probabilistic risk assessment (PRA) and its results
- SRP Guidance
  - ★ Applicant has used the PRA results and insights in an integrated fashion to identify and establish specifications and performance objectives for the plant
  - ★ Design represents a reduction in risk compared to operating plants
  - ★ Applicant has performed uncertainty, importance, and sensitivity analyses
  - ★ Assumptions made in the applicant's PRA during design development and certification are identified in the application such that they can be addressed by the combined license (COL) application

Introduction

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- Shutdown-related Requests for Additional Information (RAI)
  - ★ RAIs 1, 39, 88, and 138, plus one more planned
  - ★ 157 questions; 60 are follow-ups (40%)
- Questions relate to the criteria discussed and generally:
  - ★ Ask for clarification
  - ★ Request additions to the design control document (DCD)
  - ★ Point out inconsistencies or errors
  - ★ Ask for justification of the approach
- Majority of questions were answered completely
  - ★ Some follow-ups ask for clarification
  - ★ Some follow-ups restate the issue or provide more information
- Goals for this meeting:
  - ★ Common understanding of issues
  - ★ Discussion of path forward

Shutdown PRA Development

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- Presentation by MHI
- Question 19-206 (RAI 138): Justify the simplified treatment of plant operating states (POS) other than 8-1 in the US-APWR shutdown PRA. In addition to generally discussing the rationale, address how each specific issue below affects the ability to obtain results and insights from the US-APWR shutdown PRA.
  - ★ Uncertainty results are not available for total shutdown core damage frequency (CDF) or large release frequency (LRF).
  - ★ Quantitative importance measures are not available for POS other than 8-1, so the qualitative assessment of importance used as input to the reliability assurance program (RAP) and other programs may over- or under-estimate the importance of specific equipment.
  - ★ LRF may be overestimated, given that containment will not realistically be open in all POS.
  - ★ The assessment of additional mitigating systems (secondary cooling by the steam generators (SG) and gravity injection (GI) from the spent fuel pool (SFP)) considers dependence between human actions, but does not carry forward equipment failures from other top events in the accident sequence that could disable the SG or GI mitigating systems.
  - ★ Success criteria may be different for POS before and after refueling (RAI 88, Question 19-139).

Success Criteria

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- Presentation by MHI on success criteria development (e.g., calculations of time to uncover core in various conditions) and where these analyses are documented
  - ★ Success of residual heat removal (RHR) during early plant operating states (POS), as addressed by Questions 19-46 (RAI 39) and 19-139 (RAI 88)
    - Pump function with saturated/boiling water
    - Support system success criteria (e.g., loss of cooling definition)
    - Events when one train of RHR is available
  - ★ Development of success criteria in relation to low-temperature overpressure (LTOP) requirements, as addressed by Question 19-208 (RAI 138)

Gravity Injection Strategy

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- Presentation by MHI on strategy, equipment used, operator actions needed.
- Relevant questions: 19-44 (RAI 39), 19-147 (RAI 88), 19-206d (RAI 138).
  - ★ Why was this strategy selected when it also requires power and a different set of non-safety related pumps (i.e., not purely gravity driven)?
  - ★ How was this strategy communicated to the team that developed the reliability assurance program (RAP) to ensure all appropriate equipment was captured?
- Decision to credit gravity injection in POS 4-3 and 8-1 when pressurizer manway is open, per response to 19-237 (RAI 138)

Steam Generator Strategy

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- Presentation by MHI on strategy, equipment used, operator actions needed
- Relevant questions: 19-6 (RAI 1), 19-45 (RAI 39), 19-236 (RAI 138).
  - ★Reliance on steam generator inventory and/or emergency feedwater
  - ★How was this strategy communicated to the team that developed the RAP to ensure all appropriate equipment was captured?

Equipment Availability

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- Will shutdown PRA be used for maintenance rule implementation, or qualitative methods?
  - ★ Is this a COL decision, since the maintenance rule is left to them in a COL item?
- How have shutdown risk insights been used in the development of technical specifications (TS)?
  - ★ Only RHR and support systems are covered by TS; others have no TS requirements (e.g., letdown isolation, safety injection, charging, refueling water storage pit (RWSP), refueling water storage auxiliary tank (RWSAT), and the support systems for gravity injection and steam generator heat removal).
  - ★ Without the sensitivity study requested by the staff, the risk impact of using only voluntary measures for these systems is unclear.
- Relevant questions: 19-20c (RAI 1), 19-47 (RAI 39), 19-140 (RAI 88), 16-117 (RAI 161).

Level 2 Shutdown PRA

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- Presentation by MHI on plans for Level 2 PRA for shutdown
  - ★ Conservative assumption that core damage frequency (CDF) = large release frequency (LRF) makes shutdown dominant LRF contributor
  - ★ May limit configurations under maintenance rule and application of other risk-informed programs
  - ★ Once shutdown standard is endorsed, the fuel load PRA requirements will address this subject

Insights and Assumptions

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- Presentation on MHI on plans to gather risk insights and key assumptions in one location in the DCD
  - ★ Examples: use of freeze seals, insight about closing vent in certain conditions to prevent core damage
- Especially important when major assumptions about operations, procedures, etc. should be confirmed by COL applicant
  - ★ Plans for COL item to confirm information in table(s)?
- Relevant questions: 19-27 (RAI 1), 19-59 (RAI 39), and 19-207 (RAI 138)

Future Follow-up Qs

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- RHR success criteria (discussed previously)
- Maintenance rule (discussed previously)
- Ventilation assumptions
- Shutdown accident management framework
- Offsite power recovery
- Instrumentation and control (I&C) failures
- Maintenance assumptions

Future Follow-up Qs (cont'd)

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- Human errors for locked valves
- Loss-of-coolant accidents (LOCA)
- Isolation of RHR in LOCA scenarios
- Status of all reactor coolant system (RCS) penetrations
- Surge line flooding (gravity injection and instrumentation effects)
- RHR recovery following loss of inventory
- Isolation of fire-induced flow diversions