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.:	**445-8537**
SRP Section:	**SRP 19**
Application Section:	**19.1**
Date of RAI Issue:	**03/16/2016**

Question No. 19-96

(Follow up to RAI 8348, Question 28564)

10 CFR 52.47(a)(27) requires that a standard design certification applicant provide a description of the design specific PRA.

SRP Chapter 19.0, Revision 3, Section "II. Acceptance Criteria," states that the staff determines whether, "…the applicant has performed risk importance studies at the system, train, and component level that adequately provide insights about (1) the systems that contribute the most in achieving the low risk level assessed in the PRA, (2) events (e.g., component failures or human errors) that contribute the most to decreases in the built-in plant safety level, and (3) events that contribute the most to the assessed risk."

To allow the staff to reach a reasonable assurance finding on APR1400 PRA technical adequacy and ensure that the APR1400 risk insights are adequately identified, please provide the following:

a) the initiating event importance measures for the at-power and low power and shutdown (LPSD) internal fire and flood scenarios in the DCD, and

b) for at-power and LPSD internal fires and floods, please evaluate the risk-significant scenarios with consideration of equipment damaged by the initiating fire or flood and confirm that no additional SSC failures or human failure events need to be considered risk significant beyond what has been identified in Tables 19.1-51 through 19.1-62 and Tables 19.1-68 through 19.1- 79. Otherwise, please make any necessary update to the risk-significant SSCs and operator actions in the DCD.

Response

a) The tables already exist for some of the information requested; specifically:

- the at power flooding initiating event importance for both CDF and LRF are presented in DCD Tables 19.1-64 (Internal Flooding PRA CDF Contribution by Top Flooding Induced Initiators) and 19.1-65 (Internal Flooding PRA LRF Contribution by Top Flooding Induced Initiators), respectively;

- the LPSD flooding initiating event importance for CDF are presented in DCD Tables 19.1-106 (LPSD Internal Flooding PRA CDF Contributions for Initiating Events - All POS) and 19.1-107 (LPSD Internal Flooding PRA CDF Contributions for Initiating Events - Reduced inventory).

- the LPSD fire initiating event importance for both CDF and LRF are presented in DCD Tables 19.1-120 (LPSD Internal Fire PRA CDF Contributions for Initiating Events – All POS) and 19.1-121 (LPSD Internal Fire PRA CDF Contributions for Initiating Events – Reduced Inventory), respectively, and Tables 19.1-151 (LPSD Internal Fire PRA LRF Contribution by Initiating Events – All POS) and 19.1-152, respectively (LPSD Internal Fire PRA LRF Contribution by Initiating Events – Reduced Inventory POS), respectively.

- Note that LPSD flooding LRF is not calculated, and due to low frequency is conservatively assumed to be bounded by the CDF.

However, similar tables for at-power fire were not provided, rather tables showing the relative importance of at-power fire-induced initiating events were provided in Tables 19.1-47 and 19.1-48 for CDF and LRF, respectively. Therefore, DCD Tables 19.1-47 and 19.1-48 are being replaced with tables containing at-power fire scenario initiating event importance for both CDF and LRF (see Attachment).

b) First recall that the APR1400 DC PRA model is an asymmetric model which has assumed equipment alignments. Because of this, it is understood that equipment in certain trains will have different importance values, and the determination of risk significance for any component takes into consideration the equipment in each train of the system. So, if a component in any train of a system is risk significant, all like components in all trains of the system are considered risk significant.

Further recall that the impacts of fires and floods are incorporated into the APR1400 DC PRA model via the use of scenario flag files which set the appropriate equipment failure mode basic events for each damaged component or cable to logical TRUE prior to quantification. Due to the physical layout of the APR1400 plant, the damage from fire and flood scenarios are limited to 1 or 2 trains or a single division of equipment. Hence, the equipment available to mitigate the event is a subset of each damaged system’s equipment resulting in the inherent increase in importance of the undamaged train (e.g., if a fire damages the A SI train, the importance of the B, C and D SI trains are magnified due to the loss in system redundancy.) Since the determination of risk significance for equipment is based on review of the importance measures for all trains, the increase in importance of the undamaged equipment in fire or flood events will tend to result in the inclusion of more equipment in the risk significance list, and is not expected to mask equipment importance.

Regarding operator actions, the impact of equipment damage on operator action importance is implicitly determined via quantification. Since, due to the physical plant layout of the APR1400 plant, fire and flood damage does not result in full system failure, setting failed equipment to logical TRUE does not result in the elimination of operator actions from the system logic. Hence, the operator action importance can be calculated directly from the existing cutsets.

In conclusion, due to the methodology used in the APR1400 DC PRA to determine component risk significance and the fact that the impact of fire or flood induced equipment damage is to increase the importance of undamaged equipment, and since the impact of the equipment damage will not eliminate operator actions from the system model, there are no additional components or operator actions which need to be added to the list of risk significant equipment for fire and flood.

Impact on DCD

The DCD will be revised as shown in the Attachment.

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.

etc.). Potential MCA compartments are screened if the exposed compartment has no PRA-credited equipment since the resulting cutsets will be non-minimal to the exposing single-compartment scenario. In addition, potential scenarios involving either the main turbine building (F000-TB) or the containment building (F000-C01) are screened due to the size and geometry, which preclude the formation of a hot gas layer or oil fire spread. In total, 1,055 unscreened MCA scenarios are identified and evaluated. MCA scenarios account for about 14 percent of the CDF and 13 percent of the LRF.

19.1.5.2.2 Results from the Internal Fire Risk Evaluation

The internal fire risk evaluation is performed using the design-specific fire protection features in Chapter 9, Appendix 9A and the internal events PRA model of Subsection 19.1.4.

The fire CDF and LRF for the APR1400 are as follows:

a. Fire CDF: 1.9×10^{-6}/year

   1) Single-compartment fire CDF: 1.6×10^{-6}/year

   2) Multi-compartment fire CDF: 2.6×10^{-7}/year

b. Fire LRF: 1.7×10^{-7}/year

   1) Single-compartment fire LRF: 1.5×10^{-7}/year

   2) Multi-compartment fire LRF: 2.2×10^{-8}/year

c. Conditional large release probability: 0.09

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).

19.1.5.2.2.1 Fire-Induced Initiating Events

Significant Fire initiating events that contribute to the CDF and the LRF are shown in Table 19.1-47 and Table 19.1-48, respectively.

Table 19.1-46 shows the percentages of fires resulting in each identified fire-induced internal event initiator, ranked highest to lowest. ~~Table 19.1-47 and Table 19.1-48 present the CDF and LRF, respectively, for each fire-induced initiator ranked from highest to lowest.~~ The results show that the vast majority of the plant fire frequencies result in

general transients with the remaining initiators fairly evenly distributed. This demonstrates the effectiveness of the highly compartmentalized nature of the auxiliary building, wherein most fires will result in damage to only a few components.

~~Review of the fire-induced initiator impact on CDF and LRF reveals that the majority (about 60 percent) of all fire-induced CDF and LRF is from an MCR evacuation and loss of dc bus "B"; general transients and LOOPs make up the next significant impact, with about 30 percent of fire-induced CDF and LRF. The remaining fire-induced initiators are well distributed and not significant contributors. The MCR evacuation case's impact is all from a single fire compartment (e.g., the MCR). This disproportionate amount can be partly explained by the lack of procedures governing safe shutdown during MCR evacuation at the plant design stage; hence, an estimate of 0.1 is used as a conditional core damage probability (CCDP). A conditional large release probability (CLRP) of 0.01 is used based on the CCDP estimate, 0.1, and the calculated overall conditional large release probability, 0.09.~~

19.1.5.2.2.2 Significant Fire Scenarios

The top 100 fire PRA CDF cutsets are presented in Table 19.1-49, and the top four dominant CDF fire scenarios are described below:

#1 – F 157-AMCR-4-4 Trans Fire, Supp. Fails, ASD

Scenario F157-AMCR-4-4 involves unsuppressed transient fires in fire compartment F157-AMCR, the MCR. The MCR analysis assumes the operators have approximately 8 minutes to extinguish a transient fire before visual obscuration results in the need to evacuate the MCR and shut down from the remote shutdown console (RSC). The 8-minute time frame is based on the estimated time to the peak heat release rate common trash can fires and a review of room effects testing published in NUREG/CR-4527. An estimated CCDP of 0.1 is assumed for alternate shutdown (ASD) from the RSC. Note that due to the lack of fire PRA-credited equipment in the MCR, and use of fiber-optic cable for almost all MCR controls, the resulting initiator is likely a simple transient as no PRA-credited equipment is directly damaged by the fire, and spurious operations resulting in more complicated initiators are unlikely.

Replace to A

Table 19.1-47

Internal Fire PRA CDF Contribution by Top Fire Induced Initiators

~~Event~~	~~Description~~	~~CDF (/yr)~~	~~Contribution~~
~~MCR EVAC~~	~~Fire Induced Main Control Room Evacuation~~	~~6.03E-07~~	~~32.4%~~
~~LODCB~~	~~Fire Induced Loss of DC Bus B~~	~~4.80E-07~~	~~25.8%~~
~~GTRN~~	~~Fire Induced General Transient~~	~~2.96E-07~~	~~15.9%~~
~~LOOP~~	~~Fire Induced Loss of Offsite Power~~	~~2.44E-07~~	~~13.1%~~
~~PLOCCW~~	~~Fire Induced Partial Loss of CCW~~	~~1.27E-07~~	~~6.8%~~
~~LODCA~~	~~Fire Induced Loss of DC Bus A~~	~~4.86E-08~~	~~2.6%~~
~~LOCV~~	~~Fire Induced Loss of Condenser Vacuum~~	~~2.98E-08~~	~~1.6%~~
~~SLOCA~~	~~Fire Induced Small LOCA~~	~~1.95E-08~~	~~1.0%~~
~~LOFW~~	~~Fire Induced Loss of Feedwater~~	~~9.09E-09~~	~~0.5%~~

A(1/2)

Table 19.1-47 (1 of 2)

Internal Fire PRA CDF Contribution by Top Fire Induced Initiators

#	Basic Event ID	Frequency (/yr)	Contribution	Description
1	%F157-AMCR-4-4	2.36E-06	14.7%	FIRE IN F157-AMCR - TRANSIENT FIRE - UNSUPPRESSED - ASD
2	%F157-AMCR-3-4	1.52E-06	9.8%	FIRE IN F157-AMCR - SAFETY CONSOLE FIRE - UNSUPPRESSED - ASD
3	%F078-A19B-U	7.24E-04	9.2%	FIRE IN F078-A19B - CORRIDOR - UNSUPPRESSED
4	%F122-T01-U	7.61E-04	5.6%	FIRE IN F122-T01-U - F122-T01 - UNSUPPRESSED
5	%F078-A05D-U	3.17E-04	5.4%	FIRE IN F120-A05C - ELECTRICAL EQUIPMENT RM C - UNSUPPRESSED
6	%F157-AMCR-1-4	7.56E-07	4.7%	FIRE IN F157-AMCR - CCTV FIRE - UNSUPPRESSED - ASD
7	%F157-AMCR-2-4	7.56E-07	4.7%	FIRE IN F157-AMCR - FIRE CONTROL PANEL FIRE - UNSUPPRESSED - ASD
8	%F000-TB-LOOP2	4.70E-04	4.6%	FIRE IN F000-TB-LOOP2 - TB FIRES -LOOP
9	%F100-T15-U	5.39E-04	4.0%	FIRE IN F100-T15 - SWITCHGEAR RM - UNSUPPRESSED
10	%F078-A52D-U	3.48E-04	3.6%	FIRE IN F078-A52D - 480V N1E MCC RM - UNSUPPRESSED
11	%F120-A05C-U	2.98E-04	2.2%	FIRE IN F120-A05C - ELECTRICAL EQUIPMENT RM C - UNSUPPRESSED
12	%F157-AMCR-6-4	3.43E-07	2.1%	FIRE IN F157-AMCR - CABLE W/C FIRE - UNSUPPRESSED - ASD
13	%F157-A25C-U	1.68E-04	1.6%	FIRE IN F157-A25C - I & C EQUIP. RM - UNSUPPRESSED
14	%F137-A11C-U	1.95E-05	1.5%	FIRE IN F137-A11C – ELECTRICAL PENETRATION RM - UNSUPPRESSED
15	%F000-TB-LOCV2	3.18E-03	1.5%	FIRE IN F000-TB - TB FIRES LEADING TO LOCV

A(2/2)

Table 19.1-47 (2 of 2)

#	Basic Event ID	Frequency (/yr)	Contribution	Description
16	%F157-A01D-U	1.69E-04	1.4%	FIRE IN F157-A01D - I & C EQUIP. RM - UNSUPPRESSED
17	%F078-AEEB-U	1.35E-04	1.3%	FIRE IN F078-AEEB - CLASS 1E SWITCHGEAR 01B ROOM - UNSUPPRESSED
18	%F100-A08C-U	5.02E-04	1.3%	FIRE IN F100-A08C - N1E DC & IP EQUIPMENT RM C - UNSUPPRESSED
19	%F120-AGAC-U	2.01E-04	1.3%	FIRE IN F120-AGAC - GENERAL ACCESS AREA-120' C - UNSUPPRESSED
20	%F100-AEEB-U	3.01E-04	1.2%	FIRE IN F100-AEEB - 480V CLASS 1E MCC 01B RM - UNSUPPRESSED
21	%F000-TB-GTRN	3.23E-02	0.8%	FIRE IN F000-TB-GTR - TB FIRES - GTRN
22	%F067-T02-U	7.75E-05	0.8%	FIRE IN F067-T02 - UNDERGROUND COMMON TUNNEL - UNSUPPRESSED
23	%F000-ACVU-U	2.10E-04	0.7%	FIRE IN F000-ACVU - CVCS SYSTEM AREA - UNSUPPRESSED
24	%F120-A15B-U	1.73E-04	0.7%	FIRE IN F120-A15B - 480V CLASS 1E MCC 03B RM - UNSUPPRESSED
25	%FN-N00	2.76E-03	0.6%	FIRE IN FN-N00 – AAC T/G BUILDING FIRE - GTRN
26	%F120-A11B-U	5.45E-05	0.6%	FIRE IN F120-A11B - GENERAL ACCESS AREA-120' B - UNSUPPRESSED
27	%F055-AGAD	3.99E-04	0.5%	FIRE IN F055-AGAD - GENERAL ACCESS AREA-55' D - GTRN
28	%F000-ADGC	1.40E-03	0.5%	FIRE IN F000-ADGD - DG01D ROOM - PLOCCW
29	%F078-AGAD-U	3.55E-05	0.5%	FIRE IN F078-AGDA - DG01A ROOM - UNSUPPRESSED FIRES
30	%F078-A03D	3.11E-04	0.4%	FIRE IN F000-ADGD – CLASS !E LOAD CENTER 01D RM - GTRN

Replace to B

Table 19.1-48

Internal Fire PRA LRF Contribution by Fire Induced Initiators

~~Event~~	~~Description~~	~~LRF (/yr)~~	~~Contribution~~
~~MCR EVAC~~	~~Fire Induced Main Control Room Evacuation~~	~~6.03E-08~~	~~35.7%~~
~~LODCB~~	~~Fire Induced Loss of DC Bus B~~	~~5.19E-08~~	~~30.7%~~
~~GTRN~~	~~Fire Induced General Transient~~	~~1.60E-08~~	~~9.4%~~
~~LOOP~~	~~Fire Induced Loss of Offsite Power~~	~~2.76E-08~~	~~16.3%~~
~~PLOCCW~~	~~Fire Induced Partial Loss of CCW~~	~~6.21E-09~~	~~3.7%~~
~~LODCA~~	~~Fire Induced Loss of DC Bus A~~	~~4.35E-09~~	~~2.6%~~
~~LOCV~~	~~Fire Induced Loss of Condenser Vacuum~~	~~1.73E-09~~	~~1.0%~~
~~SLOCA~~	~~Fire Induced Small LOCA~~	~~7.53E-10~~	~~0.4%~~
~~LOFW~~	~~Fire Induced Loss of Feedwater~~	~~5.14E-10~~	~~0.3~~%

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Table 19.1-48 (1 of 2)

Internal Fire PRA LRF Contribution by Top Fire Induced Initiators

#	Basic Event ID	Frequency (/yr)	Contribution	Description
1	%F157-AMCR-4-4	2.36E-06	16.0%	FIRE IN F157-AMCR - TRANSIENT FIRE - UNSUPPRESSED - ASD
2	%F157-AMCR-4-4	1.52E-06	10.3%	FIRE IN F157-AMCR - TRANSIENT FIRE - UNSUPPRESSED - ASD
3	%F157-A01D-U	1.69E-04	8.7%	FIRE IN F157-A01D - I & C EQUIP. RM - UNSUPPRESSED
4	%F122-T01-U	7.61E-04	6.8%	FIRE IN F122-T01-U - F122-T01 UNSUPPRESSED
5	%F078-AEEB-U	1.35E-04	6.5%	FIRE IN F078-AEEB - CLASS 1E SWITCHGEAR 01B ROOM - UNSUPPRESSED
6	%F000-TB-LOOP2	4.70E-04	6.1%	FIRE IN F000-TB-LOOP2 - TB FIRES LEADING TO LOOP (SEVERE)
7	%F120-AGAC	7.56E-07	5.1%	FIRE IN F120-AGAC - GENERAL ACCESS AREA-120' C
8	%F157-AMCR-3-4	7.56E-07	5.1%	FIRE IN F157-AMCR - SAFETY CONSOLE FIRE - UNSUPPRESSED - ASD
9	%F120-AGAD-U	5.39 E-04	4.6%	FIRE IN F120-AGAD - GENERAL ACCESS AREA-120' D - UNSUPPRESSED
10	%F078-A52D-U	3.48E-04	3.1%	FIRE IN F078-A52D - 480V N1E MCC RM - UNSUPPRESSED
11	%F120-A11B-U	5.45 E-05	2.7%	FIRE IN F120-A11B - GENERAL ACCESS AREA-120' B - UNSUPPRESSED
12	%F157-AMCR-6-4	3.43E-07	2.3%	FIRE IN F157-AMCR - CABLE W/C FIRE - UNSUPPRESSED - ASD
13	%F078-A19B-U	7.24E-04	2.2%	FIRE IN F078-A19B - CORRIDOR - UNSUPPRESSED
14	%F120-A05C-U	2.98E-04	1.5%	FIRE IN F120-A05C - ELECTRICAL EQUIPMENT RM C - UNSUPPRESSED
15	%F078-A05D-U	3.17 E-04	1.5%	FIRE IN F120-A05C - ELECTRICAL EQUIPMENT RM C - UNSUPPRESSED

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Table 19.1-48 (2 of 2)

#	Basic Event ID	Frequency (/yr)	Contribution	Description
16	%F157-A25C-U	1.68E-04	1.1%	FIRE IN F157-A25C - I & C EQUIP. RM - UNSUPPRESSED
17	%F055-AGAC-U	2.10E-04	1.1%	FIRE IN F055-AGAC - GENERAL ACCESS AREA-55' C - UNSUPPRESSED
18	%F000-TB-LOCV2	3.18E-03	1.0%	FIRE IN F000-TB - TB FIRES LEADING TO LOCV
19	%F067-T02-U	7.75E-05	1.0%	FIRE IN F067-T02-U – F067-T02 UNSUPPRESSED
20	%F100-AEEB-U	3.10E-04	0.8%	FIRE IN F100-AEEB - 480V CLASS 1E MCC 01B RM - UNSUPPRESSED
21	%FN-N00	2.76E-03	0.7%	FIRE IN FN-N00 – AAC T/G BUILDING FIRE LEADING TO GTRN
22	%F000-TB-GTRN	3.23E-02	0.6%	FIRE IN F000-TB-GTR - TB FIRES LEADING TO GTRN
23	%F000-ACVU-U	2.10E-04	0.5%	FIRE IN F000-ACVU - CVCS SYSTEM AREA - UNSUPPRESSED
24	%F100-A08C-U	5.02E-04	0.5%	FIRE IN F100-A08C - N1E DC & IP EQUIPMENT RM C - UNSUPPRESSED
25	%F120-A15B-U	1.73E-04	0.5%	FIRE IN F120-A15B - 480V CLASS 1E MCC 03B RM - UNSUPPRESSED
26	%F055-AGAD-U	3.55E-05	0.4%	FIRE IN F055-AGAD - GENERAL ACCESS AREA-55' D – UNSUPPRESSED
27	%F137-A11C-U	1.95E-05	0.4%	FIRE IN F137-A11C – ELECTRICAL PENETRATION RM - UNSUPPRESSED
28	%F000-RW	8.77E-03	0.4%	FIRE IN F000-RW– ACCESS AREA FIRES - GTRN
29	%F120-A01C	1.28E-05	0.2%	FIRE IN F120-A01C – PIPING CABLE AREA RM - LODCA
30	%F055-AGAD	3.99E-04	0.3%	FIRE IN F055-AGAD - GENERAL ACCESS AREA-55' D - GTRN