REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**434-8352**
SRP Section:	**SRP 19**
Application Section:	**19.1**
Date of RAI Issue:	**03/08/2016**

Question No. 19-92

10 CFR 52.47(a)(27) states that a design certification (DC) application must contain an FSAR that includes a description of the design-specific PRA and its results. In addition, SRP Chapter 19.0, draft Revision 3, Section II "Acceptance Criteria," Item 4 on Page 19.0-13 states "The staff will determine that the applicant has identified risk-informed safety insights based on systematic evaluations of the risk associated with the design such that the applicant can identify and describe the following: A. The design's robustness, levels of defense-in-depth, and tolerance of severe accidents initiated by either internal or external events and B. The risk significance of potential human errors associated with the design." In addition, Item 13 on Page 19.0-16 states "The staff will determine that the assumptions made in the applicant's PRA during design development and certification, in which a specific site may not have been identified or all aspects of the design (e.g., balance of plant) may not have been fully developed, are identified in the DC application and either remain valid or are adequately addressed within the COL application." Furthermore, Item 14 on Page 19.0-16 states that "The staff will determine that FSAR Chapter 19 includes PRA qualitative results, including the identification of key PRA assumptions, the identification of PRA-based insights, and discussion of the results and insights from importance, sensitivity, and uncertainty analyses."

Thus, in this context, the staff reviewed APR1400 DCD Table 19.1-4 "Risk Insights and Key Assumptions" and found this table is not comprehensive in identifying the APR1400 PRA-related key assumptions and insights. Therefore, in order for the staff to reach a reasonable assurance finding, please enhance Table 19.1-4 of the DCD to identify all PRA key assumptions and PRA-based insights, and also the insights from the importance, sensitivity, and uncertainty analyses.

Response – (Rev.5)

The purpose of this revised response (Rev. 5) is to reflect changes due to the following:

1. address conflicts between previous responses to RAI 19-28 Rev.4 and RAI 19-92 Rev.1,

2. reflect vendor proprietary information related to RCP seal LOCA probability provided in RAI 19-16 Rev.2, and

3. reconcile conflicts between previous responses to RAI 19-92 Rev.1 and AI 19-51 Rev.1.

4. renumbering COL items and to address consistency issues between subsection 19.1.9 and Table 1.8-2,

5. reflect changes due to updates of APR 1400 PRA-based SMA, and

6. make editorial Changes

The DCD Table 19.1-4 “Risk Insights and Key Assumptions” provides risk insights that are based on key design features, severe accident design features, and PRA that includes key assumptions, importance, and sensitivity analyses. There were total of fifty-eight (58) specific items listed in Table 19.1-4, and ten (10) additional items, mostly related to LPSD conditions, were added during the DCD review.

Table 19.1-4 was reviewed during the PRA update, and incorporated the changes to several key PRA assumptions, to ensure that risk insights listed in the table are consistent with the risk insights and the key assumptions, and also the insights from the importance, sensitivity, and uncertainty analyses. The detailed sensitivity and uncertainty analysis will be documented in APR1400-K-P-NR-01308-P, “APR1400 PRA Sensitivity and Uncertainty Analysis,” which will be made available in the Electronic Reading Room.

a) A comprehensive assessment of the impact of uncertainties in key assumptions will be performed with considerations of risk insights and risk quantifications of CDF and LRF using the PRA update, and the assessment will be documented in APR1400-K-P-NR-01308-P, “APR1400 PRA Sensitivity and Uncertainty Analysis.”

   Some example assumptions (not limited to these examples) that were evaluated for uncertainty are as follows:

   - fire ignition frequencies (e.g., consideration of more recent fire ignition frequency estimates)
   - RCP seal failure probability and model (e.g., based on new technical bases), Assumption No. 1 in DCD Table 19.1-4.
   - Room heat-up calculations (e.g., based on new calculations) , Assumption No. 5 in DCD Table 19.1-4

b) The uncertainty assessment will consider all PRA models included in the APR1400 DC PRA (i.e., all operating modes, hazards, and PRA levels) using the PRA update.

c) The uncertainty and key assumptions related to the PRA update were identified in DCD Table 19.1-4, see Assumptions 1, 5, 7, 11,.14, 15, 21, and 66.

The DCD markups from the PRA update results and insights are provided in Attachments 1 and 2 of RAI 434-8352 Question 19-92 Rev.1. The Table 1 to this RAI response shows the update status of the DCD Section 19.1 tables from 2017 PRA update.

The Table 2 to this RAI response shows the update status of the DCD Section 19.1 table to add basic event probability in CDF and LRF cutsets in table in Attachment of RAI 434-8352 Question 19-92 Rev.2.

COL item numbers for DCD Section 19.1 have been rearranged given the deletion of COL 19.1(22), and COL 19.1(25) has been inserted to assure consistency between subsection 19.1.9 and Table 1.8-2. These changes are provided in Attachments 2, 4 and 10.

Information provided to address NRC observations identified as Punch List Items No. 23, (a) - (f) and No. 32 (c):

Observation 23 (a)

In the top 100 internal events cutsets, cutsets 55 and 73 include only one basic event indicating a potential fundamental issue relevant to the single failure requirement described in GDC 21. The staff reviewed the DCD markups and finds no discussion, justification, nor technical basis behind these cutsets. The staff is unable to draw any conclusions on these scenarios. Such results restrict staff's ability to make an adequate safety determination.

Response 23 (a)

Components can be impacted or unavailable depending on LLOCA location. For example, if a LLOCA occurs on hot leg connected with SI pump from train D, only one hot leg injection flow path connected with a SI pump from train C can be possible. To consider the different effects by LOCA location, the LLOCA initiator was divided into three areas: (1) cold leg, (2) hot leg and (3) direct vessel injection line (DVI).

However, the recent thermal-hydraulic (T/H) analysis in DCD Chapter.15 shows that boron precipitation is not expected under the condition that there is no hot leg injection during a hot leg LLOCA, and thus no core damage should occur in the accident sequence that hot leg injection fails in a hot leg LLOCA (see APR1400-F-A-NR-14003-P, Rev.1 "Post-LOCA Long Term Cooling Evaluation Model", see ML17143A428).

Cutsets #55, #73 appear in table 19.1-19 since hot leg injection in a hot leg LLOCA is assumed and modeled in APR 1400 PRA. The history of this modeling is as follows:

a. To perform realistic analysis for system availability (mitigation capacity) for a LLOCA, KHNP divided three types LLOCAs, i.e. cold leg break, DVI break and hot leg break.

b. When APR1400 PRA model was docketed, T/H analysis results in DCD Chapter 15 were not finalized, and it had not yet been determined whether hot leg injection was required during a LLOCA in the hot leg or not.

c. Consequently, hot leg injection during a LLOCA in hot leg was considered in the PRA model based on the APR 1400 Emergency Operating Guidelines (EOG).

The cutsets (#55 and #73) describes that failure of hot leg injection due to a single failure of the SI pump leads to core damage when a hot leg LLOCA occurs. It does not correspond with the single failure requirement described in GDC 21, however, those cutsets appeared due to the modeling of hot leg injection in a hot leg LLOCA compared to the Chapter 15 analysis. A single failure of the SI pump would not lead to core damage when the COL applicant reviews modeling of hot leg injection in the APR 1400 PRA to decide if the modeling of hot leg injection should be considered in a hot leg LLOCA.

A sensitivity analysis for not modeling hot leg injection during a LLOCA in hot leg shows that the core damage frequency (CDF) is estimated to be 1.1E-06/yr. This is the same as the base model CDF, and therefore, there is no impact even if hot leg injection is modeled.

Other chapters within the DCD would not be affected since the CDF changes are negligible.

Therefore, KHNP believes that hot leg injection in a hot leg LLOCA, for the purposes of risk analysis in Chapter 19, is modeled in APR 1400 PRA. KHNP proposes adding the issue of hot leg injection modeling as a COL item and providing additional information in the DCD as follows:

1) Add assumption “I” in the DCD section 19.1.4.1.2.5.

   i) It is assumed for the purpose of analysis that hot leg injection during a hot leg LLOCA is required and modeled in the APR 1400 PRA. This assumption is less restrained compared to T/H analysis results in DCD Chapter 15.

   The mark-up is provided in Attachment 1.

2) Add COL item “19.1(26)” in the DCD section 19.1.9 and Table 1.8-2.

   COL 19.1(26) The COL applicant will ensure the APR1400 thermal-hydraulic (T/H) analysis supporting the application is reflected in the updated PRA model including those design and operational features for mitigation of a hot leg LLOCA.

   The mark-up is provided in Attachment 2.

3) Add Modeling history for hot leg injection in a hot leg LLOCA and explanation for cutsets (#55, #73) in the DCD section 19.1.4.1.2.3.

   To perform realistic analysis for system availability (mitigation capacity) for a LLOCA, the PRA analysis evaluated three types of LLOCAs, i.e. cold leg break, DVI break and hot leg break. Consequently, hot leg injection during a LLOCA in hot leg was modeled in the PRA since the guidance in the APR 1400 Emergency Operating Guidelines (EOG) requires the initiation of hot leg injection during a potential LLOCA scenario. For the purposes of the APR 1400 PRA analysis, a failure of hot leg injection due to a single failure of the SI pump resulted in two cutsets within the top 100 which reflected that the modeling could lead core damage when a hot leg LLOCA occurs. However, the recent thermal-hydraulic (T/H) analysis in DCD Chapter.15 shows that boron precipitation is not expected under the condition that there is no hot leg injection during a hot leg LLOCA, and thus no core damage should occur in the accident sequence that hot leg injection fails in a hot leg LLOCA (see APR1400-F-A-NR-14003-P, Rev.1 “Post-LOCA Long Term Cooling Evaluation Model”, Therefore, based on the T/H analysis performed to support Chapter 15 of the APR1400 design, no single failure will result in core damage or the loss of safety or protection function. To assess this relative to design criteria and T/H analysis performed for deterministic purposes, e.g. Chapter 15, a sensitivity analysis for not modeling hot leg injection during a LLOCA in hot leg shows that the core damage frequency (CDF) is estimated to be 1.1E-06/yr. This is the same as the full power internal base model CDF, and therefore, there is no impact even if hot leg injection is modeled (COL 19.1(26).

   The mark-up is provided in Attachment 3.

Observations 23 (b) and (e)

(b) CCF higher in the data notebook than Random Failures. CCF appears to have not been included in the dominant cutsets, e.g. EDG, T-D Pump, etc., explain.

(e) Cutsets #10, #11, and #12 include the combination of individual failures of similar components such as the AFW TDPs or the 2 of the 4 EDGs. However, the CCF of the similar components does not show up in the cutsets, e.g. a CCF of the ‘C’ and ‘D’ EDGs would result in a higher cutset probability. This has implications for the CCF combinations omitted and the total plant CDF.

Response 23 (b) and (e)

As shown in the table below, running failure probability for one AF TDP is 3.52E-02, and therefore, running failure probability for two AF TDPs can be calculated to be 1.24E-03 (3.52E-02 x 3.52E-02 = 1.24E-03). This means that the running failure probability for two AF TDPs (1.24E-03) is higher than that of 2/2 running CCF (6.89E-04), and thus, running failure events for AF TDPs can appear in a higher cutset than 2/2 running CCF event. The 2/2 running CCF event for AF TDPs, AFTPKD2-TDP01A/B, appears in a cutset #26.

Basic Event	Description	Failure Probability
AFTPR1A-TDP01A	FAILS TO RUN AFW TDP PP01A	3.52E-02
AFTPR1B-TDP01B	FAILS TO RUN AFW TDP PP01B	3.52E-02
AFTPKD2-TDP01A/B	2/2 CCF OF FOR AFW TDP PP01/A/B FAIL TO RUN	6.89E-04

The issue for running failure and 2/4 running CCF for EDGs can also be interpreted in the same context.

In other cases, CCF probability could be higher than that of random failure probability. For instance, as shown in the table below, 4/4 running CCF probability for EDGs (5.95E-05) is higher than that of random failure combination for EDGs (2.50E-02 x 2.50E-02 x 2.50E-02 x 2.50E-02 = 3.91E-07). The 4/4 running CCF event for EDGs appears in a cutset #14 while random failure combination for EDGs appears in a cutset #2151.

Basic Event	Description	Failure Probability
DGDGR-A-DGA	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01A	2.50E-02
DGDGR-B-DGB	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01B	2.50E-02
DGDGR-C-DGC	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01C	2.50E-02
DGDGR-D-DGD	FAILS TO RUN OF EMERGENCY DIESEL GENERATOR DG01D	2.50E-02
DGDGKQ4-DG01ABCD	4/4 CCF OF EDG 01A/01B/01C/01D FAIL TO RUN	5.95E-05

In conclusion, the random failures (e.g., start failure and running failure) and the CCFs for EDGs and AF TDPs are modeled as basic events in the APR 1400 PRA model. CCF probability could

be higher and lower than that of random failure probability, and therefore, the cutset level would be different based on event's failure probability.

Observation 23 (c)

The cutsets 28, 51 and 100 include the unavailability due to test and maintenance of two of the same type of component that would not be allowed by Tech Specs, e.g. Containment Spray Heat exchanger, EDGs, and DC Batteries.

Response 23 (c)

Cutsets 28, 51 and 100 should not be presented as a PRA result. For example, cutset 28 is that combination of test and maintenance (T&M) for CS heat exchangers of all of CS Trains. This test and maintenance configuration is not allowed by APR1400 Technical Specifications. Therefore, KHNP reviewed mutually exclusive cutsets (MUX) in the scope of at power and LPSD conditions (for both internal Level 1/Level2 and external Level 1/Level 2), to assess the effects on CDF and LRF. Recovery rules were made and reviewed for deleting MUX. The MUX rule file consists of 91 combinations of T&M cutset. The MUX rules are based on Technical Specifications provided in Chapter 16 of DCD (Rev.1), and are included in the Attachment 8.

The MUX rule file is applied for the PRA results and the effects on other chapters are provided in Attachment 9. The total CDF/LRF slightly decreases about 1.75% and 0.66% respectively. KHNP has reviewed the impact on the DCD other chapters, and it has been identified that the change of results does not have the impact on the DCD other chapters. However, there is small impact on the DCD related document for chapter 18, Human Factor Engineering. It is limited to editorial issue of the human factors engineering program element technical report, APR1400-E-I-NR-14006, "Treatment of Important Human Actions Implementation Plan."

Considering the results of applying the MUX rule file and their limited impact on the DCD other chapters, KHNP proposes to provide additional information in the DCD as follows:

In Chapter 19, section 19.1.4.1.1.4, "Systems Analysis", subsection b. "Conditions concerning level of detail", add assumption (6):

6) The APR1400 PRA model currently contains some "test and maintenance" configurations which are not permissible by APR1400 Technical Specifications. While these configurations are outside current Technical Specifications for operations, inclusion of these maintenance configurations in the current PRA is conservative with respect to CDF and LRF. The improper cutsets will be excluded from the cutsets resulting from the plant specific PRA, maintenance programs and Technical Specifications developed by the COL applicant (COL 19.1(27)).

The mark-up is provided in Attachment 4.

In Chapter 19, section 19.1.9, add the following COL item:

COL 19.1(27) The COL applicant will review the Technical Specifications and incorporate logic into the PRA model to ensure cutsets reflect permissible maintenance configurations.

The mark-up is provided in Attachment 2.

In addition, KHNP notices that APR 1400 PRA model does not meet QU-B7 and QU-B8 in the ASME standard due to the improper cutsets that would not be allowed by Tech Specs of APR1400 PRA. Therefore, KHNP proposes to revise the DCD in Chapter 19, Table 19.1-1, “Characterization of PRA Relative to Supporting Requirements in ASME PRA Standard”, to change “Quantification (QU)” characteristics to read as follows:

The quantification was performed by solving the overall core damage model using the linked fault-tree approach. The quantification satisfies at least Category I for each of the supporting requirements except for two (2) supporting requirements, QU-B7 and QU-B8. The logic of mutually exclusive events (MUX) did not cover all MUX, thus, some improper test and maintenance events appeared in the PRA results.

The mark-up is provided in Attachment 5.

Observation 23 (d)

The list of cutsets does not include the asymmetric equivalent of Cutset 55, such that the unavailability of the “A” SI pump in combination with a LLOCA would be in a similar and equivalent cutset.

Response 23 (d)

In section 19.1.4.1.1.4 “Systems Analysis”, in subsection b. “Conditions concerning level of detail”, add assumption 7):

7) The APR1400 PRA model is an asymmetric model. Therefore, location specific initiating events are assigned to a single location, e.g., SGTR is assumed to occur in SG #2, DVI line Large LOCA is assumed to occur in DVI line 1B, etc. System models reflect these locational initiating events, e.g., DVI large LOCA is assumed to result in the direct failure of SI pump PP02D and SIT TK01D since the injection flow from these components would be lost via the break in DVI line 1B. In addition, normally operating systems whose trains are operated on a rotational basis (e.g., CC, SX, etc.) have an assumed configuration with one train assumed to be the operating train, and the other train is assumed to be the standby train. Note that for the purposes of determining the CDF and LRF risk metrics, model asymmetry has no impact. The main impact is that the importance of equipment in those systems can differ on a train basis; however, for risk applications related to risk ranking, this can be compensated for by assigning the highest importance measure of a component within a group to all members within the group (COL 19.1(22)).

The mark-up is provided in Attachment 4.

Observation 23 (f)

Cutset 55 assumes a LLOCA and Hot Leg Injection using an SI Pump. It is not clear what is the specific SI Pump success criteria for injecting into the core and to prevent boron precipitation by hot leg injection.

Response 23 (f)

Since RCS inventory makeup and hot leg injection by safety injection pumps are required in response to a large break LOCA (LLOCA), components can be impacted or unavailable depending on the LLOCA locations. For example, if a LLOCA occurs on hot leg connected with SI pump from train D, only one hot leg injection flow path connected with SI pump from train C can be possible. To consider the different effects by LOCA location, the LLOCA initiator was divided into three areas: (1) cold leg, (2) hot leg and (3) direct vessel injection line (DVI). As a result, SI Pump success criteria for injecting into the core and to prevent boron precipitation by hot leg injection (HLI) were identified as follows:

	Cold Leg Break	DVI Leg Break	Hot Leg Break
SI Pump success criteria for safety injection	DVI : 2/4	DVI : 2/3	DVI : 2/4
SI Pump success criteria for hot leg injection	HLI : 1/2 DVI : 1/2	HLI : 1/2 DVI : 1/2	HLI : 1/1 DVI : 1/2

Observation 32 (c)

DCD, Risk Insights table, Item 25, on the C & D Batteries, it should say “no load shedding” instead of “not dc loading"

Response 32 (c)

The mark-up addressing this observation relating to the risk insights, Table 19.1-4, item No. 25 is provided in Attachment 6, and an editorial change to the same table, item Nos. 40, 41, and 43 is provided in Attachment 7.

Changes due to the conflict between RAI 19-28 Rev.4 response and RAI 19-92 Rev.1

The Tier 2 DCD Rev.2 subsection 19.1.6.2.2.7 is revised in accordance with RAI 409-8325 Question 19-28 Rev.4 to resolve the conflict between RAI 409-8325 Question 19-28 Rev.4 and RAI 434-8352 Question 19-92 Rev.1 in the 19.1.6.2.2.7 Risk insight. Associated markups to resolve the conflict are provided in the Attachment 13.

Changes due to the mark-ups about RCP seal LOCA probability in RAI 19-16 Rev.2

The Tier 2 DCD Rev.2 Table 19.1-16 and Table 19.1-50 are revised to reflect the markups for RCP seal LOCA probability as provided in the Attachment 14.

Changes due to the conflict between RAI 19-92_Rev.1 response and AI 19-51 Rev.1

The Tier 2 DCD subsection 19.1.9 is revised in accordance with AI 19-51 19.1_#PRA-51 Rev.1 to resolve the conflict between AI 19-51 19.1 #PRA-51 Rev.1 and RAI 434-8352 Question 19-92 Rev.1 in the 19.1.9 Combined License Information. Associated mark-ups are provided in the Attachment 15.

Changes due to Update of APR 1400 PRA-based SMA

The Tier 2 DCD subsections 19.1.5.1 and 19.1.6.5 are revised in accordance with revised responses to RAI 434-8352 Question 19-85 Rev. 3 and RAI 232-7864 Question 19-10 Rev.2, respectively. Associated mark-ups due to the PRA-based SMA update, including COL items and risk insights, Table 19.1-4 item No. 66, are provided in Attachments 2, 4 and 10.

Editorial Changes

The Tier 2 DCD 19.1.6.2.4.2.6 has been revised to correct wording from “internal fire” to “internal flooding”, and DCD 19.1.4.1.1.4 has been revised to add a bullet item “Initiating events which affect to the system”. The markups addressing these corrections are provided in Attachment 11 and 12, respectively

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Impact on DCD

DCD Section 19.1 & DCD Table 1.8-2 will be revised as indicated in the Attachment 1 & 2.

In the previous revised response (Rev.2), the Attachment only includes the tables changed from RAI 434-8352 Question 19-92 Rev.1.

In this revised response (Rev.3), the Attachments 1, 2, 3, 4, 5, 6 and 7 includes mark-ups changed from RAI 434-8352 Question 19-92 Rev.1 & Rev.2.

In this revised response (Rev.4), the Attachments 2, 3, 4, 10, 11 and12 includes mark-ups changed from RAI 434-8352 Question 19-92 Rev.3.

In this revised response (Rev.5), DCD Section 19.1.6.2.2.7, Table 19.1-16 and Table 19.1-50, Section 19.1.9 will be revised as shown in the Attachment 13, 14, 15 respectively.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

Table 1 - Section 19.1 Table Update Status from 2017 PRA Update

Table Number	Table Title	Update Status
Table 19.1-1	Characterization of PRA Relative to Supporting Requirements in ASME PRA Standard	Unchanged
Table 19.1-2	Key Design Features in APR1400	Unchanged
Table 19.1-3	Design Features Addressing Potential Risk Challenges	Unchanged
Table 19.1-4	Risk Insights and Key Assumptions	Partial Update
Table 19.1-5	Relation of the Plant Safety Functions and the Initiating Events Types	Unchanged
Table 19.1-6	Internal Events PRA Initiating Event Frequencies	Table Replaced
Table 19.1-7	Level 1 Internal Events PRA Event Tree List	Unchanged
Table 19.1-8	Event Tree Top Events and Success Criteria	Unchanged
Table 19.1-9	PRA Modeled Systems	Unchanged
Table 19.1-10a	Dependency between Initiating Events and Front Line Systems	Unchanged
Table 19.1-10b	Dependency between Initiating Events and Support Systems	Unchanged
Table 19.1-11a	Front Line System Dependencies on Support Systems	Unchanged
Table 19.1-11b	Support System Dependencies on Other Support Systems	Unchanged
Table 19.1-12	RELAP Thermal-Hydraulic Run Summaries	Unchanged
Table 19.1-13	MAAP Thermal-Hydraulic Run Summaries	Unchanged
Table 19.1-14	Component Failure Rate Data	Table Replaced
Table 19.1-14a	Component Unavailability Data	New Table
Table 19.1-15	Component Boundaries	Unchanged
Table 19.1-16	Special Basic Events	Table Replaced
Table 19.1-17	Level 1 Internal Events CDF Contribution by Initiating Events	Table Replaced
Table 19.1-18	Level 1 Internal Events Top Accident Sequences	Table Replaced
Table 19.1-19	Level 1 Internal Events Top 100 CDF Cutsets	Table Replaced
Table 19.1-20	Level 1 Internal Events Key Basic Events RAW (CDF)	Table Replaced
Table 19.1-21	Level 1 Internal Events Key Basic Events by FV (CDF)	Table Replaced
Table 19.1-22	Level 1 Internal Events Key CCF Events by RAW (CDF)	Table Replaced
Table 19.1-23	Level 1 Internal Events Key CCF Events by FV (CDF)	Table Replaced
Table 19.1-24	Level 1 Internal Events Key Operator Actions by RAW (CDF)	Table Replaced
Table 19.1-25	Level 1 Internal Events Key Operator Actions by FV (CDF)	Table Replaced
Table 19.1-26	PDS Grouping Parameters	Unchanged
Table 19.1-27	Frequency of Dominant PDSs	Table Replaced
Table 19.1-28	Containment Failure Modes and Results	Unchanged

Table 1 - Section 19.1 Table Update Status from 2017 PRA Update

Table Number	Table Title	Update Status
Table 19.1-28a	Comparison of Containment Pressure Between 19.1, 19.2 and 19.3	Unchanged
Table 19.1-29	Summary of Source Term Evaluation	Unchanged
Table 19.1-30	Source Term Category Frequencies and Contributions to LRF for Internal Events	Table Replaced
Table 19.1-30a	Source Term Category Frequencies and Contributions to LRF for Internal Fire Events	Table Replaced
Table 19.1-30b	Source Term Category Frequencies and Contributions to LRF for Internal Flooding Events	Table Replaced
Table 19.1-31	Level 2 Internal Events Top 100 LRF Cutsets	Table Replaced
Table 19.1-32	Level 2 Internal Events LRF Contributions by Initiating Events	Table Replaced
Table 19.1-33	~~Significant PDS Contributors to LRF~~	Table Deleted
Table 19.1-34	Level 2 Internal Events Key Basic Events by RAW (LRF)	Table Replaced
Table 19.1-35	Level 2 Internal Events Key Basic Events by FV (LRF)	Table Replaced
Table 19.1-36	Level 2 Internal Events Key CCF Events by RAW (LRF)	Table Replaced
Table 19.1-37	Level 2 Internal Events Key CCF Events by FV (LRF)	Table Replaced
Table 19.1-38	Level 2 Internal Events Key Operator Actions by RAW (LRF)	Table Replaced
Table 19.1-39	Level 2 Internal Events Key Operator Actions by FV (LRF)	Table Replaced
Table 19.1-40	Results of LRF Sensitivity Analyses	Table Replaced
Table 19.1-41	Systems Considered for Seismic Equipment List	See RAI 19-10 Response
Table 19.1-42	Seismic Equipment List	See RAI 19-10 Response
Table 19.1-43	Seismic Fragility Analysis Results Summary	See RAI 19-10 Response
Table 19.1-44	Dominant Contributors to the Plant HCLPF	Table Replaced
Table 19.1-45	Fire Compartment Initiator Development and Screening	Unchanged
Table 19.1-46a	Internal Fire PRA Fire – Induced Initiators IEF	Table Replaced
Table 19.1-46b	Internal Fire PRA CDF Contribution by Top Fire Induced Initiators	Table Replaced
Table 19.1-46c	Internal Fire PRA LRF Contribution by Top Fire Induced Initiators	Table Replaced
Table 19.1-47	Internal Fire PRA CDF Contribution by Top Fire Scenario	Table Replaced
Table 19.1-48	Internal Fire PRA LRF Contribution by Top Fire Scenario	Table Replaced
Table 19.1-49	Internal Fire PRA Top 100 CDF Cutsets	Table Replaced
Table 19.1-50	Internal Fire PRA Top 100 LRF Cutsets	Table Replaced

Table 1 - Section 19.1 Table Update Status from 2017 PRA Update

Table Number	Table Title	Update Status
Table 19.1-51	Internal Fire PRA Key Basic Events by RAW (CDF)	Table Replaced
Table 19.1-52	Internal Fire PRA Key Basic Events by FV (CDF)	Table Replaced
Table 19.1-53	Internal Fire PRA Key CCF Events by RAW (CDF)	Table Replaced
Table 19.1-54	Internal Fire PRA Key CCF Events by FV (CDF)	Table Replaced
Table 19.1-55	Internal Fire PRA Key Operator Actions by RAW (CDF	Table Replaced
Table 19.1-56	Internal Fire PRA Key Operator Actions by FV (CDF)	Table Replaced
Table 19.1-57	Internal Fire PRA Key Basic Events by RAW (LRF)	Table Replaced
Table 19.1-58	Internal Fire PRA Key Basic Events by FV (LRF)	Table Replaced
Table 19.1-59	Internal Fire PRA Key CCF Events by RAW (LRF)	Table Replaced
Table 19.1-60	Internal Fire PRA Key CCF Events by FV (LRF)	Table Replaced
Table 19.1-61	Internal Fire PRA Key Operator Actions by RAW (LRF)	Table Replaced
Table 19.1-62	Internal Fire PRA Key Operator Actions by FV (LRF)	Table Replaced
Table 19.1-62a	Flood Sources by Flood Area	Unchanged
Table 19.1-63	Internal Flooding Initiating Event Summary	Table Replaced
Table 19.1-64	Internal Flooding PRA CDF Contribution by Top Flooding Induced Initiators	Table Replaced
Table 19.1-65	Internal Flooding PRA LRF Contribution by Top Flooding Induced Initiators	Table Replaced
Table 19.1-66	Internal Flooding PRA Top 100 CDF Cutsets	Table Replaced
Table 19.1-67	Internal Flooding PRA Top 100 LRF Cutsets	Table Replaced
Table 19.1-68	Internal Flooding PRA Key Basic Events by RAW (CDF)	Table Replaced
Table 19.1-69	Internal Flooding PRA Key Basic Events by FV (CDF)	Table Replaced
Table 19.1-70	Internal Flooding PRA Key CCF Events by RAW (CDF)	Table Replaced
Table 19.1-71	Internal Flooding PRA Key CCF Events by FV (CDF)	Table Replaced
Table 19.1-72	Internal Flooding PRA Key Operator Actions by RAW (CDF)	Table Replaced
Table 19.1-73	Internal Flooding PRA Key Operator Actions by FV (CDF)	Table Replaced
Table 19.1-74	Internal Flooding PRA Key Basic Events by RAW (LRF)	Table Replaced
Table 19.1-75	Internal Flooding PRA Key Basic Events by FV (LRF)	Table Replaced
Table 19.1-76	Internal Flooding PRA Key CCF Events by RAW (LRF)	Table Replaced
Table 19.1-77	Internal Flooding PRA Key CCF Events by FV (LRF)	Table Replaced
Table 19.1-78	Internal Flooding PRA Key Operator Actions by RAW (LRF)	Table Replaced
Table 19.1-79	Internal Flooding PRA Key Operator Actions by FV (LRF)	Table Replaced
Table 19.1-80	Summary of External Hazard Dispositions	See RAI 19-14 Response

Table 1 - Section 19.1 Table Update Status from 2017 PRA Update

Table Number	Table Title	Update Status
Table 19.1-81	LPSD Plant Operating States	Unchanged
Table 19.1-82	LPSD PRA Loss of SCS Initiators	Unchanged
Table 19.1-83	LPSD PRA General LOCA Initiators	Table Replaced
Table 19.1-84	LPSD PRA Shutdown-Specific LOCA Initiators	Unchanged
Table 19.1-85	LPSD PRA (LOOP)(SBO) Initiators	Table Replaced
Table 19.1-86	LPSD PRA Loss of Supporting System Initiators	Table Replaced
Table 19.1-87	LPSD PRA Transient Events Initiators	Table Replaced
Table 19.1-88	LPSD PRA Accident Sequences Summary	Unchanged
Table 19.1-89	LPSD PRA Success Criteria Summary for Events Involving Loss of Operating SCS Train	Unchanged
Table 19.1-90	LPSD PRA Success Criteria Summary for Events Involving RCS Inventory	Unchanged
Table 19.1-91	LPSD PRA Success Criteria Summary for SBO Events	Unchanged
Table 19.1-92	LPSD PRA Success Criteria Summary for TLOCCW/TLOESW Events	Unchanged
Table 19.1-92a	The Results of Thermal-Hydraulic Analyses for POS 12B	Unchanged
Table 19.1-92b	Summary of Analysis Results for Plant Operating States	Unchanged
Table 19.1-93	LPSD PRA Internal Events CDF Contributions for Initiating Event - All POS	Table Replaced
Table 19.1-94	LPSD PRA Internal Events CDF Contributions for Initiating Event – Reduced Inventory	Table Replaced
Table 19.1-95	LPSD Internal Events PRA CDF Contributions by Plant Operating State	Table Replaced
Table 19.1-96	LPSD Internal Events PRA Top 100 CDF Cutsets - All POS	Table Replaced
Table 19.1-97	LPSD Internal Events PRA Top 100 CDF Cutsets - Reduced Inventory	Table Replaced
Table 19.1-98	LPSD Internal Events PRA Key Basic Events by RAW (CDF) - All POS	Table Replaced
Table 19.1-99	LPSD Internal Events PRA Key Basic Events by RAW (CDF) - Reduced Inventory	Table Replaced
Table 19.1-100	LPSD Internal Events PRA Key Basic Events by FV (CDF) - All POS	Table Replaced
Table 19.1-101	LPSD Internal Events PRA Key Basic Events by FV (CDF) - Reduced Inventory	Table Replaced
Table 19.1-102	LPSD Internal Events PRA Key CCF Events by RAW (CDF)	Table Replaced
Table 19.1-103	LPSD Internal Events PRA Key CCF Events by FV (CDF)	Table Replaced
Table 19.1-104	LPSD Internal Events PRA Key Operator Actions by	Table Replaced

Table 1 - Section 19.1 Table Update Status from 2017 PRA Update

Table Number	Table Title	Update Status
	RAW (CDF)	
Table 19.1-105	LPSD Internal Events PRA Key Operator Actions by FV (CDF)	Table Replaced
Table 19.1-105a	LPSD Internal Events PRA Key Initiating Events by FV (CDF)	Table Replaced
Table 19.1-105b	LPSD Internal Events PRA Key Initiating Events by RAW (CDF)	Table Replaced
Table 19.1-105c	LPSD Internal Events PRA Key Initiating Events by RRW (CDF)	Table Replaced
Table 19.1-106	LPSD Internal Flooding PRA CDF Contributions for Initiating Events - All POS	Table Replaced
Table 19.1-107	LPSD Internal Flooding PRA CDF Contributions for Initiating Events - Reduced Inventory	Table Replaced
Table 19.1-107a	LPSD Internal Events PRA Key Initiating Events by RAW (CDF)	See Table 19.1-105b
Table 19.1-108	LPSD Internal Flooding PRA CDF Contributions by Plant Operating State	Table Replaced
Table 19.1-108a	LPSD Internal Events PRA Key Initiating Events by RRW (CDF)	See Table 19.1-105c
Table 19.1-109	LPSD Internal Flooding PRA CDF Top 100 Cutsets – All POS	Table Replaced
Table 19.1-110	LPSD Internal Flooding PRA CDF Top 100 Cutsets – Reduced Inventory	Table Replaced
Table 19.1-111	LPSD Internal Flooding PRA Key Basic Events by RAW (CDF) – All POS	Table Replaced
Table 19.1-112	LPSD Internal Flooding PRA Key Basic Events by RAW (CDF) – Reduce Inventory	Table Replaced
Table 19.1-113	LPSD Internal Flooding PRA Key Basic Events by FV (CDF) – All POS	Table Replaced
Table 19.1-114	LPSD Internal Flooding PRA Key Basic Events by FV (CDF) – Reduced Inventory	Table Replaced
Table 19.1-115	LPSD Internal Flooding PRA Key CCF by RAW (CDF)	Table Replaced
Table 19.1-116	LPSD Internal Flooding PRA Key CCF by FV (CDF)	Table Replaced
Table 19.1-117	LPSD Internal Flooding PRA Key Operator Actions by RAW (CDF)	Table Replaced
Table 19.1-118	LPSD Internal Flooding PRA Key Operator Actions by FV (CDF)	Table Replaced
Table 19.1-119	LPSD Fire PRA CDF Contributions by Plant Operating State	Table Replaced
Table 19.1-120	LPSD PRA CDF Contributions for Internal Fire Initiating Events - All POS	Table Replaced

Table 1 - Section 19.1 Table Update Status from 2017 PRA Update

Table Number	Table Title	Update Status
Table 19.1-121	LPSD PRA CDF Contributions for Internal Fire Initiating Events – Reduced Inventory	Table Replaced
Table 19.1-122	LPSD PRA CDF Internal Fire Top 100 Cutsets – All POS	Table Replaced
Table 19.1-123	LPSD PRA CDF Internal Fire Top 100 Cutsets – Reduced Inventory	Table Replaced
Table 19.1-124	LPSD Internal Fire PRA Key Basic Events by RAW (CDF) – All POS	Table Replaced
Table 19.1-125	LPSD Internal Fire PRA Key Basic Events by RAW (CDF) – Reduced Inventory	Table Replaced
Table 19.1-126	LPSD Internal Fire PRA Key Basic Events by FV (CDF) – All POS	Table Replaced
Table 19.1-127	LPSD Internal Fire PRA Key Basic Events by FV (CDF) – Reduced Inventory	Table Replaced
Table 19.1-128	LPSD Internal Fire PRA Key CCF by RAW (CDF)	Table Replaced
Table 19.1-129	LPSD Internal Fire PRA Key CCF by FV (CDF)	Unchanged
Table 19.1-130	LPSD Internal Fire PRA Key PRA Operator Actions by RAW (CDF)	Table Replaced
Table 19.1-131	LPSD Internal Fire PRA Key PRA Operator Actions by FV (CDF)	Table Replaced
Table 19.1-132	APR1400 Shutdown LRF Screening Methodology	Table Replaced
Table 19.1-133	APR1400 LPSD Internal Events Release Fractions	Table Replaced
Table 19.1-134	Internal Events LPSD LRF by POS	Table Replaced
Table 19.1-135	LPSD Internal Events PRA Top 100 Cutsets (LRF) – All POS	Table Replaced
Table 19.1-136	LPSD Internal Events PRA Top 100 Cutsets (LRF) – Reduced Inventory	Table Replaced
Table 19.1-137	LPSD Internal Events PRA LRF Contribution by Initiating Events – POS 4B to 12A	Table Replaced
Table 19.1-138	LPSD Internal Events PRA LRF Contribution by Initiating Events – Reduced Inventory POS	Table Replaced
Table 19.1-139	LPSD Internal Events PRA Key Basic Events by RAW (LRF) – POS 4B to 12A	Table Replaced
Table 19.1-140	LPSD Internal Events PRA Key Basic Events by RAW (LRF) – Reduced Inventory	Table Replaced
Table 19.1-141	LPSD Internal Events PRA Key Basic Events by FV (LRF) – POS 4B to 12A	Table Replaced
Table 19.1-142	LPSD Internal Events PRA Key Basic Events by RAW (LRF) – Reduced Inventory	Table Replaced
Table 19.1-143	LPSD Internal Events PRA Key CCF Events by RAW (LRF)	Table Replaced
Table 19.1-144	LPSD Internal Events PRA Key CCF Events by FV	Table Replaced

Table 1 - Section 19.1 Table Update Status from 2017 PRA Update

Table Number	Table Title	Update Status
	(LRF)	
Table 19.1-145	LPSD Internal Events PRA Key Operator Actions by RAW (LRF)	Table Replaced
Table 19.1-146	LPSD Internal Events PRA Key Operator Actions by FV (LRF)	Table Replaced
Table 19.1-147	LPSD Internal Events Source Term Category Frequencies and Contributions to LRF (POS 4B-12A)	Table Replaced
Table 19.1-148	LPSD Fire LRF by POS	Table Replaced
Table 19.1-149	LPSD Internal Fire PRA Top 100 Cutsets (LRF) – All POS	Table Replaced
Table 19.1-150	LPSD Internal Fire PRA Top 100 Cutsets (LRF) – Reduced Inventory	Table Replaced
Table 19.1-151	LPSD Internal Fire PRA LRF Contribution by Initiating Events – All POS	Table Replaced
Table 19.1-152	LPSD Internal Fire PRA LRF Contribution by Initiating Events – Reduced Inventory POS	Table Replaced
Table 19.1-153	LPSD Internal Fire PRA Key Basic Events by RAW (LRF) –All POS	Table Replaced
Table 19.1-154	LPSD Internal Fire PRA Key Basic Events by RAW (LRF) –Reduced Inventory	Table Replaced
Table 19.1-155	LPSD Internal Fire PRA Key Basic Events by FV (LRF) – All POS	Table Replaced
Table 19.1-156	LPSD Internal Fire PRA Key Basic Events by FV (LRF) – Reduced Inventory	Table Replaced
Table 19.1-157	LPSD Internal Fire PRA Key CCF Events by RAW (LRF)	Table Replaced
Table 19.1-158	LPSD Internal Fire PRA Key CCF Events by FV (LRF)	Table Replaced
Table 19.1-159	LPSD Internal Fire PRA Key Operator Actions by RAW (LRF)	Table Replaced
Table 19.1-160	LPSD Internal Events PRA Key Operator Actions by FV (LRF)	Table Replaced
Table 19.1-161	LPSD FPRA Source Term Category Frequencies and Contributions to LRF (POS 4B-12A)	Table Replaced
Table 19.1-162	AFWS Unreliability Results	See RAI 19-45

Table 2 - Section 19.1 Revised Table Update Status

Table Number	Table Title	Update Status
Table 19.1-31	Level 2 Internal Events Top 100 LRF Cutsets	Table Modified
Table 19.1-66	Internal Flooding PRA Top 100 CDF Cutsets	Table Modified
Table 19.1-67	Internal Flooding PRA Top 100 LRF Cutsets	Table Modified
Table 19.1-96	LPSD Internal Events PRA Top 100 CDF Cutsets - All POS	Table Modified
Table 19.1-97	LPSD Internal Events PRA Top 100 CDF Cutsets - Reduced Inventory	Table Modified
Table 19.1-109	LPSD Internal Flooding PRA CDF Top 100 Cutsets – All POS	Table Modified
Table 19.1-110	LPSD Internal Flooding PRA CDF Top 100 Cutsets – Reduced Inventory	Table Modified
Table 19.1-135	LPSD Internal Events PRA Top 100 Cutsets (LRF) – All POS	Table Modified
Table 19.1-136	LPSD Internal Events PRA Top 100 Cutsets (LRF) – Reduced Inventory	Table Modified

models. The digital I&C model is retained as is with a single event representing the software/communication links as a black box event. The event probability in the fault tree model is based on engineering judgment. The dependency between hardware and software/communication links is not evaluated, but will be evaluated when design details are finalized.assumptions are described in Section 19.1.4.1.1.4 general assumption c.8.

Add A

19.1.4.1.2.6 Uncertainty Analysis

Uncertainty in the Level 1 internal events PRA results is quantified using the SAREXUNCERT code to run Monte Carlo simulations (5,000 samples). The results of the parametric uncertainty analysis for the Level 1 internal events CDF are summarized below:

- 5 percent value: 4.53.5 × 10^{-77}/year
- Mean value: 1.9 3 × 10^{-6}/year
- 95 percent value: 3.83.4 × 10^{-6}/year

This 95th percentile CDF value is more than an order of magnitude below the NRC goal of 1 × 10^{-4}/year.

The results for parametric uncertainty, the mean value from Monte Carlo simulation, is larger than the point estimate. This is due to the "state of knowledge correlation" as defined in the ASME/ANS PRA Standards, which is important for cutsets that contain multiple basic events whose probabilities are based on the same data, particularly when the uncertainty of the parameter value is large. In the Monte Carlo sampling approach, the same value is used for each basic event probability, since the "state of knowledge" about the parameter value is the same for each event. This results in a mean value for the joint probability that is larger than the product of the mean values of the event probabilities.

Importance of the redundant equipment and the state-of-knowledge dependencies is limited for the equipment where CCFs dominate the results. The impact of the redundant equipment is more important in the case where equipment single failures are also significant contributors to the results.

More detailed discussion on parametric and modeling uncertainty is as follows:

A

i) It is assumed for the purpose of analysis that hot leg injection during a hot leg LLOCA is required and modeled in the APR 1400 PRA. This assumption is less restrained when compared to T/H analysis results in DCD Chapter 15.

COL 19.1(20) The COL applicant is to perform the seismic-fire interactions walkdown to confirm a qualitative seismic-fire interaction assessment.

COL 19.1(21) The COL applicant is to develop outage procedures to ensure that in fire compartments containing post-seismic or post-fire safe shutdown equipment that: 1) the seismic ruggedness of temporary ignition sources is adequate, or that the duration that these temporary ignition sources are in these areas is minimized, 2) the seismic ruggedness of temporary equipment such as scaffolding in fire compartments containing potential seismic-fire ignition sources, or near fire protection equipment is adequate, and 3) either the duration of activities which could impact manual firefighting is minimized, or alternative firefighting equipment (e.g., pre-stage portable smoke removal equipment, prestage additional firefighting equipment, etc.) is supplied.

~~COL 19.1(22) The COL applicant is to demonstrate that failure of buildings that are not seismic Category I (e.g., turbine building and compound building) does not impact SSCs designed to be seismic Category I.~~

COL 19.1(~~23~~ 22) The COL applicant is to ensure that asymmetric conditions due to modeling simplicity will be addressed or properly accounted for when the PRA is used for decision making.

COL 19.1(~~24~~ 23) The COL applicant will demonstrate that maintenance-induced floods are negligible contributors to flood risk when the plant specific data are available.

Add A

19.1.10 References

1. ASME/ANS RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications" (Revision 1 RA-S-2002), American Society of Mechanical Engineers, April 2008.

2. ASME/ANS RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008," American Society of Mechanical Engineers, February 2009.

RAI 434-8352 Question 19-92_Rev.3

RAI 434-8352 Question 19-92_Rev.4

26

A

COL 19.1(~~27~~) The COL applicant will ensure the APR1400 thermal-hydraulic (T/H) analysis supporting the application is reflected in the updated PRA model including those design and operational features for mitigation of a hot leg LLOCA.

COL 19.1(~~28~~) The COL applicant will review the Technical Specifications and incorporate logic into the PRA model to ens ure cutsets reflect permissible maintenance configurations.

27

Table 1.8-2 (36 of 38)

Item No.	Description
COL 19.1(21)	The COL applicant is to develop outage procedures to ensure that in fire compartments containing post-seismic or post-fire safe shutdown equipment that: 1) the seismic ruggedness of temporary ignition sources is adequate, or that the duration that these temporary ignition sources are in these areas is minimized, 2) the seismic ruggedness of temporary equipment such as scaffolding in fire compartments containing potential seismic-fire ignition sources, or near fire protection equipment is adequate, and 3) either the duration of activities which could impact manual firefighting is minimized, or alternative firefighting equipment (e.g., pre-stage portable smoke removal equipment, prestage additional firefighting equipment, etc.) is supplied.
~~COL 19.1(22)~~	~~The COL applicant is to demonstrate that failure of buildings that are not seismic Category I (e.g., turbine building and compound building) does not impact SSCs designed to be seismic Category I.~~
COL 19.1(~~23~~ 22)	The COL applicant is to ensure that asymmetric conditions due to modeling simplicity will be addressed or properly accounted for when the PRA is used for decision making.
COL 19.1(~~24~~ 23)	The COL applicant will demonstrate that maintenance-induced floods are negligible contributors to flood risk when the plant specific data are available.
Add B	
COL 19.2(1)	The COL applicant is to perform and submit site-specific equipment survivability assessment in accordance with 10 CFR 50.34(f) and 10 CFR 50.44 which reflects the equipment identified and the containment atmospheric assessments of temperature, pressure and radiation described in Subsection 19.2.3.3.7.
COL 19.2(2)	The COL applicant will demonstrate that the covers for large penetrations such as equipment hatch and personnel airlocks meet the Service Level C requirements in Subsection NE-3220 of the ASME code and explain how the consideration of containment leakage is accounted for when modeling local regions of containment.
COL 19.2(3)	The COL applicant is to develop and submit an accident management plan.
COL 19.3(1)	The COL applicant is to perform site-specific seismic hazard evaluation and seismic risk evaluation as applicable in accordance with NTTF Recommendation 2.1 as outlined in the NRC RFI.
COL 19.3(2)	The COL applicant is to address the flood requirements for wet sites
COL 19.3(3)	The COL applicant is to develop the details for offsite resources.
COL 19.3(4)	The COL applicant is to address the details of selecting suitable storage locations for FLEX equipment that provide reasonable protection during specific external events as provided in NEI 12-06 guidance Sections 5 through 9, and the details of the guidance for storage of FLEX equipment provided in the Technical Report (Reference 5) Section 6.2.9.
COL 19.3(5)	The COL applicant is to confirm, satisfy, or fulfill the specific design functional requirements of raw water tank including the associated instrument, capacity, location, flow path to on-site, the valve pit connected to FLEX equipment, and any other design features as described in Section 19.3 in support of BDBEE mitigation strategies.
COL 19.3(6)	The COL applicant is to confirm and ensure that the raw water tank and flow path to the FLEX equipment (structures, piping, components, and connections) are designed to be robust with respect to applicable hazards (e.g., seismic events, floods, high winds, and associated missiles).

RAI 434-8352 Question 19-92_Rev.3

RAI 434-8352 Question 19-92_Rev.4

B

26

COL 19.1(~~27~~)	The COL applicant will ensure the APR1400 thermal-hydraulic (T/H) analysis supporting the application is reflected in the updated PRA model including those design and operational features for mitigation of a hot leg LLOCA.
COL 19.1(~~28~~)	The COL applicant will review the Technical Specifications and incorporate logic into the PRA model to ensure cutsets reflect permissible maintenance configurations.

27

remaining 43%. Only one Two accident sequence contributes over 10 percent of the CDF, LOOP_005 and MLOCA_002; these is sequences involves the following elements:

a. LOOP_005

- LOOP initiating event
- b. Success of reactor trip (i.e., not an ATWS event)
- c. No POSRV challenge (i.e., not an induced LOCA event)
- d. Success of one or more EDGs (i.e., not an SBO event)
- e. Failure of secondary heat removal
- f. Failure of bleed for feed and bleed operation

a. MLOCA_002

- MLOCA initiating event
- Success of reactor trip (i.e., not an ATWS event)
- Success of Safety Injection
- Failure of containment heat removal via CS

The significant top 100 cutsets for the internal events are provid illustrated in Table 19.1-19. The top 100 cutsets contribute approximately 39 37 percent of the total CDF. Cutset contribution to the internal events CDF is equally distributed. Only eight three of the top cutsets contribute more than 1 percent to the total CDF. The number of top cutsets that cumulatively contribute to 95 percent of the CDF is over 200293,000. These results show that there are no significant cutset outliers in the APR1400 internal events CDF.

Add A

19.1.4.1.2.4 Significant SSCs, Common Cause Events, and Operator Actions

Table 19.1-20 shows the risk-significant SSCs based on the RAW importance measure. The most important pieces of equipment are DC-MC01A/1B (the Class 1E 125 Vdc bus 1A

RAI 434-8352 Question 19-92_Rev.3

RAI 434-8352 Question 19-92_Rev.4

A

To perform realistic analysis for system availability (mitigation capacity) for a LLOCA, the PRA analysis evaluated three types of LLOCAs, i.e. cold leg break, DVI break and hot leg break. Consequently, hot leg injection during a LLOCA in hot leg was modeled in the PRA since the guidance in the APR 1400 Emergency Operating Guidelines (EOG) requires the initiation of hot leg injection during a potential LLOCA scenario. For the purposes of the APR 1400 PRA analysis, a failure of hot leg injection due to a single failure of the SI pump resulted in two cutsets within the top 100 which reflected that the modeling could lead core damage when a hot leg LLOCA occurs. However, the recent thermal-hydraulic (T/H) analysis in DCD Chapter.15 shows that boron precipitation is not expected under the condition that there is no hot leg injection during a hot leg LLOCA, and thus no core damage should occur in the accident sequence that hot leg injection fails in a hot leg LLOCA (see APR1400-F-A-NR-14003-P, Rev.1 "Post-LOCA Long Term Cooling Evaluation Model", Therefore, based on the T/H analysis performed to support Chapter 15 of the APR1400 design, no single failure will result in core damage or the loss of safety or protection function. To assess this relative to design criteria and T/H analysis performed for deterministic purposes, e.g. Chapter 15, a sensitivity analysis for not modeling hot leg injection during a LLOCA in hot leg shows that the core damage frequency (CDF) is estimated to be 1.1E-06/yr. This is the same as the full power internal base model CDF, and therefore, there is no impact even if hot leg injection is modeled (COL 19.1(~~27~~).

26

General assumptions and conditions applied to system analysis are summarized below.

a. General modeling conditions:

1) Models reflect the design as-designed and as-to-be-built to the extent possible.

2) Systems that participate in the necessary response to events or that provide critical support to such systems are modeled.

3) Models reflect the success criteria for the systems to mitigate each identified accident sequence.

4) Models capture the impact of dependencies, including support systems and harsh environmental impacts.

5) Operator errors of commission are not included in the system model.

b. Conditions concerning level of detail

1) The level of detail in the model matches one for one the simplified diagrams and includes key active components and potential misaligned components based upon data availability.

2) Models include contributions due to random component failures, outages for maintenance and test, support system failures, CCFs, initiating events which affect the system, human errors to restore equipment to its operable state, and human errors involving failure to perform procedural actions.

3) Models include both failure modes of active and passive components that impact the function of the system.

4) A thorough treatment of CCFs, intra-system dependencies, and selected intersystem dependencies is provided.

5) The fault tree is developed to the level of detail that existing data can support.

Add A

c. Failure modes of components modeled are as follows:

A

6) The APR1400 PRA model currently contains some "test and maintenance" configurations which are not permissible by APR1400 Technical Specifications. While these configurations are outside current Technical Specifications for operations, inclusion of these maintenance configurations in the current PRA is conservative with respect to CDF and LRF. The improper cutsets will be excluded from the cutsets resulting from the plant specific PRA, maintenance programs and Technical Specifications developed by the COL applicant (COL 19.1(~~28~~)). 27

7) The APR1400 PRA model is an asymmetric model. Therefore, location specific initiating events are assigned to a single location, e.g., SGTR is assumed to occur in SG #2, DVI line Large LOCA is assumed to occur in DVI line 1B, etc. System models reflect these locational initiating events, e.g., DVI large LOCA is assumed to result in the direct failure of SI pump PP02D and SIT TK01D since the injection flow from these components would be lost via the break in DVI line 1B. In addition, normally operating systems whose trains are operated on a rotational basis (e.g., CC, SX, etc.) have an assumed configuration with one train assumed to be the operating train, and the other train is assumed to be the standby train. Note that for the purposes of determining the CDF and LRF risk metrics, model asymmetry has no impact. The main impact is that the importance of equipment in those systems can differ on a train basis; however, for risk applications related to risk ranking, this can be compensated for by assigning the highest importance measure of a component within a group to all members within the group (COL 19.1(~~23~~)). 22

Table 19.1-1 (3 of 3)

Technical Area	APR1400 PRA Characteristics
Internal Flooding (IF)	Some aspects of the internal flooding analysis are limited by the lack of plant-specific details. Specific areas in which the internal flooding analysis does not meet at least Category I include the following: • Plant information reflecting as-built, as-operated conditions does not yet exist. • Walkdowns cannot be conducted until the plant is constructed. • Some sources of flooding will account for plant/site-specific features not yet available. • Conservative assumptions were made with respect to propagation pathways and areas that could be affected.
Quantification (QU)	~~The quantification was performed by solving the overall core damage model using the linked fault-tree approach. The quantification satisfies at least Category I for each of the supporting requirements.~~ The quantification was performed by solving the overall core damage model using the linked fault-tree approach. The quantification satisfies at least Category I for each of the supporting requirements except for two (2) supporting requirements, QU-B7 and QU-B8. The logic of mutually exclusive events (MUX) did not cover all MUX, thus, some improper test and maintenance events appeared in the PRA results.
LERF (LE)	A detailed assessment of containment response and release frequency was conducted. The assessment satisfies at least Capability Category I for the supporting requirements, except for such aspects as system failure analysis and human reliability analysis. A detailed assessment of containment response and release frequency was conducted. The assessment satisfies at least Capability Category I for the supporting requirements, except for such aspects as system failure analysis and human reliability analysis, as addressed for technical areas SY, HF, and DA above.

Table 19.1-4 (13 of 27)

No.	Insight	Disposition
Risk Insights from Key Design Features		
24	The Class 1E onsite power system has four trains with two trains per division. Each train is connected to one EDG. The two EDGs of a single division (i.e., Trains A and C, or Trains B and D) are sufficient to meet the emergency load requirements for a safe shutdown during a LOOP. Each EDG train and its associated auxiliaries are installed in a separate room within physically separate seismic Category I structures that provide protection against tornadoes, hurricanes, external missiles and seismic phenomena, and are electrically isolated from the circuits of other EDG trains and non-Class 1E circuits. Each EDG room is a separate fire area with 3-hour fire-rated walls, floors, and ceilings. Each EDG room is provided with its own independent ventilation system that automatically maintains the design room temperature for proper equipment operation and personnel access. The EDG room HVAC system and other EDG support auxiliaries are powered from the same electrical train as the EDG. Per the Technical Specifications, two EDGs on the same division (i.e., EDG A and C, or EDG B and D) can be out-of-service (OOS) together during an online maintenance. This allows two EDG maintenance cases to be retained in the PRA results, as compared to allowing only one EDG maintenance case.	Subsection 8.3.1.1.3 Subsection 16.3.8.1
25	The onsite Class 1E 125 Vdc power system is composed of four independent subsystems (Trains A, B, C, and D) and supplies reliable power to the plant safety system dc loads and essential I&C system loads. Each dc power subsystem consists of a battery, two battery chargers (normal and standby), a dc control center, and distribution panels. The station batteries A and B will last up to 2 hours without ~~dc load shedding~~ load shedding and 8 hours with load shedding. The station batteries C and D will last up to 16 hours without ~~dc loading~~ load shedding. The operator action to perform the load shedding is included in the PRA model.	Subsection 8.3.2.1.2 Subsection 8.3.2.1.2

Table 19.1-4 (18 of 27)

No.	Insight	Disposition
	Risk Insights from Key Design Features	
36	Flood protection is integrated into the auxiliary building floor drainage systems. The flood drainage systems are separated by quadrants with no common drain lines between the quadrants. The floor drainage systems are separated by division and Safety Class 3, seismic Category I valves that prevent backflow of water to areas containing safety-related equipment. Each quadrant contains its own separate sump equipped with redundant Safety Class 3, seismic Category I sump pumps and associated instrumentation.	Subsection 3.4.1.3 Subsection 9.3.3.1 Subsection 9.3.3.2
37	The potential for consequential flooding of safety-related SSCs due to flooding in the turbine building is prevented by the following design features: (a) no openings to safety-related structures exist below grade, (b) openings to safety-related structures above the maximum design basis flood level for the turbine building are sealed, (c) very large openings to allow flow out of the turbine building once level exceeds plant grade, and (d) site grade moves water away from structures where safety-related equipment is located.	Subsection 10.4.1.3
38	No water lines are routed above or through the MCR and the computer room. HVAC water lines contained in rooms around the MCR are located in rooms with raised curbs to prevent leakage from entering the MCR.	Subsection 3.4.1.5.2
39	All fire barriers that provide separation between the two divisions are rated for at least 3 hours.	Subsection 9.5.1.1
40	The emergency containment spray backup subsystem (ECSBS) for severe accident management is provided. The ECSBS is used as an alternate means of providing containment spray in the event of a beyond design basis accident in which all CSPs/SCPs or the IRWST are unavailable. The ECSBS is to be placed in service 24 hours after a severe accident to prevent a catastrophic failure of the containment. The fire engine truck as ECSBS pumping device is used to deliver water from external water sources to the ECSBS containment spray header after the initiation of a severe accident. The operating procedure(s) for use of the ECSBS is to be developed by the COL applicant.	Subsection 6.2.2.2 COL 19.2(3) ~~COL 19.2(2)~~

Table 19.1-4 (19 of 27)

No.	Insight	Disposition
	Risk Insights from Severe Accident Design Features	
41	The reactor cavity is configured to promote retention of and heat removal from the postulated core debris during a severe accident, thus serving roles in accident mitigation. The reactor cavity is designed to prevent or mitigate the effect of severe accident phenomena such as HPME/DCH, EVSE and MCCI. The reactor cavity design characteristics include a core debris chamber inside a reactor cavity, a convoluted gas vent path, large floor area, and the CFS. The cavity flooding system consists of two independent divisions and is supplied, via gravity, from the IRWST via the HVT. Procedures for use of the cavity flood system during a severe accident are to be developed by the COL applicant as part of its plant-specific severe accident management guidelines (SAMG).	Subsection 19.2.3.3 Subsection 6.8.3.1 COL 19.2(3) ~~COL 19.2(2)~~
42	In-vessel retention of core debris as result of external RV cooling is a potential means to mitigate a severe accident. The goal of external cooling is to retain the molten core debris in the RV lower plenum and thus prevent vessel failure. In-vessel retention precludes the possible ex-vessel physical phenomena related to debris relocation such as steam explosions and molten core-concrete interaction (MCCI). The plant is designed to allow operators to fill the reactor cavity with water and thereby submerge the RV in coolant. This can achieve ex-vessel cooling and in-vessel retention. However, in-vessel retention is not credited as a mitigation feature due to uncertainty surrounding the associated phenomena along with the need for operators to take additional manual actions.	Subsection 19.2.3.3.1
43	The hydrogen mitigation system (HMS) consists of igniters and passive autocatalytic recombiners (PARs) to control hydrogen concentration during a severe accident. HMS consists of eight igniters and 30 passive autocatalytic recombiners (PARs), which are strategically located inside the containment. The SAMG will address use of the HMS.	Subsection 6.2.5.1 Subsection 6.2.5.2 COL 19.2(3) ~~COL 19.2(2)~~

Attachment 5. Recovery rules for delete MUX

```
**RECOVERY RULES**
**DELETE**
;
; LCO 3.5.2
;
SIMPM1A-PP02A     SIMPM1B-PP02B
SIMPM1A-PP02A     SIMPM2A-PP02C
SIMPM1A-PP02A     SIMPM2B-PP02D
SIMPM1B-PP02B     SIMPM2A-PP02C
SIMPM1B-PP02B     SIMPM2B-PP02D
SIMPM2A-PP02C     SIMPM2B-PP02D
;
; LCO 3.6.6
;
CSMPM2A-PP01A     CSMPM2B-PP01B
CSHEM2A-HE01A     CSMPM2B-PP01B
CSHEM2B-HE01B     CSMPM2A-PP01A
CSHEM2A-HE01A     CSHEM2B-HE01B
;
; LCO 3.7.5
;
AFMPM2A-MDP02A  AFMPM2B-MDP02B      AFTPM1A-TDP01A      AFTPM1B-TDP01B
;
; LCO 3.7.12
;
VKAHM1A-AH01A     VKAHM1B-AH01B       VKAHM1C-AH01C
VKAHM1A-AH01A     VKAHM1B-AH01B       VKAHM1D-AH01D
VKAHM1A-AH01A     VKAHM1C-AH01C       VKAHM1D-AH01D
VKAHM1B-AH01B     VKAHM1C-AH01C       VKAHM1D-AH01D
;
; LCO 3.8.1
;
DGDGM-A-DGA       DGDGM-B-DGB
DGDGM-A-DGA       DGDGM-D-DGD
DGDGM-B-DGB       DGDGM-C-DGC
DGDGM-C-DGC       DGDGM-D-DGD
DGDGM-A-DGA       VDHVM-B-HV12B
DGDGM-A-DGA       VDHVM-B-HV13B
DGDGM-A-DGA       VDHVM-D-HV12D
DGDGM-A-DGA       VDHVM-D-HV13D
DGDGM-B-DGB       VDHVM-A-HV12A
DGDGM-B-DGB       VDHVM-A-HV13A
DGDGM-B-DGB       VDHVM-C-HV12C
DGDGM-B-DGB       VDHVM-C-HV13C
DGDGM-C-DGC       VDHVM-B-HV12B
DGDGM-C-DGC       VDHVM-B-HV13B
DGDGM-C-DGC       VDHVM-D-HV12D
DGDGM-C-DGC       VDHVM-D-HV13D
DGDGM-D-DGD       VDHVM-A-HV12A
DGDGM-D-DGD       VDHVM-A-HV13A
DGDGM-D-DGD       VDHVM-C-HV12C
DGDGM-D-DGD       VDHVM-C-HV13C
VDHVM-A-HV12A     VDHVM-B-HV12B
VDHVM-A-HV12A     VDHVM-B-HV13B
VDHVM-A-HV12A     VDHVM-D-HV12D
VDHVM-A-HV12A     VDHVM-D-HV13D
VDHVM-A-HV13A     VDHVM-B-HV12B
VDHVM-A-HV13A     VDHVM-B-HV13B
VDHVM-A-HV13A     VDHVM-D-HV12D
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VDHVM-A-HV13A VDHVM-D-HV13D
VDHVM-B-HV12B VDHVM-C-HV12C
VDHVM-B-HV12B VDHVM-C-HV13C
VDHVM-B-HV13B VDHVM-C-HV12C
VDHVM-B-HV13B VDHVM-C-HV13C
VDHVM-C-HV12C VDHVM-D-HV12D
VDHVM-C-HV12C VDHVM-D-HV13D
VDHVM-C-HV13C VDHVM-D-HV12D
VDHVM-C-HV13C VDHVM-D-HV13D
DGDGM-A-DGA DOMPM-B-PP01B DOMPM-B-PP02B
DGDGM-A-DGA DOMPM-D-PP01D DOMPM-D-PP02D
DGDGM-B-DGB DOMPM-A-PP01A DOMPM-A-PP02A
DGDGM-B-DGB DOMPM-C-PP01C DOMPM-C-PP02C
DGDGM-C-DGC DOMPM-B-PP01B DOMPM-B-PP02B
DGDGM-C-DGC DOMPM-D-PP01D DOMPM-D-PP02D
DGDGM-D-DGD DOMPM-A-PP01A DOMPM-A-PP02A
DGDGM-D-DGD DOMPM-C-PP01C DOMPM-C-PP02C
DOMPM-A-PP01A DOMPM-A-PP02A VDHVM-B-HV12B
DOMPM-A-PP01A DOMPM-A-PP02A VDHVM-B-HV13B
DOMPM-A-PP01A DOMPM-A-PP02A VDHVM-D-HV12D
DOMPM-A-PP01A DOMPM-A-PP02A VDHVM-D-HV13D
DOMPM-B-PP01B DOMPM-B-PP02B VDHVM-A-HV12A
DOMPM-B-PP01B DOMPM-B-PP02B VDHVM-A-HV13A
DOMPM-B-PP01B DOMPM-B-PP02B VDHVM-C-HV12C
DOMPM-B-PP01B DOMPM-B-PP02B VDHVM-C-HV13C
DOMPM-C-PP01C DOMPM-C-PP02C VDHVM-B-HV12B
DOMPM-C-PP01C DOMPM-C-PP02C VDHVM-B-HV13B
DOMPM-C-PP01C DOMPM-C-PP02C VDHVM-D-HV12D
DOMPM-C-PP01C DOMPM-C-PP02C VDHVM-D-HV13D
DOMPM-D-PP01D DOMPM-D-PP02D VDHVM-A-HV12A
DOMPM-D-PP01D DOMPM-D-PP02D VDHVM-A-HV13A
DOMPM-D-PP01D DOMPM-D-PP02D VDHVM-C-HV12C
DOMPM-D-PP01D DOMPM-D-PP02D VDHVM-C-HV13C
DOMPM-A-PP01A DOMPM-A-PP02A DOMPM-B-PP01B DOMPM-B-PP02B
DOMPM-A-PP01A DOMPM-A-PP02A DOMPM-D-PP01D DOMPM-D-PP02D
DOMPM-B-PP01B DOMPM-B-PP02B DOMPM-C-PP01C DOMPM-C-PP02c
DOMPM-C-PP01C DOMPM-C-PP02C DOMPM-D-PP01D DOMPM-D-PP02D
;
; LCO 3.8.4
;
DCBTM-A-BT01A DCBTM-B-BT01B
DCBTM-A-BT01A DCBTM-C-BT01C
DCBTM-A-BT01A DCBTM-D-BT01D
DCBTM-B-BT01B DCBTM-C-BT01C
DCBTM-B-BT01B DCBTM-D-BT01D
DCBTM-C-BT01C DCBTM-D-BT01D
;
; LCO 3.8.7
;
IPINM-A-IN01A IPINM-B-IN01B
IPINM-A-IN01A IPINM-C-IN01C
IPINM-A-IN01A IPINM-D-IN01D
IPINM-B-IN01B IPINM-C-IN01C
IPINM-B-IN01B IPINM-D-IN01D
IPINM-C-IN01C IPINM-D-IN01D

Attachment 6. The sensitivity Analysis Results for Appling MUX Rule File

1. The MUX rule file is applied for all parts of PRA and the results are introduced below.

a. At-Power

1) At-Power Level 1 Internal Event

	CDF	Decrease CDF	MCS
Rev.1 model	1.10E-06	-	655,609
Delete MUX	1.01E-06	9.00E-08 (8.18%)	591,841

2) At-Power Level 1 Internal Fire

	CDF	Decrease CDF	MCS
Rev.1 model	2.22E-06	-	620,856
Delete MUX	2.20E-06	2.00E-08 (0.90%)	594,235

3) At-Power Level 1 Internal Flooding

	CDF	Decrease CDF	MCS
Rev.1 model	4.00E-07	-	190,960
Delete MUX	4.00E-07	0.00E-00 (0.00%)	189,374

4) At-Power Level 2 Internal Event

	LRF	Decrease LRF	MCS
Rev.1 model	1.00E-07	-	52,966
Delete MUX	9.65E-08	3.50E-09 (3.50%)	44,764

5) At-Power Level 2 Internal Fire

	LRF	Decrease LRF	MCS
Rev.1 model	1.85E-07	-	93,971
Delete MUX	1.85E-07	0.00E-00 (0.00%)	92,751

6) At-Power Level 2 Internal Flooding

	LRF	Decrease LRF	MCS
Rev.1 model	2.54E-08	-	226,874
Delete MUX	2.54E-08	0.00E-00 (0.00%)	226,106

b. Low Power and Shutdown

1) LPSD Level 1 Internal Event

	CDF	Decrease CDF	MCS
Rev.1 model	1.80E-06	-	80,843
Delete MUX	1.80E-06	0.00E-00 (0.00%)	79,914

2) LPSD Level 1 Internal Fire

	CDF	Decrease CDF	MCS
Rev.1 model	1.25E-06	-	39,639
Delete MUX	1.25E-06	0.00E-00 (0.00%)	39,639

3) LPSD Level 1 Internal Flooding

	CDF	Decrease CDF	MCS
Rev.1 model	8.02E-08	-	10,923
Delete MUX	8.02E-08	0.00E-00 (0.00%)	10,923

4) LPSD Level 2 Internal Event

	LRF	Decrease LRF	MCS
Rev.1 model	7.02E-08	-	129,683
Delete MUX	7.02E-08	0.00E-00 (0.00%)	129,679

5) LPSD Level 2 Internal Fire

	LRF	Decrease LRF	MCS
Rev.1 model	6.68E-08	-	56474
Delete MUX	6.68E-08	0.00E-00 (0.00%)	56474

6) LPSD Level 2 Internal Flooding

	CDF	Decrease CDF	MCS
Rev.1 model	8.02E-08	-	10,923
Delete MUX	8.02E-08	0.00E-00 (0.00%)	10,923

Note: The CDF for LPSD level 1 internal flooding is 8.02E-08/y. This value is very low compared with LPSD level 1 internal event and internal fire, both of which are 1.8E-06/year and 1.2E-06/y respectively. Thus, LPSD internal flooding CDF is conservatively assigned to the LRF. In other words, there is no separate cutsets for LRF and it is bounded by level 1 LPSD flooding.

c. Summary of Results

The table below summarizes the results above. As shown in the table, there is a CDF decrease 9.00E-08 (8.18%) by deleting MUX for at-power Level 1 internal events PRA. Overall, the total CDF and LRF are decreased by 1.75% and 0.66% respectively. With deletion of MUX, it has no effect on the LPSD PRA. This is due to the configuration of each system and the maintenance of equipment are analyzed separately during shutdown cooling operation (POS 3A through 13). Therefore, the results of CDF and LRF are not changed.

	At-Power			**LPSD**			**Total CDF**
	Level 1			**Level 1**			
	IE	**Fire**	**Flood**	**IE**	**Fire**	**Flood**	
Rev.1 model	1.10E-06	2.22E-06	4.00E-07	1.80E-06	1.25E-06	8.02E-08	**6.85E-06**
Delete MUX	1.01E-06	2.19E-06	4.00E-07	1.80E-06	1.25E-06	8.02E-08	**6.73E-06**
Decrease	9.00E-08	2.00E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**1.20E-07**
Decrease (%)	8.18%	0.90%	0.00%	0.00%	0.00%	0.00%	**1.75%**

	At-Power			**LPSD**			**Total LRF**
	Level 2			**Level 2**			
	IE	**Fire**	**Flood**	**IE**	**Fire**	**Flood**	
Rev.1 model	1.00E-07	1.85E-07	2.54E-08	7.02E-08	6.68E-08	8.02E-08	**5.28E-07**
Delete MUX	9.65E-08	1.85E-07	2.54E-08	7.02E-08	6.68E-08	8.02E-08	**5.24E-07**
Decrease	3.50E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**3.50E-09**
Decrease (%)	3.50%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.66%**

2) The impact of DCD Other Chapters by Appling MUX Rule File

KHNP has reviewed the impact on DCD other chapters resulted from applying MUX rule file. With respect to Physical Security (Ch. 13.6), ITAAC (Ch. 14.3), Technical Specifications (Ch. 16), Reliability Assurance Program (Ch. 17.4) and Severe Accidents (Ch. 19.2) are not affected by deleting cutsets in the PRA results. With respect to Human Factor Engineering (Ch. 18), two (2) human failure events were identified and added as a RIHA by deleting MUX. However, Most of specific human factors designs in the APR1400 are COL items.

PRA Scope	Additional RIHA	Remark
Internal Events at power Level 1 & Level 2	CVOPH-S-BORATION	added by FV in at power Level 1 internal events
	VKOPH-S-ECCS	added by FV in at power Level 2 internal events
Internal Fire at Power Level 1 & Level 2	-	No Change
Internal Flood at Power Level 1 & Level 2	-	No Change
Internal Events for LPSD Level 1 & Level 2	-	No Change
Internal Fire for LPSD Level 1 & Level 2	-	No Change
Internal Flood for LPSD Level 1 & Level 2	-	No Change

Thus, it is expected that the change of RIHAs has no effect on human factors design, but only one document, APR1400-E-I-NR-14006 “Treatment of Important Human Actions Implementation Plan”, is required for revising RIHAs list.

Table 1.8-2 (35 of 39)

Item No.	Description
COL 17.5(1)	The COL applicant is to establish and implement a QA program that is applicable to site-specific design activities related to the plant construction and operation phases.
COL 17.6(1)	The COL applicant is to provide in its Final Safety Analysis Report a description of the Maintenance Rule program and a plan for implementing it to meet the requirements of 10 CFR 50.65.
COL 18.12(1)	The COL applicant is to provide the human performance monitoring program.
COL 19.0(1)	The COL applicant is either to confirm that the PRA in the design certification bounds the site-specific design information and any design changes or departures, or to update the PRA to reflect the site-specific design information and any design changes or departures.
COL 19.1(1)	The COL applicant is to describe the uses of PRA in support of licensee programs, and to identify and describe risk-informed applications being implemented during the combined license application phase.
COL 19.1(2)	The COL applicant is to describe the uses of PRA in support of licensee programs, and identify and describe risk-informed applications being implemented during the construction phase.
COL 19.1(3)	The COL applicant is to describe the uses of PRA in support of licensee programs, and identify and describe risk-informed applications being implemented during the operational phase.
COL 19.1(4)	The COL applicant is to review as-designed and as-built information and conduct walkdowns as necessary to confirm that the assumptions used in the PRA (including PRA inputs to RAP and SAMDA) remain valid with respect to internal events, internal flood and fire events (fire barrier and fire barrier penetrations, routings and locations of pipe, cable, and conduit), and HRA analyses (development of operating procedures, emergency operating procedures, and severe accident management guidelines and training), external events including PRA-based seismic margins and HCLPF fragilities, and LPSD procedures.
COL 19.1(5)	The COL applicant is to conduct a peer review of the PRA relative to the industry PRA Standard prior to use of the PRA to support risk-informed applications, as applicable.
COL 19.1(6)	The COL applicant is to describe the PRA maintenance and upgrade program.
COL 19.1(7)	The COL applicant is to develop management procedures for charging pump operation, following recovery from a loss of offsite power (LOOP), to ensure that deboration is not resumed until after at least one Reactor Coolant Pump (RCP) has been restarted.
COL 19.1(8)	The COL applicant is to confirm that the PRA-based seismic margin assessment is bounding for the selected site, and to update the assessment to include site-specific SSC and soil effects (including sliding, overturning liquefaction, and slope failure). The COL applicant is to confirm that the as-built plant has adequate seismic margin and do not exceed the CDF and LERF design targets specified in Subsection 1.2.1.1.1 e. The COL applicant is to demonstrate that HCLPF capacity is equal to or exceed 1.67 times the GMRS for site-specific structures (ESWIS and CCW Hx Building). The COL applicant is to demonstrate that HCLPF capacity is equal to or exceed 1.67 times the CSDRS for BOP components and is to complete the SEL. The COL applicant is to demonstrate that the seismic capacity for equipment qualified by testing should remain functionally operational within 1.67 times the required response spectra (CSDRS-based RRS) in the procurement specification.

Replace with "A"

RAI 434-8352 Question 19-92_Rev.4

RAI 434-8352 Question 19-92_Rev.5

"A"

	The COL applicant will confirm and update from new information from the site, e.g. site features, design departures, etc, that the PRA-based seismic margin assessment is bounding for the selected site, site-specific SSC and soil effects (including sliding, overturning, liquefaction, and slope failure). The COL applicant is to confirm that the as-built plant has adequate seismic margin and do not exceed the CDF and LRF design targets specified in Subsection 1.2.1.1.1 e. See Subsection 19.1.5.1.2. The COL applicant is to demonstrate that site-specific structures (the turbine building, compound building, ESW IS and CCW HX building) have a HCLPF capacity that is equal to or greater than ~~0.5g~~ 1.67 times GMRS and will update the PRA-based seismic margin analysis with the site-specific structure HCLPF value, accordingly. The COL applicant is to demonstrate that HCLPF capacity is equal to or exceed 1.67 times the CSDRS for BOP components and is to complete the SEL. The COL applicant is to demonstrate that the seismic capacity for equipment and relay qualified by testing should remain functionally operational within 1.67 times the required response spectra (CSDRS based RRS) in the procurement specification. The COL applicant is to demonstrate that the inherently rugged components identified in 19.1.5.1.1.2 have seismically rugged capacity. The COL applicant is to demonstrate that the steam generator tube HCLPF is higher than HCLPF for the steam generator nozzle.

Table 1.8-2 (37 of 39)

Item No.	Description
COL 19.1(19)	The COL applicant is to describe the uses of PRA in support of licensee programs such as the reactor oversight process during the operational phase.
COL 19.1(20)	The COL applicant is to perform the seismic-fire interactions walkdown to confirm a qualitative seismic-fire interaction assessment.
COL 19.1(21)	The COL applicant is to develop outage procedures to ensure that in fire compartments containing post-seismic or post-fire safe shutdown equipment that: 1) the seismic ruggedness of temporary ignition sources is adequate, or that the duration that these temporary ignition sources are in these areas is minimized, 2) the seismic ruggedness of temporary equipment such as scaffolding in fire compartments containing potential seismic-fire ignition sources, or near fire protection equipment is adequate, and 3) either the duration of activities which could impact manual firefighting is minimized, or alternative firefighting equipment (e.g., pre-stage portable smoke removal equipment, prestage additional firefighting equipment, etc.) is supplied.
~~COL 19.1(22)~~	~~The COL applicant is to demonstrate that failure of buildings that are not seismic Category I (e.g., turbine building and compound building) does not impact SSCs designed to be seismic Category I.~~
COL 19.1(~~23~~) 22	The COL applicant is to ensure that asymmetric conditions due to modeling simplicity will be addressed or properly accounted for when the PRA is used for decision making.
COL 19.1(~~24~~) 23	The COL applicant will demonstrate that maintenance-induced floods are negligible contributors to flood risk when the plant specific data are available.
COL 19.1(~~25~~) 24	SAMGs are entered to initiate SI with the core exit thermocouple indicating 1200 °F.
COL 19.1(25)	The COL applicant and/or holder ensures that the fire protection features required for preventing fire-induced damage of the PRA-credited components will be properly incorporated in the cable design.
COL 19.2(1)	The COL applicant is to perform and submit site-specific equipment survivability assessment including flooding effect in accordance with 10 CFR 50.34(f) and 10 CFR 50.44 which reflects the equipment identified and the containment atmospheric assessments of temperature, pressure and radiation described in Subsection 19.2.3.3.7.
COL 19.2(2)	The COL applicant will demonstrate that the covers for large penetrations such as equipment hatch and personnel airlocks meet the Service Level C requirements in Subsection NE-3220 of the ASME code and explain how the consideration of containment leakage is accounted for when modeling local regions of containment.
COL 19.2(3)	The COL applicant and/or holder is to develop and submit an accident management plan including the evaluation of the effect of higher water level in the cavity on steam explosion loading when using In-Vessel Retention and External Reactor Vessel Cooling for accident management.
COL 19.3(1)	The COL applicant is to perform site-specific seismic hazard evaluation and seismic risk evaluation as applicable in accordance with NTTF Recommendation 2.1 as outlined in the NRC RFI.
COL 19.3(2)	The COL applicant is to address the flood requirements for wet sites
COL 19.3(3)	The COL applicant is to develop the details for offsite resources.
COL 19.3(4)	The COL applicant is to address the details of selecting suitable storage locations for FLEX equipment that provide reasonable protection during specific external events as provided in NEI 12-06 guidance Sections 5 through 9, and the details of the guidance for storage of FLEX equipment provided in the Technical Report (Reference 5) Section 6.2.9.
COL 19.3(5)	The COL applicant is to confirm, satisfy, or fulfill the specific design functional requirements of raw water tank including the associated instrument, capacity, location, flow path to on-site, the valve pit connected to FLEX equipment, and any other design features as described in Section 19.3 in support of BDBEE mitigation strategies.

l. Failure of auxiliary steam (AS) or steam generator blowdown (SD) system piping in the auxiliary building is assumed to be incapable of resulting in pipe whip or unique jet impingement failures.

m. Lines that are not normally pressurized or charged, such as drain lines or abandoned in-place systems, are not considered as credible flood or spray sources. For example, relief lines downstream of a relief valve are not normally pressurized and are not included.

19.1.5.3.1.5 Initiating Event Analysis

The flooding-induced initiating events are divided into three categories of causes:

a. Tank rupture events causing flooding

b. Maintenance-related events causing flooding

c. System pipe rupture events causing flooding

No tank ruptures are identified as causing unique effects or contributing to internal flooding events. Maintenance-induced flooding events are expected to be insignificant contributors to overall flooding risk. However, absent the availability of plant-specific maintenance procedures and equipment unavailability data, calculation of maintenance-induced flood frequency cannot be performed. The COL applicant will demonstrate that maintenance-induced floods are negligible contributors to risk when such information is available (COL 19.1(~~24~~ 23)).

A limited number of flood-vulnerable plant systems are identified for inclusion as potential flood sources, and are listed in below along with their corresponding rupture rate group as defined in EPRI 1021086 (Reference 46). Reasons for selecting these systems include:

a. The system has adequate inventory to present an obvious submergence threat.

b. The system piping is close to equipment that is important to accident mitigation.

c. The system itself is important to accident mitigation and could be made unavailable by a system pipe rupture.

Ruptures of the heat sinks for the SCS (component cooling and service water) are subsumed into general failures of the SCS and are not reanalyzed. Some CC system ruptures are retained because they could potentially fail a power supply and thus posed a broader threat than the loss of an SC train.

Consistent with the assumption one SDC train is operating during the first part of the outage and other SDC train is operating during the second part of the outage, the LPSD internal flooding analysis assumes that flood barriers separating the two divisions of the auxiliary building are maintained consistent with the internal flooding design basis during POS that SDC is required. Therefore, the propagation analysis developed for the at-power internal flooding analysis should be applicable to the LPSD flooding analysis when considering events that could cause failure of the operating SDC train.

Outage work is conducted on a train basis. That is, while work on train A equipment is planned, no maintenance is performed on any train B equipment and vice versa. This assumption regarding maintenance includes flood barriers separating the two divisions.

Additionally, the analysis assumes that auxiliary building flood barriers separating trains within a division are maintained consistent with the internal flooding design basis for the normally operating SDC train. The normally-operating SDC train is from the Division which is not scheduled for maintenance during that portion of the outage. Therefore, the propagation analysis developed for the at-power internal flooding analysis should be applicable to the LPSD flooding analysis when considering events that could cause failure of the operating SDC train. Maintenance-induced flooding events are expected to be insignificant contributors to overall flooding risk. However, absent the availability of plant-specific maintenance procedures and equipment unavailability data, calculation of maintenance-induced flood frequency cannot be performed. The COL applicant will demonstrate that maintenance-induced floods are negligible contributors to risk when such information is available (COL 19.1(~~24~~ 23)).

19.1.6.4.1.3 Accident Sequence

The AS development for LPSD flooding uses the loss of shutdown cooling sequences in the LPSD internal events analysis. While there are many initiating events (i.e., many floods that can fail one or both trains of SC), each unique IE use the same, basic loss of shutdown cooling (LOSC) event tree for the subsequent accident analysis.

respect to internal events, internal flood and fire events (fire barrier and fire barrier penetrations, routings and locations of pipe, cable, and conduit), and HRA analyses (development of operating procedures, emergency operating procedures, and severe accident management guidelines and training), external events including PRA-based seismic margins and HCLPF fragilities, and LPSD procedures. See Subsection 19.1.2.2.

COL 19.1(5) The COL applicant and/or holder is to conduct a peer review of the PRA relative to the industry PRA Standard prior to use of the PRA to support risk-informed applications, as applicable. See Subsection 19.1.2.3.

COL 19.1(6) The COL applicant is to describe the PRA maintenance and upgrade program. See Subsection 19.1.2.4.

COL 19.1(7) The COL applicant and/or holder is to develop management procedures for charging pump operation, following recovery from a loss of offsite power (LOOP), to ensure that deboration is not resumed until after at least one Reactor Coolant Pump (RCP) has been restarted.

COL 19.1(8) ~~The COL applicant is to confirm that the PRA-based seismic margin assessment is bounding for the selected site, and to update the assessment to include site-specific SSC and soil effects (including sliding, overturning liquefaction, and slope failure). The COL holder is to confirm that the as-built plant has adequate seismic margin and does not exceed the CDF and LRF design targets specified in Subsection 1.2.1.1.1 item e. See Subsection 19.1.5.1.2.~~

~~The COL applicant is to demonstrate that HCLPF capacity is equal to or exceed 1.67 times the GMRS for site-specific structures (ESWIS and CCW Hx Building).~~

~~The COL applicant is to demonstrate that HCLPF capacity is equal to or exceed 1.67 times the CSDRS for BOP components and is to complete the SEL.~~

~~The COL holder is to demonstrate that the seismic capacity for equipment qualified by testing should remain functionally operational within 1.67~~

times the required response spectra (CSDRS-based RRS) in the procurement specification.

Add "B"

COL 19.1(9) When developing post-earthquake safe shutdown procedures, the COL applicant and/or holder should consider the potential for multiple spurious alarms from photoelectric detectors following a seismic event.

COL 19.1(10) The COL applicant and/or holder needs to ensure that screened events do not have a site-specific susceptibility and do not exceed the CDF and LRF design targets specified in Subsection 1.2.1.1.1 item e. The COL applicant and/or holder is to address the following issues with a site-specific risk assessment, as applicable:

- Tsunami
- Aircraft crash event
- External flooding
- Extreme winds and tornadoes
- Industrial or military facility
- Lightning
- Pipeline accident
- Release of chemicals from onsite storage
- River diversion/River flooding
- Storm surge
- Toxic gas
- Transportation accidents

In addition, the COL applicant and/or holder is to ensure the site-specific susceptibility is not an outlier for the following issues, as applicable:

- Avalanche

RAI 434-8352 Question 19-92_Rev.4

RAI 434-8352 Question 19-92_Rev.5

"B"

The COL applicant will confirm and update from new information from the site, e.g. site features, design departures, etc, that the PRA-based seismic margin assessment is bounding for the selected site, site-specific SSC and soil effects (including sliding, overturning, liquefaction, and slope failure).

The COL applicant is to confirm that the as-built plant has adequate seismic margin and do not exceed the CDF and LRF design targets specified in Subsection 1.2.1.1.1 e. See Subsection 19.1.5.1.2.

The COL applicant is to demonstrate that site-specific structures (the turbine building, compound building, ESW IS and CCW HX building) have a HCLPF capacity that is equal to or greater than ~~0.5g~~ 1.67 times GMRS and will update the PRA-based seismic margin analysis with the site-specific structure HCLPF value, accordingly.

The COL applicant is to demonstrate that HCLPF capacity is equal to or exceed 1.67 times the CSDRS for BOP components and is to complete the SEL.

The COL applicant is to demonstrate that the seismic capacity for equipment and relay qualified by testing should remain functionally operational within 1.67 times the required response spectra (CSDRS based RRS) in the procurement specification.

The COL applicant is to demonstrate that the inherently rugged components identified in 19.1.5.1.1.2 have seismically rugged capacity.

The COL applicant is to demonstrate that the steam generator tube HCLPF is higher than HCLPF for the steam generator nozzle.

COL 19.1(18) The COL applicant is to describe the uses of PRA in support of licensee programs such as Maintenance Rule implementation during the operational phase. See Subsection 19.1.7.2.

COL 19.1(19) The COL applicant is to describe the uses of PRA in support of licensee programs such as the reactor oversight process during the operational phase. See Subsection 19.1.7.3.

COL 19.1(20) The COL holder is to perform the seismic-fire interactions walkdown to confirm a qualitative seismic-fire interaction assessment.

COL 19.1(21) The COL applicant and/or holder is to develop outage procedures to ensure that in fire compartments containing post-seismic or post-fire safe shutdown equipment that: 1) the seismic ruggedness of temporary ignition sources is adequate, or that the duration that these temporary ignition sources are in these areas is minimized, 2) the seismic ruggedness of temporary equipment such as scaffolding in fire compartments containing potential seismic-fire ignition sources, or near fire protection equipment is adequate, and 3) either the duration of activities which could impact manual firefighting is minimized, or alternative firefighting equipment (e.g., pre-stage portable smoke removal equipment, prestage additional firefighting equipment, etc.) is supplied.

~~COL 19.1(22) The COL applicant and/or holder is to demonstrate that failure of buildings that are not seismic Category I (e.g., turbine building and compound building) does not impact SSCs designed to be seismic Category I.~~

COL 19.1(~~23~~ 22) The COL applicant and/or holder is to ensure that asymmetric conditions due to modeling simplicity will be addressed or properly accounted for when the PRA is used for decision making.

COL 19.1(~~24~~ 23) The COL holder will demonstrate that maintenance-induced floods are negligible contributors to flood risk when the plant specific data are available.

COL 19.1(~~25~~ 24) SAMGs are entered to initiate SI with the core exit thermocouple indicating 1200°F.

COL 19.1(~~26~~ 25) The COL applicant and/or holder ensures that the fire protection features required for preventing fire-induced damage of the PRA-credited components will be properly incorporated in the cable design.

19.1.10 References

1. ASME/ANS RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications" (Revision 1 RA-S-2002), American Society of Mechanical Engineers, April 2008.

2. ASME/ANS RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008," American Society of Mechanical Engineers, February 2009.

3. Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," Rev. 2, U.S. Nuclear Regulatory Commission, March 2009.

4. NUREG/CR-2300, "PRA Procedures Guide," U.S. Nuclear Regulatory Commission, January 1983.

5. NUREG/CR-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," U.S. Nuclear Regulatory Commission, December 1990.

6. NUREG/CR-6850, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," U.S. Nuclear Regulatory Commission, September 2005.

7. APR1400-E-P-NR-14001-P, "PRA Summary Report," Rev. 0, KHNP.

8. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor Designs," U.S. Nuclear Regulatory Commission, Letter issued April 2, 1993 and Staff Requirements Memoranda issued July 21, 1993.

9. ANS/ASME-58-22-201x draft, "Low Power and Shutdown PRA Methodology," American Nuclear Society, American Society of Mechanical Engineers, July 2013.

10. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, June 2007.

Replaced with "C"

Table 19.1-4 (26 of 27)

No.	Insight	Disposition
	Risk Insights from PRA Models	
66	The COL applicant is to demonstrate that HCLPF capacity is equal to or exceed 1.67 times the GMRS for site-specific structures (ESWIS and CCW Hx Building) and HCLPF capacity is equal to or exceeds 1.67 times the CSDRS for BOP components, and is to complete the SEL. At the design certification phase, specific design data for the BOP components such as material properties, analysis results, qualification test information, etc. are not available. Appendix E of EPRI-NP-1002988 (Reference 58) presents example calculations showing that the equipment designed for 0.25g SSE can have 0.5g or higher HCLPF considering the conservatism in the design process. The EPRI-NP-6041 (Reference 39) indicates that Seismic Category I concrete structure and BOP equipment can have 0.5g HCLPF as long as the structure and the equipment are designed in accordance with the current code and standard and the anchorage is rugged. The generic fragility data provided by the Electric Power Research Institute (EPRI) Utility Requirements Document (Reference 37) show the BOP components have HCLPF capacities higher than 0.5g.	COL 19.1(8)
	The COL applicant is to demonstrate that failure of buildings that are not seismic Category I (e.g., turbine building and compound building) does not impact SSCs designed to be seismic Category I.	COL 19.1(22)
	The containment structure is assumed to have the same median capacity in shutdown configurations as it does for the full power fragility calculation. That is, collapse of the structure is not affected by whether or not the equipment hatch is removed or installed with four bolts. Additionally, failure of the containment to provide an effective fission product boundary during LPSD conditions when the equipment hatch installed using four bolts has the same fragility as for at-power conditions when the equipment hatch is installed with all bolts.	

"C"

The HCLPF capacity is equal to or exceeds 1.67 times the CSDRS for BOP components, and is to complete the SEL.	COL 19.1(8)
The COL applicant is to demonstrate that site-specific structures (the turbine building, compound building, ESW IS and CCW HX building) have a HCLPF capacity that is equal to or greater than ~~0.5g~~ 1.67 times GMRS and will update the PRA-based seismic margin analysis with the site-specific structure HCLPF value, accordingly.	COL 19.1(8)
The HCLPF for test equipment including relay need to be equal to or higher than 1.67 times CSDRS.	COL 19.1(8)
The COL applicant is to demonstrate that the inherently rugged components identified in 19.1.5.1.1.2 have seismically rugged capacity.	COL 19.1(8)
The important operator action and random failure event for PRA-based SMA should be managed by COL holder to improve the human error.	Subsection 19.1.5.1.2.4

Due to their low probability, common cause events are relatively low contributors to average plant risk; there are only 3 CCF events that have an FV value in excess of 0.5 percent, and all 3 relate to recovery from LOOP events.

19.1.6.4.2.5 Sensitivity Analysis

No sensitivity analyses have been performed for LPSD flooding, because its contribution to total LPSD and plant risk is very low.

19.1.6.4.2.6 Uncertainty Analysis

The parametric uncertainty results for Level 1 internal ~~fire~~ flooding CDF during LPSD are summarized below:

5 percent value: 3.2×10^{-8}/year

Mean value: 8.4×10^{-8}/year

95 percent value: 1.8×10^{-7}/year

Parametric uncertainty was represented by selecting an uncertainty distribution for each parameter type. Modeling uncertainty was not represented in the shutdown model.

19.1.6.4.2.7 Risk Insights

The general risk insight from the LPSD flooding analysis is that the APR1400 has been effectively designed to establish flood protection at shutdown. Specific insights are described below:

a. The overall LPSD internal flooding CDF is extremely low. This low frequency may be attributed primarily to the following factors: (1) low initiating event frequencies; (2) effective separation of divisions, for the SC pumps and their power supplies, via flood barriers; and (3) the large emergency overflow lines (EOLs), which serve as high capacity drains.

b. The dominant initiating event is a fire protection flood in room 78-A44B. This flood submerges both trains of the SC pumps as well as one power supply. This IE is the dominant risk contributor at 23 percent of the total internal flooding CDF.

The fault tree models include contributions due to the following:

- Random component failures
- Outages for maintenance and testing
- Support system failures
- CCFs
- Initiating events which affect the system
- Human errors involving failure to restore equipment to its operable state
- Human errors involving failure to perform procedural actions

Fault trees are developed to the level of detail for which existing data can be applied. For active systems, passive failures that are potentially significant are included.

General assumptions and conditions applied to system analysis are summarized below.

a. General modeling conditions:

1) Models reflect the design as-designed and as-to-be-built to the extent possible.

2) Systems that participate in the necessary response to events or that provide critical support to such systems are modeled.

3) Models reflect the success criteria for the systems to mitigate each identified accident sequence.

4) Models capture the impact of dependencies, including support systems and harsh environmental impacts.

5) Operator errors of commission are not included in the system model.

b. Conditions concerning level of detail

1) The level of detail in the model matches one for one the simplified diagrams and includes key active components and potential misaligned components based upon data availability.

Offsite power recovery for LOOP sequences that did not result in SBO has a significant impact on the LRF. The Level 2 analysis credits offsite power recovery in non-SBO LOOP sequences to estimate a more realistic LRF.

The ability to close the containment equipment hatch in POS 3B and 4A is significant. Without credit for hatch closure, these POS would yield an LRF of 2.5×10^{-8}/year. However, with credit for hatch closure, these two POS contribute 7.9×10^{-9}/year to the LRF (6.7 percent).

The LPSD CDF and LRF are highly dependent on the LPSD human error probabilities, as is expected for an LPSD PRA. To ensure that dependence between HEPs is properly evaluated, the LPSD Level 2 performed an HEP dependency analysis using the same methodology as the Level 1 PRA. Add "A"

19.1.6.3 Internal Fire PRA for Low Power and Shutdown Operations

The following subsections describe the development of the internal fires risk evaluation during low power and shutdown conditions, and the analysis results.

19.1.6.3.1 Description of Internal Fire PRA for Low Power and Shutdown Operations

The low power and shutdown (LPSD) fire PRA (FPRA) methodology for the APR1400 is based on NUREG/CR-7114 (Reference 52) and NUREG/CR-6850 (Reference 6). NUREG/CR-7114 provides a framework for quantitative analysis of fire risk during LPSD conditions. NUREG/CR-6850 provides a state-of-the-art methodology for fire PRAs. The steps in the LPSD fire PRA methodology are the same as those used in the at-power internal fire PRA (AP-FPRA) (see Subsection 19.1.5.2.1) with the exception that they are applied to the LPSD internal events model (see Subsection 19.1.6.1). The exceptions to the at-power FPRA methodology used in the development of the LPSD FPRA are described below. It should be noted that units for CDF and LRF are expressed in terms of “reactor calendar year” (shortened to “/year” when displayed in the text in this section).

19.1.6.3.1.1 Deviations from the Industry Methodology

All of the tasks described in Subsection 19.1.5.2.1 are required to perform a LPSD FPRA. These tasks involve various types of screening to eliminate assessment of non-risk-significant fire scenarios. Since the plant is in the design stage, some specific plant details

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RAI 434-8352 Question 19-92_Rev.5

The LPSD CDF and LRF are highly dependent on the LPSD human error probabilities, as is expected for an LPSD PRA. In the development of the LRF model, consistent with the CDF model, a floor HEP of 10^{-6} was applied to cutsets with a combined probability of all human errors below 10^{-6}. A sensitivity was performed examining what the impact to LRF would be if a floor HEP of 1E-5 was utilized. The result of the sensitivity was that the total LRF of POSs 4B-12A would increase from $7.0x10^{-8}$/year to $9.3x10^{-8}$/year (33 percent increase). The total LRF of all POSs would increase from $1.2x10^{-7}$/year to $1.4x10^{-7}$/year (20 percent increase). Therefore, the sensitivity demonstrates that the impact on the total LPSD LRF is small, and would not alter the conclusions of the DCD.

Table 19.1-16 (1 of 2)

Special Basic Events

Basic Event	Value	EF	Description	Data Source
MTC-UET-TTS-1	0.027	N/A	Adverse MTC UET percentage given turbine trip when no POSRVs fail	KEPCO E&C /ND/ TR/12-022 (Reference 69)
MTC-UET-TTS-2	0.3241	N/A	Adverse MTC UET percentage given turbine trip when 1 POSRV fails	
MTC-UET-TTS-3	0.4859	N/A	Adverse MTC UET percentage given turbine trip when 2 POSRV fail	
MTC-UET-TTS-4	0.7552	N/A	Adverse MTC UET percentage given turbine trip when 3 POSRV fail	
MTC-UET-TTF-1	0.2702	N/A	Adverse MTC UET percentage given turbine trip failure and no POSRVs fail	
MTC-UET-TTF-2	0.4320	N/A	Adverse MTC UET percentage given turbine trip failure when 1 POSRV fails	
MTC-UET-TTF-3	0.6475	N/A	Adverse MTC UET percentage given turbine trip failure when 2 POSRVs fail	
MTC-UET-TTF-4	0.8627	N/A	Adverse MTC UET percentage given turbine trip failure when 3 POSRVs fail	
RC-CSFP-CBO-ISO	**	1.05E-07*	Conditional seal failure probability given CBO is isolated within 20 min and RCS Cold Leg Subcooling < 50oF	WCAP-18067-P (Reference 64, Table 9.1-7)
RC-CSFP-NO-CBO-ISO	**	1.00E-07*	Conditional seal failure probability given CBO is NOT isolated within 20 min and RCS Cold Leg Subcooling < 50oF	WCAP-18067-P (Reference 64, Table 9.1-7)
RAC16H-PL	1.09E-01	34.25	Probability of non-recovery of offsite power within 16 hours after plant-centered LOOP	Analysis of LOOP events, 2014 update (Reference 67)
RAC16H-SW	1.25E-01	15.30	Probability of non-recovery of offsite power within 16 hours after switchyard-centered LOOP	Analysis of LOOP events, 2014 update (Reference 67)

Table 19.1-16 (2 of 2)

Basic Event	Value	EF	Description	Data Source
RAC16H-GR	5.34E-02	7.91	Probability of non-recovery of offsite power within 16 hours after grid-related LOOP	Analysis of LOOP events, 2014 update (Reference 67)
RAC16H-WE	3.73E-01	27.53	Probability of non-recovery of offsite power within 16 hours after weather-related LOOP	Analysis of LOOP events, 2014 update (Reference 67)
RAC12H-PL	1.36E-01	34.25	Probability of non-recovery of offsite power within 12 hours after plant-centered LOOP	Analysis of LOOP events, 2014 update (Reference 67)
RAC12H-SW	1.64E-01	15.30	Probability of non-recovery of offsite power within 12 hours after switchyard-centered LOOP	Analysis of LOOP events, 2014 update (Reference 67)
RAC12H-GR	8.30E-02	7.91	Probability of non-recovery of offsite power within 12 hours after grid-related LOOP	Analysis of LOOP events, 2014 update (Reference 67)
RAC12H-WE	4.29E-01	27.53	Probability of non-recovery of offsite power within 12 hours after weather-related LOOP	Analysis of LOOP events, 2014 update (Reference 67)
PFLOOP-NO-SI	2.0E-03	N/A	Conditional LOOP after Initiators which do not Initiate a SI Signal	EPRI Interim Technical Report, Section 3.1.5.3 (Reference 68)
PFLOOP-SI	2.0E-02	N/A	Conditional LOOP after Initiators which Initiate a SI Signal	EPRI Interim Technical Report (Reference 68)

* Variance provided in Reference ~~18~~ 64 is used as the uncertainty parameter.

** Values are provided in Reference 64 (Table 9.1-7).

Table 19.1-50 (45 of 46)

Rank	Cutset Prob.	Cum. %	BE Prob	Event	Event Description
97	8.01E-11	62.7%	2.86E-04	%F120-AGAC	FIRE IN F120-AGAC - GENERAL ACCESS AREA-120' C
			*	RC-CSFP-NO-CBO-ISO	COND. FAILURE PROB. OF RCP SEALS GIVEN FAILURE TO ISOLATE CBO WITHIN 20 MIN.
			1.20E-03	BF_F120-AGAC_F120-AGAD	BARRIER FAILURE BETWEEN FIRE COMPS F120-AGAC & F120-AGAD
98	7.90E-11	62.8%	1.75E-03	%F000-AFHL	FIRE IN F000-AFHL - FUEL HANDLING LOWER AREA
			9.00E-02	L2-PROB-RCSFAIL-2-2-LK	RCSFAIL DET - prob that SG-LEAK = 2OF2-LEAK
			9.00E-01	L2-PROB-RCSFAIL-NOSG-DEP	RCSFAIL DET - prob that SGDEPRESS = NO-DEPRESS
			9.76E-01	L2-PROB-RCSFAIL-NOSGSORV	RCSFAIL DET - prob that SGSORV = NO-DEPRESS
			8.89E-01	L2-PROB-RCSFAIL-NOSORV	RCSFAIL DET - probability that RCSSORV = Intact
			5.00E-01	L2-PROB-RCSFAIL-RCSDEPR	RCSFAIL DET - prob that CSSORV_LATE = RCS-DEPR
			1.07E-01	L2-PROB-RCSFAIL-SGTR-2D	RCSFAIL DET - prob that PI-SGTR = PI-SGTR (2 SGs depressurized)
			1.20E-05	PPSO-AP-LC	CCF OF PPS LC APPLICATION SOFTWARE

Table 19.1-50 (46 of 46)

Rank	Cutset Prob.	Cum. %	BE Prob	Event	Event Description
99	7.90E-11	62.8%	1.75E-03	%F000-AFHL	FIRE IN F000-AFHL - FUEL HANDLING LOWER AREA
			9.00E-02	L2-PROB-RCSFAIL-2-2-LK	RCSFAIL DET - prob that SG-LEAK = 2OF2-LEAK
			9.00E-01	L2-PROB-RCSFAIL-NOSG-DEP	RCSFAIL DET - prob that SGDEPRESS = NO-DEPRESS
			9.76E-01	L2-PROB-RCSFAIL-NOSGSORV	RCSFAIL DET - prob that SGSORV = NO-DEPRESS
			8.89E-01	L2-PROB-RCSFAIL-NOSORV	RCSFAIL DET - probability that RCSSORV = Intact
			5.00E-01	L2-PROB-RCSFAIL-RCSINT	RCSFAIL DET - prob that CSSORV_LATE = RCS-INTACT
			1.07E-01	L2-PROB-RCSFAIL-SGTR-2D	RCSFAIL DET - prob that PI-SGTR = PI-SGTR (2 SGs depressurized)
			1.20E-05	PPSO-AP-LC	CCF OF PPS LC APPLICATION SOFTWARE
100	7.86E-11	62.8%	2.86E-04	%F120-AGAC	FIRE IN F120-AGAC - GENERAL ACCESS AREA-120' C
			3.52E-02	AFTPR1A-TDP01A	AFW TDP PP01A FAILS TO RUN FOR > 1HR
			6.49E-03	AFTPS1B-TDP01B	AFW TDP PP01B FAILS TO START
			1.20E-03	BF_F120-AGAC_F120-AGAD	BARRIER FAILURE BETWEEN FIRE COMPS F120-AGAC & F120-AGAD

* Value is provided in Reference 64 (Table 9.1-7).

times the required response spectra (CSDRS-based RRS) in the procurement specification.

COL 19.1(9) When developing post-earthquake safe shutdown procedures, the COL applicant and/or holder should consider the potential for multiple spurious alarms from photoelectric detectors following a seismic event.

COL 19.1(10) The COL applicant and/or holder needs to ensure that screened events do not have a site-specific susceptibility and do not exceed the CDF and LRF design targets specified in Subsection 1.2.1.1.1 item e. The COL applicant and/or holder is to address the following issues with a site-specific risk assessment, as applicable:

- Tsunami
- Dam failure
- Aircraft crash event
- External flooding
- Extreme winds and tornadoes
- Industrial or military facility
- Lightning
- Pipeline accident
- Release of chemicals from onsite storage
- River diversion/River flooding
- Storm surge
- Toxic gas
- Transportation accidents

In addition, the COL applicant and/or holder is to ensure the site-specific susceptibility is not an outlier for the following issues, as applicable:

- Avalanche

- Biological events
- Coastal erosion
- Drought
- Forest fire
- High summer temperature
- Hurricane
- Landslide
- Low lake/river water level
- Low winter temperature
- Sandstorm
- ~~Tsunami~~
- Volcanic activity

See Subsection 19.1.5.4.

COL 19.1(11) The COL applicant and/or holder is to develop outage management procedures that limit planned maintenance that can potentially impair one or both SC trains during the shutdown modes.

COL 19.1(12) The COL applicant and/or holder is to develop procedures and a configuration management strategy to address the period of time when one SC train is unexpectedly unavailable (including the termination of any testing or maintenance that can affect the remaining train and restoration of all equipment to its nominal availability). The COL applicant is to ensure operation of the emergency diesel generator sequencer throughout low power and shutdown operations (not including defueled plant operating states).