

Unresolved Issues Related to U.S. EPR Probabilistic Risk Assessment (PRA), Severe Accident Evaluation, and Reliability Assurance Program (RAP)

August 6, 2009

Agenda

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Overview

- **RAIs to Date**
 - ★ 28 on Chapter 19 (5 with unanswered questions)
 - ★ 3 on Section 17.4
 - ★ 2 on Section 17.6
- **Questions to Date**
 - ★ 367 on Chapter 19 (23 unanswered)
 - ★ 20 on Section 17.4
 - ★ 2 on Section 17.6
- *2 more draft RAIs (2 questions) in progress*

19.1.4.1: Level 1 Internal (1/3)

- **8 unanswered questions**
 - ★ 6 from RAI 227, mainly digital instrumentation and control (I&C)
 - ★ 2 from RAI 257
- **1 unresolved issue related to digital I&C topical report review**
 - ★ Potential for common-cause failure (CCF) of AV42 priority actuation control (PAC) modules
 - ★ ANP-10273P under review by I&C staff

19.1.4.1: Level 1 Internal (2/3)

- **Question 19-284 (RAI 227)**
 - ★ Basis for assumed software failure probabilities, supported by additional sensitivity studies
 - ★ Response expected 9/18/2009
- **Question 19-287 (RAI 227)**
 - ★ Systems or functions actuated by undeveloped instrumentation and control (I&C) systems and potential for common-cause failure (CCF) between these systems and the protection system (PS)
 - ★ Response expected 9/18/2009
- **Question 19-292 (RAI 227)**
 - ★ Potential for software CCFs that both cause an initiating event and affect mitigation
 - ★ Response expected 9/18/2009
- **Questions 19-293 to 19-295 (RAI 227)**
 - ★ Grouping of processor and sensor failures and exclusion of input and output (I/O) modules from I&C model
 - ★ Response expected 9/18/2009

19.1.4.1: Level 1 Internal (3/3)

- **Question 19-316 (RAI 257)**
 - ★ Inconsistencies and areas needing clarification in FSAR Tables 19.1-2, 19.1-5, 19.1-102, 19.1-108, and 19.1-109
 - ★ Response expected 8/17/2009
- **Question 19-318 (RAI 257)**
 - ★ Modeling of failure of ventilation in a safeguard building (SB): associated conservatism and potential procedural actions
 - ★ Response expected 8/17/2009

19.1.4.2: Level 2 Internal (1/5)

- **8 unanswered questions**
 - ★ Questions 19-319 to 19-326 (RAI 262)
 - Information needed from AREVA MAAP 4.0.7 calculations for use in MELCOR confirmatory assessment task
 - Response expected 8/31/2009
- **4 unresolved issues related to response to questions from RAI 133**
 - ★ Question 19-230 on ex-vessel steam explosion analysis
 - ★ Question 19-232 on source term analyses related to confirmatory assessment
 - ★ Question 19-233 on multiple induced steam generator tube ruptures (SGTR)
 - ★ Question 19-240 on induced SGTR phenomena

19.1.4.2: Level 2 Internal (2/5)

- **Unresolved issue related to Question 19-230 (RAI 133)**
 - ★ Basis of Question
 - FSAR analysis indicates that cavity or reactor pit expected to fail at loads > 20 kPa-s
 - AP1000 analysis (NUREG/CR-6849) predicted significantly higher dynamic loads
 - Requested an evaluation of loads on RPV vessel
 - Requested an analysis of the impact of reactor pit failure on severe accident progression
 - ★ Summary of RAI response
 - New ex-vessel steam explosion analysis
 - Pre-mixing (IKEMIX/IKEJET), detonation and propagation (IDEMO)
 - Benchmarked against FARO, KROTOS experiments and other codes in OECD-SERENA project
 - Discussed differences with respect to the AP1000 analysis (NUREG/CR-6849)
 - Presented static structural capacity for the reactor pit and re-evaluation of cavity conditional failure probability
 - Documented an uncertainty analysis to assess the impact of FCI loads as compared to the AP1000 analysis (NUREG/CR-6849)
 - ★ The RAI response is still being evaluated with the focus on:
 - Potential implications of phenomenological uncertainties in the pre-mixing phase not assessed by AREVA (differences between IKEMIX/IKEJET with PM-ALPHA and TEXAS)
 - Justifications for ignoring 25 kPa-s capacity in the FSAR
 - Applicability of “static” capacity for “dynamic” loading conditions and the technical basis for the proposed pit capacity
 - ★ Follow-up RAI possible

19.1.4.2: Level 2 Internal (3/5)

- **Unresolved issue related to Question 19-232c (RAI 133)**
 - ★ Basis of Question: There was an apparent anomaly in results of SrO source terms from molten core-concrete interactions presented in the response to Question 19-84d in RAI 6. An explanation was requested.
 - ★ Summary of RAI response: The anomaly is evidently based on the assumed thickness of the base mat. Changing the assumptions may have removed the anomaly.
 - ★ The response is being evaluated via the confirmatory assessment task using MELCOR. The task is nearly complete.

19.1.4.2: Level 2 Internal (4/5)

- **Unresolved issue related to Question 19-233 (RAI 133)**
 - ★ Basis of Question: Follow-up to Question 19-84e, requesting the likelihood for multiple induced tube ruptures and provision of associated source terms.
 - ★ Summary of RAI response
 - Additional MAAP cases run.
 - Maximum number of tubes susceptible to fail estimated
 - Likelihood estimated with a Poisson distribution
 - Source terms calculated for each MAAP case
 - ★ The response is being evaluated as part of the MELCOR confirmatory assessment task.
 - A follow-up question is possible related to potential differences in fission product releases.

19.1.4.2: Level 2 Internal (5/5)

- **Unresolved issue related to Question 19-240 (RAI 133)**
 - ★ Basis of Question: Follow-up to Question 19-79a
 - There is a need to evaluate the amount of time available to depressurize the primary system before induced rupture of damaged steam generator tubes, or hot leg creep rupture, would occur.
 - ★ Summary of RAI Response Related to Variations of MAAP Case 1.1i Related to Tube Thinning – see Table
 - Need hot leg creep rupture times.
 - ★ Results establish the importance of prompt depressurization and the need for a good HRA assessment of probability of failing to depressurize, and potential impact on LRF.
 - ★ A follow-up question on HRA modeling of failure to depressurize is possible.

Wall Thinning	Core Outlet Temp. Reaches 650°C (OSSA Entry)	Hot Leg Creep Rupture	Induced SGTR	Time Interval Between OSSA Entry and SGTR
50%	2.88 hr	???	3.20 hr	19.2 min
67%	2.88 hr	???	3.19 hr	18.6 min
75%	2.87 hr	???	3.17 hr	18.0 min

19.1.5: External Events (1/1)

- **2 unanswered questions**

- ★ Question 19-304 (RAI 234)

- Additional information on seismic margins, including definition of seismic margin earthquake
- Response expected 10/30/2009

- ★ Question 19-XXX (DRAFT RAI XXX)

- Conditional core damage probability (CCDP) for reactor coolant pump (RCP) oil fire
- Response date not established yet

- **1 unresolved issue**

- ★ Seismic hazard analysis (certified seismic design response spectra)

19.1.6.1: Level 1 Shutdown (1/1)

- **No additional unanswered questions or unresolved issues**
 - ★ **From 19.1.4.1:** Some parts of Question 19-316 (RAI 257) apply to the shutdown PRA; response expected 8/15/2009

19.1.6.3: Level 2 Shutdown (1/1)

- **2 unanswered questions**
 - ★ Question 19-298 (RAI 227)
 - Maintenance of passive autocatalytic recombiners
 - Response expected 8/28/2009
 - ★ Question 19-317 (RAI 257)
 - Venting during mid-loop (relates to containment closure)
 - Response expected 8/17/2009

19.1: Miscellaneous (1/1)

- **3 unresolved issues in 19.1.2.4**

- ★ **Thermal barrier cooling design change**

- Questions 19-164 (RAI 26), 19-247 (RAI 138), and 19-279 (RAI 197)
- Significant reduction in fire and flood risk predicted
- Staff expects PRA maintenance and update process to result in revision before design certification review ends

- ★ **Emergency feedwater system (EFWS) design change**

- Questions 19-274 (RAI 197), 19-296 (RAI 227), and 19-297 (RAI 227)
- Small increase in core damage frequency (CDF) predicted, but insights (e.g., importance of EFWS tanks) expected to change
- Staff expects PRA maintenance and update process to result in revision before design certification review ends

- ★ **Potential future design changes**

19.2: Severe Accidents (1/5)

- **4 unanswered questions**
 - ★ 2 from RAI 234 on containment performance
 - ★ 2 from RAI 236 on stabilized ZrO₂ thermo-mechanical behavior and on SAMDA issues
- **1 unresolved issue related to severe accident management**
 - ★ Severe accident management technical basis

19.2: Severe Accidents (2/5)

- **Question 19-305 (RAI 234)**
 - ★ Analyses of containment loading
 - ★ Response expected 10/30/2009
- **Question 19-306 (RAI 234)**
 - ★ Evaluation of containment performance
 - ★ Response expected 10/30/2009

19.2: Severe Accidents (3/5)

- **Question 19-312 (RAI 236):**
 - ★ Basis of question: **follow-up to Question 19-231 of RAI 133**
 - Additional information needed on material characteristics and industry knowledge base for of ZrO_2 , relevant experimental data on interaction of metallic melts with ZrO_2 , and results of theoretical predictions vs. experimental data
 - ★ Response expected 9/11/09

19.2: Severe Accidents (4/5)

- **Question 19-313 (RAI 236):**

- ★ **Basis of question:** Document the basis for changes to SAMDA evaluation and show any changes to Maximum Benefit Evaluation if top 100 LRF cutsets were used instead of top 100 CDF cutsets.
 - A new section on risk metrics (Section 4.1) is included in the “AREVA NP Environmental Report Standard Design Certification,” ANP-10290, draft Revision 1,
 - The actual radiological risk is used to quantify averted costs for offsite consequences.
 - Through various RAI responses, AREVA has corrected the radionuclide core inventory to higher values.
 - The offsite consequence results used in the SAMDA analysis indicate slight reduction in total offsite population dose, which contradicts the expected higher value.
 - Top 100 LRF cutsets better represent offsite consequences.
- ★ Response expected 9/11/09

19.2: Severe Accidents (5/5)

- **Unresolved issue related to Question 19-243 (RAI 133)**
 - ★ **Basis of question (follow-up to Question 19-192):** Staff needs to evaluate the technical basis for severe accident management.
 - Describe the first two phases of AREVA's Operating Strategies for Severe Accidents (OSSA) that would be developed based on symptoms and phenomena, and any supplemental analyses demonstrating the effectiveness of the operator actions to plant response, as well as any supporting MAAP analyses.
 - ★ Response received on 6/19/09 addresses the first two phases of OSSA.
 - This material and the PRA Level 2 and severe accident information in Tier 2 of the FSAR collectively provide the technical basis for the severe accident management guidelines that are yet to be provided to the staff.
 - ★ ***The response is still being reviewed by the staff.***

17.4: RAP (1/1)

- **1 unanswered question**

- ★ Question 19-XXX (DRAFT RAI XXX)

- Exclusion of fire water distribution system (FWDS), sprinkler/deluge system, and core melt stabilization system (CMSS) from the list of equipment
- Response date not established yet

Conclusion

- **From nearly 400 questions asked:**
 - ★ **25** unanswered questions (including 2 drafts)
 - ★ **10** unresolved issues
- Staff working to resolve as many issues as possible before Phase 2 ends (9/30/2009)