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.:	**418-8348**
SRP Section:	**SRP 19**
Application Section:	**19.1**
Date of RAI Issue:	**02/23/2016**

Question No. 19-47

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 (Draft), Section "II. Acceptance Criteria," states that the staff determines whether,"…the technical adequacy of the PRA is sufficient to justify the specific results and risk insights that are used to support the DC or COL application. Toward this end, the applicant's PRA submittal should be consistent with prevailing PRA standards, guidance, and good practices as needed to support its uses and applications and as endorsed by the NRC (e.g., RG 1.200)."

To allow the staff to reach a reasonable assurance finding on APR1400 PRA technical adequacy, please:

a) Include in the design control document (DCD) the basis for excluding the fire-induced opening of POSRVs as an initiating event

b) If power is removed from certain valves to prevent the inadvertent opening of the POSRVs, discuss in the DCD how this configuration and relevant procedures are addressed in the PRA models and in the HRAs for the feed and bleed operation.

Response

a) The following change will be added to DCD 19.1.5.2.1.2 as shown in Attachment 1. "Spurious opening of pressurizer Pilot Operated Safety Relief Valves (POSRVs) due to a fire is not considered, because the power to the POSRVs is removed during normal operation and can only be provided by manual operator action."

   POSRV consists of main valve (RC-200/RC-201/RC-202/RC-203), two pairs of motor operated pilot valves (RC-130,131/RC-132,133/RC-134,135/RC-136,137), two pairs of

spring-loaded pilot valves (RC-300,301/RC-302,303/RC-304, 305/RC-306, 307), two pairs of motor-operated isolation valves (RC-120,121/RC-122, 123/RC-124, 125/RC-126,127) and two pairs of manual isolation valve (RC-310,311/RC-312, 313/RC-314, 315/RC-316, 317).

- Spring-loaded pilot valves (RC-300,301/RC-302,303/RC-304, 305/RC-306, 307) are operated automatically dependent on set pressure.

- Motor operated pilot valves (RC-130,131/RC-132,133/RC-134,135/RC-136,137) are normally closed and power of one of two valves for each POSRV (RC-130/RC-132/RC0134/RC-136) is racked out outside control room for preventing spurious operation during plant operation (alarm on power connected) and opened by operator for feed and bleed operation.

- Motor-operated isolation valves (RC-120,121/RC-122, 123/RC-124, 125/RC-126,127 are normally open but are manually closed by an operator to prevent discharge when spring-loaded pilot valves fail to (re)close.

- Manual isolation valves (RC-310,311/RC-312, 313/RC-314, 315/RC-316, 317) are closed in case of maintenance and set-point test of spring-loaded pilot valves.

b) The design concept of POSRV is described in DCD Section 1.5.2 and typical diagram of POSRVs is presented in DCD Figure 5.4.14-1.

- The opening of POSRVs for feed and bleed operation are needed for remote and manual operation by operators. It is described in DCD Section 1.5.2 as “The motor-operated pilot valves are normally closed, but an operator remotely and manually opens the valves to open the main valve for the rapid depressurization of the RCS.”

- When one of two motor-operated pilot valves fails to open, bleed operation for feed and bleed operation is inoperable, thus fail to open of motor operated pilot valves are considered in PRA model.

- The remotely and manually operation of POSRVs is considered in HFEs (RCOPH-S-SDSE and RCOPH-S-SDSL) for Feed and Bleed (F&B) operation in HRA as shown in the Attachment 2.

Impact on DCD

DCD 19.1 will be revised to reflect the response of this RAI.

The contents for explaining for excluding the fire-induced opening of POSRVs as an initiating event will be added in the DCD 19.1.5.2.1.2 as shown in the Attachment 1

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 Environment Report.

limit the spread of oil fires. Therefore, fire spread to adjacent fire compartments from the turbine building is not considered credible. Likewise, hot gases entering the turbine building from an adjacent fire compartment via a failed barrier will be directed upwards and out the numerous roof vents; hence, fire spread to the turbine building is not considered credible (Task 11).

n. Due to the size of the containment building (F000-C01), any hot gas layer formed would be near the top of the dome. This is true regardless of whether the fire originated within containment, or entered containment via a failed barrier from the auxiliary building. The top of the dome is well over 45.7 m (150 ft) above the highest cable tray in containment and the highest penetrations to the auxiliary building. Therefore, any hot gas layer formation in the containment would not be located where it is credible to assume: 1) damage to cables within containment, and 2) spread into the auxiliary building. Therefore, potential fire spread scenarios from or to the containment building are not considered credible (Task 11).

o. It is assumed that automatic suppression systems are designed so that, if successfully activated, they will extinguish the fire prior to additional damage beyond the ignition source itself. Hence, if the ignition source is not a fire PRA-credited component, successful operation of the automatic suppression system will result in a general transient (likely a manual trip) with no PRA-credited equipment damaged. If the ignition source is a PRA-credited component, and the automatic suppression system successfully operates, the fire-induced initiator will be dependent upon the ignition source (e.g., fire in dc bus A will result in LODCA initiator), but will only involve the failure of the ignition source. Failure of an automatic suppression system is assumed to result in full room burnout and possible spread to adjacent compartments.

p. Spurious opening of pressurizer Pilot Operated Safety Relief Valves (POSRVs) due to a fire is not considered, because the power to the POSRVs is removed during normal operation and can only be provided by manual operator action.

19.1.5.2.1.3 Analysis ~~Details~~

Task 1, Plant Boundary and Partitioning, is conducted in two parts. The first activity involves definition of the global plant analysis boundary, which is defined to be the plant protected area and switchyard; however, it does not include all of the licensee-controlled areas. Notable facilities that are located within the licensee-controlled area but not in the global plant analysis boundary include the engineering building, wastewater treatment

RCOPH-S-SDSE-FW, Operator Fails to Open POSRVs in Early Phase for F&B Operation

Plant	Data File	File Size	File Date	Record Date
APR1400-DC	APR1400_DC_HRA-Rev .10.hra	1806336	07/24/13	07/24/13
	Name			**Date**
Analyst	Namcheol Kim			
Reviewer	Kisu Kim			

HEP Summary				
	P_{cog}	P_{exe}	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	2.0e-02	3.4e-02		
With Recovery	4.1e-03	5.1e-03	9.1e-03	5

Identification and Definition
1. Initial Conditions : Steady state, full power operation 2. Initiating Events: GTRN, SGTR, SLOCA, SBO, PR-SL, PLOESW, PLOCCW, LSSB-U, LSSB-D, LOOP, LOIA, LOFW, LODCA, LODCB, LOCV, GRID-LOOP, FWLB 3. Preceding operator error or success in sequence : N/A 4. Operator action success criterion : Operator should open POSRV(s) for RCS heat removal. 5. Consequence of failure : Core Damage 6. Definition : In this HFE, RCS heat removal using SG is failed and temperature of RCS cold leg rises. Thus operator opens POSRVs for RCS heat removal. The POSRVs operation is performed with FRG HR-3.

Assigned Basic Events

Cues and Indications	
Initial Cue	S/G Low Level
Recovery Cue	Step 7 of HR-3 in EOG-10
Cue Comments	
Degree of Clarity	Very Good

Procedures and Training	
Cognitive Procedure	EOG-07 (Revision: 0)
Cognitive Step Number	7
Cognitive Instruction	Entry into EOG-10, HR-03
Execution Procedure	EOG-10, HR3 (Revision: 0)
Job Performance Measure	
Classroom Training	None
Simulator Training	None
Notes	

The procedure and training information is not available in DC phase. However, APR1400 EOG is used and training is assumed for this operator action.

Crew Member	Total Available	Required for Execution	Notes
Shift Supervisor	1	0	
STA	1	0	
Reactor Operator	1	1	
Turbine Operator	1	0	
Electrical Operator	1	0	
Local Reactor Operator	2	1	
Local Turbine Operator	2	0	

Dependencies (Related Human Interactions)

Key Assumptions

Operator Interview Insights
Operator interview is not available in DC phase.

Timing Analysis	
T_{sw}	60.00 Minutes
T_{delay}	0.00 Minutes
$T_{1/2}$	28.00 Minutes
T_M	15.00 Minutes
Time available for recovery	17.00 Minutes
SPAR-H Available time (cognitive)	45.00 Minutes
SPAR-H Available time (execution) ratio	2.13
Minimum level of dependence for recovery	MD

Notes

MAAP analysis shows that if F&B is succeeded within 60 min, it is possible to prevent core damage.
For LOFW Event with Early F&B, (refer to Table 5-9 1(a) ~ 1(f) of the Success Criteria Notebook)
1. Rx Trip : 0 hr (22.126 sec)
2. Core Uncovery : 0.88 hr (3171.808 sec)
3. F&B completion timing : 70 min
4. Core Damage : no occurrence within 24 hours
5. CSAS Generation : 7.2 hr (28162.430 sec)

[EOG Driven Action]
* T0 = LOFW
* Tsw = 60 min (F&B completion by MAAP Analysis)
* Td = 0 min
* T1/2 = 28 min (SPTA EOG + DA EOG + EOG-07 steps #7 + FRG HR-3 step #7, 15+7+6)
* Tm = 15 min (power recovery at local and manual opening of POSRVs)

Cognitive Analysis		
Pc Failure Mechanism	**Branch**	**HEP**
P_{ca}: Availability of Information	a	neg.
Notes: Operator can access to all information and required indication to operate a plant in the main control room.		
P_{cb}: Failure of Attention	i	neg.
Notes: In general, within 2 hours from accident initiation, work load is assumed to be high for CBDTM unless the work load relevant to a specific HFE cannot be judged appropriately. This HFE is to open POSRVs manually and thus the operator only performs and one-time check of SG level and status of related components and variables. It is not necessary to check them continuously. It's assumed that the indicator to be checked is always displayed on the front panel of the MCR because all of the controls in the modern control room are expected to be located in the front of the room. It is assumed that operators concentrate on EOG and performs EOG-driven actions after reactor trip. Thus operators can not respond to alarms until related parameter are mentioned in the EOG step.		
P_{cc}: Misread/miscommunicate data	a	neg.
Notes: It is assumed that required indicator on the control board such as layout, demarcation, labeling and others is always located easily. With the advanced digital I&C interface in the MCR, the indication is assumed to be "good" unless there are scenario specific considerations to warrant otherwise, in which case, justification for the deviation will be provided. It is assumed that formal communications will always be used when the specified value is transferred between operators.		
P_{cd}: Information misleading	b	3.0e-03
Notes: In this HFE, the related parameter values dose not satisfy the range of EOG description values and related system does not respond automatically(i.e. Failure of RCS heat removal by secondary side). Thus operators recover RCS heat removal with POSRVs. The EOG provides contingeny actions which are instructions on how to proceed if the cue states are not as stated.		
P_{ce}: Skip a step in procedure	a	1.0e-03
Notes: It's assumed that it's always transparent for operators to proceed the relevant instruction or stand-alone numbered step on the EOGs. The MCR operator is not required to use an an additional procedure in addition to the EOG, so "single" branch is selected for this HFE. Only if there are special or distinct marks are provided in the procedure, "YES" branch in the "Graphically Distinct" should be selected. For this operator action, related procedure step is hold point step and has graphically distinct. The use of placekeeping aids is always assumed to be used due to the nature of the computerized procedure system (CPS) software, i.e., the operator will be required to confirm completion of a step as the procedural items are addressed. Scenarios for which deviations from this assumption are possible, justification for the choice made will be provided.		
P_{cf}: Misinterpret Instructions	a	neg.
Notes: It is generally assumed that the wording of the procedures will be standard versus ambiguous for the Misinterpret Instruction decision tree, pcf, of the CBDTM. The step present all information required to identify the actions directed and their objects.		

P_{cg}: Misinterpret decision logic	A	1.6e-02
Notes: If diagnosis is performed just after EOG-01 completion, select sequence (a) or (b) because "NOT, AND, OR, BOTH AND and OR" are present through EOG01 and EOG02. Otherwise, "No" branch should be selected on the "NOT Statement" branch. The operators are always trained and practiced about specified scenario to perform.		
P_{ch}: Deliberate violation	a	neg.
Notes: The operators are always assumed to believe in the adequacy of instruction presented.		
Initial P_c(without recovery credited)		2.0e-02
Notes		
Equipment Accessibility	MCR: Accessible	

Cognitive Recovery											
	Initial HEP	**Self Review**	**Extra Crew**	**STA Review**	**Shift Change**	**ERF Review**	**Recovery Matrix**	**Dependency Level**	**Multiply HEP By**	**Override Value**	**Final Value**
Pc_a	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Pc_b	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Pc_c	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Pc_d	3.0e-03	-	-	X	-	-	N/A	MD	1.5e-01		4.5e-04
Pc_e	1.0e-03	-	-	-	-	-	N/A	-	1.0e+00		1.0e-03
Pc_f	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Pc_g	1.6e-02	-	-	X	-	-	N/A	MD	1.6e-01		2.6e-03
Pc_h	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Final Pc (with recovery credited)											4.1e-03
Notes											
STA review is possible through RCS heat removal section of SFSC.											

Execution Performance Shaping Factors		
Special Requirements	Tools	Adequate
	Parts	Adequate
	Clothing	Adequate
Environment	Lighting	Normal
	Heat	Normal
	Radiation	Background
	Atmosphere	Normal
Equipment Accessibility	Local - SWGR Room	Accessible
Stress	**High**	
	Plant Response As Expected:	No
	Workload:	N/A
	Performance Shaping Factors:	N/A
Notes		
This HFE is to recover RCS heat removal after the failure of RCS heat removal with secondary side. This operator action have to be performed under limited condition to prevent undesired plant state.		
Execution Complexity	Simple	

Execution Unrecovered							
Procedure: EOG-10, HR3, Functional Recovery Guideline - Core and RCS Heat Removal Once-Through-Cooling		**Comment**				**Stress Factor**	**Over Ride**
Step No.	**Instruction/Comment**	**Error Type**	**THERP**		**HEP**		
			Table	**Item**			
EOG-10, HR-3, #2-d.1	Ensure electrical pwer is available to motor operated pilot valves.						
	Location: Local (Outside MCR)	EOM	20-8a	1	1.3e-03	5	
		EOC	20-12	8a	2.7E-4		
					Total Step HEP		7.9e-03
EOG-10, HR-3, #7-1	Confirm POSRV open status - POSRV leakage alarm and associated POSRV discharge line temperature						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-9	2	1.3E-3		
					Total Step HEP		8.7e-03
EOG-10, HR-3, #7-2	Manually open ALL motor operated pilot valves.						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-12	4	1.3E-3		
					Total Step HEP		8.7e-03
EOG-10, HR-3, #8	Verify the motor operated pilot valves are fully opened.						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-9	2	1.3E-3		
					Total Step HEP		8.7e-03
EOG-10, HR-3, #9	If pressurizer pressure is less than or equal to low pressurizer pressure SIAS setpoint, then ensure SIAS is actuated.						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-12	3	1.3E-3		
					Total Step HEP		8.7e-03
EOG-10, HR-3, #10-b	Verify SI flow of each pump is greater than SI flow delivery curve.						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-9	2	1.3E-3		
					Total Step HEP		8.7e-03

Execution Recovered							
Critical Step No.	**Recovery Step No.**	**Action**	**HEP (Crit)**	**HEP (Rec)**	**Dep.**	**Cond. HEP (Rec)**	**Total for Step**
EOG-10, HR-3, #2-d.1		Ensure electrical pwer is available to motor operated pilot valves.	7.9e-03				1.2e-03
	EOG-10, HR-3, #8	Verify the motor operated pilot valves are fully opened.		8.7e-03	MD	1.5e-01	
EOG-10, HR-3, #7-1		Confirm POSRV open status - POSRV leakage alarm and associated POSRV discharge line temperature	8.7e-03				1.3e-03
	EOG-10, HR-3, #8	Verify the motor operated pilot valves are fully opened.		8.7e-03	MD	1.5e-01	
EOG-10, HR-3, #7-2		Manually open ALL motor operated pilot valves.	8.7e-03				1.3e-03
	EOG-10, HR-3, #8	Verify the motor operated pilot valves are fully opened.		8.7e-03	MD	1.5e-01	
EOG-10, HR-3, #9		If pressurizer pressure is less than or equal to low pressurizer pressure SIAS setpoint, then ensure SIAS is actuated.	8.7e-03				1.3e-03
	EOG-10, HR-3, #10-b	Verify SI flow of each pump is greater than SI flow delivery curve.		8.7e-03	MD	1.5e-01	
		Total Unrecovered:	3.4e-02			**Total Recovered:**	5.1e-03

RCOPH-S-SDSL, Operator Fails to Open POSRVs in Late Phase for F&B Operation

Plant	Data File	File Size	File Date	Record Date
APR1400-DC	APR1400_DC_HRA-Rev .10.hra	1806336	07/24/13	07/24/13
	Name			**Date**
Analyst	Namcheol Kim			
Reviewer	Kisu Kim			

HEP Summary				
	P_{cog}	P_{exe}	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	2.0e-02	3.4e-02		
With Recovery	3.2e-03	5.1e-03	8.3e-03	5

Identification and Definition
1. Initial Conditions : Steady state, full power operation 2. Initiating Events: GTRN, SGTR, SLOCA, SBO, PR-SL, PLOESW, PLOCCW, LSSB-U, LSSB-D, LOOP, LOIA, LOFW, LODCA, LODCB, LOCV, GRID-LOOP, FWLB 3. Preceding operator error or success in sequence : N/A 4. Operator action success criterion : Operator should open POSRV(s) for RCS heat removal. 5. Consequence of failure : Core Damage 6. Definition : In this HFE, RCS heat removal using SG is failed and temperature of RCS cold leg rises. Thus operator opens POSRVs for RCS heat removal. The POSRVs operation is performed with FRG HR-3.

Assigned Basic Events	
Cues and Indications	
Initial Cue	S/G Low Level
Recovery Cue	Step 8 of HR-3 in EOG-10
Cue Comments	
Degree of Clarity	Very Good

Procedures and Training	
Cognitive Procedure	EOG-07 (Revision: 0)
Cognitive Step Number	7
Cognitive Instruction	Entry into EOG-10, HR-03
Execution Procedure	EOG-10, HR3 (Revision: 0)
Job Performance Measure	
Classroom Training	None
Simulator Training	None
Notes	
The procedure and training information is not available in DC phase. However, APR1400 EOG is used and training is assumed for this operator action.	

Crew Member	Total Available	Required for Execution	Notes
Shift Supervisor	1	0	
STA	1	0	
Reactor Operator	1	1	
Turbine Operator	1	0	
Electrical Operator	1	0	
Local Reactor Operator	2	1	
Local Turbine Operator	2	0	

Dependencies (Related Human Interactions)

Key Assumptions

Operator Interview Insights
Operator interview is not available in DC phase.

Timing Analysis	
T_{sw}	240.00 Minutes
T_{delay}	0.00 Minutes
$T_{1/2}$	31.00 Minutes
T_M	15.00 Minutes
Time available for recovery	194.00 Minutes
SPAR-H Available time (cognitive)	225.00 Minutes
SPAR-H Available time (execution) ratio	13.93
Minimum level of dependence for recovery	ZD

Notes

For LOFW Event with Late F&B, (refer to Table 5-9 2(a) ~ 2(f) of the Success Criteria Notebook)
1. Rx Trip : 0 hr (22.126 sec)
2. AFAS Generation : 0 hr (152.599 sec)
3. SHR Failure : 8.5 hr (30604.176 sec)
4. F&B completion timing : 12.5 hr
5. Core Damage : no core damage

[EOG Driven Action]
* T0 = SHR Failure
* Tsw = 240 min (F&B completion, assumption based on MAAP Analysis)
* Td = 0 min
* T1/2 = 31 min (SPTA EOG + DA EOG + SFSC + FRG HR-3 step #7, 15+10+6)
* Tm = 15 min (power recovery at local and manual opening of POSRVs)

Cognitive Analysis		
Pc Failure Mechanism	**Branch**	**HEP**
P_{ca}: Availability of Information	a	neg.
Notes: Operator can access to all information and required indication to operate a plant in the main control room.		

P_{cb}: Failure of Attention	a	neg.
Notes: In general, within 2 hours from accident initiation, work load is assumed to be high for CBDTM unless the work load relevant to a specific HFE cannot be judged appropriately. This HFE is to open POSRVs manually and thus the operator only performs and one-time check of SG level and status of related components and variables. It is not necessary to check them continuously. It's assumed that the indicator to be checked is always displayed on the front panel of the MCR because all of the controls in the modern control room are expected to be located in the front of the room.		
P_{cc}: Misread/miscommunicate data	a	neg.
Notes: It is assumed that required indicator on the control board such as layout, demarcation, labeling and others is always located easily. With the advanced digital I&C interface in the MCR, the indication is assumed to be "good" unless there are scenario specific considerations to warrant otherwise, in which case, justification for the deviation will be provided. It is assumed that formal communications will always be used when the specified value is transferred between operators.		
P_{cd}: Information misleading	b	3.0e-03
Notes: In this HFE, the related parameter values dose not satisfy the range of EOG description values and related system does not respond automatically(i.e. Failure of RCS heat removal by secondary side). Thus operators recover RCS heat removal with POSRVs. The EOG provides contingeny actions which are instructions on how to proceed if the cue states are not as stated.		
P_{ce}: Skip a step in procedure	a	1.0e-03
Notes: It's assumed that it's always transparent for operators to proceed the relevant instruction or stand-alone numbered step on the EOGs. The MCR operator is not required to use an an additional procedure in addition to the EOG, so "single" branch is selected for this HFE. Only if there are special or distinct marks are provided in the procedure, "YES" branch in the "Graphically Distinct" should be selected. For this operator action, related procedure step is hold point step and has graphically distinct.		
P_{cf}: Misinterpret Instructions	a	neg.
Notes: It is generally assumed that the wording of the procedures will be standard versus ambiguous for the Misinterpret Instruction decision tree, pcf, of the CBDTM. The step present all information required to identify the actions directed and their objects.		
P_{cg}: Misinterpret decision logic	a	1.6e-02
Notes: If diagnosis is performed just after EOG-01 completion, select sequence (a) or (b) because "NOT, AND, OR, BOTH AND and OR" are present through EOG01 and EOG02. Otherwise, "No" branch should be selected on the "NOT Statement" branch. The operators are always trained and practiced about specified scenario to perform.		
P_{ch}: Deliberate violation	a	neg.
Notes: The operators are always assumed to believe in the adequacy of instruction presented.		
Initial P_c(without recovery credited)		2.0e-02
Notes		
Equipment Accessibility	MCR: Accessible	

Cognitive Recovery											
	Initial HEP	Self Review	Extra Crew	STA Review	Shift Change	ERF Review	Recovery Matrix	Dependency Level	Multiply HEP By	Override Value	Final Value
Pc_a	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Pc_b	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Pc_c	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Pc_d	3.0e-03	-	-	X	-	-	N/A	MD	1.5e-01		4.5e-04
Pc_e	1.0e-03	X	-	-	-	-	N/A	MD	1.4e-01		1.4e-04
Pc_f	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Pc_g	1.6e-02	-	-	X	-	-	N/A	MD	1.6e-01		2.6e-03
Pc_h	neg.	-	-	-	-	-	N/A	-	1.0e+00		
Final Pc (with recovery credited)											3.2e-03
Notes											
STA review is possible through RCS heat removal section of SFSC. CPS provides the tool to prevent skip a step in the procedure. Therefore self review is available for pce.											

Execution Performance Shaping Factors		
Special Requirements	Tools	Adequate
	Parts	Adequate
	Clothing	Adequate
Environment	Lighting	Normal
	Heat	Normal
	Radiation	Background
	Atmosphere	Normal
Equipment Accessibility	Local - SWGR Room	Accessible
Stress	**High**	
	Plant Response As Expected:	No
	Workload:	N/A
	Performance Shaping Factors:	N/A
Notes		
This HFE is to recover RCS heat removal after the failure of RCS heat removal with secondary side. This operator action have to be performed under limited condition to prevent undesired plant state.		
Execution Complexity	Simple	

Execution Unrecovered							
Procedure: EOG-10, HR3, Functional Recovery Guideline - Core and RCS Heat Removal Once-Through-Cooling		**Comment**				**Stress Factor**	**Over Ride**
Step No.	**Instruction/Comment**	**Error Type**	**THERP**		**HEP**		
			Table	**Item**			
EOG-10, HR-3, #2-d.1	Ensure electrical pwer is available to motor operated pilot valves.						
	Location: Local (Outside MCR)	EOM	20-8a	1	1.3e-03	5	
		EOC	20-12	8a	2.7E-4		
					Total Step HEP		7.9e-03
EOG-10, HR-3, #7-1	Confirm POSRV open status - POSRV leakage alarm and associated POSRV discharge line temperature						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-9	2	1.3E-3		
					Total Step HEP		8.7e-03
EOG-10, HR-3, #7-2	Manually open ALL motor operated pilot valves.						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-12	4	1.3E-3		
					Total Step HEP		8.7e-03
EOG-10, HR-3, #8	Verify the motor operated pilot valves are fully opened.						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-9	2	1.3E-3		
					Total Step HEP		8.7e-03
EOG-10, HR-3, #9	If pressurizer pressure is less than or equal to low pressurizer pressure SIAS setpoint, then ensure SIAS is actuated.						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-12	3	1.3E-3		
					Total Step HEP		8.7e-03
EOG-10, HR-3, #10-b	Verify SI flow of each pump is greater than SI flow delivery curve.						
	Location: MCR	EOM	20-7b	1	4.3e-04	5	
		EOC	20-9	2	1.3E-3		
					Total Step HEP		8.7e-03

Execution Recovered							
Critical Step No.	**Recovery Step No.**	**Action**	**HEP (Crit)**	**HEP (Rec)**	**Dep.**	**Cond. HEP (Rec)**	**Total for Step**
EOG-10, HR-3, #2-d.1		Ensure electrical pwer is available to motor operated pilot valves.	7.9e-03				1.2e-03
	EOG-10, HR-3, #8	Verify the motor operated pilot valves are fully opened.		8.7e-03	MD	1.5e-01	
EOG-10, HR-3, #7-1		Confirm POSRV open status - POSRV leakage alarm and associated POSRV discharge line temperature	8.7e-03				1.3e-03
	EOG-10, HR-3, #8	Verify the motor operated pilot valves are fully opened.		8.7e-03	MD	1.5e-01	
EOG-10, HR-3, #7-2		Manually open ALL motor operated pilot valves.	8.7e-03				1.3e-03
	EOG-10, HR-3, #8	Verify the motor operated pilot valves are fully opened.		8.7e-03	MD	1.5e-01	
EOG-10, HR-3, #9		If pressurizer pressure is less than or equal to low pressurizer pressure SIAS setpoint, then ensure SIAS is actuated.	8.7e-03				1.3e-03
	EOG-10, HR-3, #10-b	Verify SI flow of each pump is greater than SI flow delivery curve.		8.7e-03	MD	1.5e-01	
		Total Unrecovered:	3.4e-02			**Total Recovered:**	5.1e-03

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.:	**418-8348**
SRP Section:	**SRP 19**
Application Section:	**19.1**
Date of RAI Issue:	**02/23/2016**

Question No. 19-48

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 (Draft), Section "II. Acceptance Criteria," states that the staff determines whether, "…the technical adequacy of the PRA is sufficient to justify the specific results and risk insights that are used to support the DC or COL application. Toward this end, the applicant's PRA submittal should be consistent with prevailing PRA standards, guidance, and good practices as needed to support its uses and applications and as endorsed by the NRC (e.g., RG 1.200)."

The staff reviewed the applicant's human reliability analysis (HRA) performed to support the internal fire PRA, for both at-power and LPSD conditions, and found that a sufficient description of the HRA is not available in the DCD. Please include in the DCD a summary of the HRA performed to support the internal fire analysis for both at-power and LPSD conditions, and include any relevant assumptions used.

Response

DCD Section 19.1.5.2.1.3 will be revised to include additional detail on the full power internal fire HRA (see Attachment 1). This analysis was based on the screening methodology described in Section 5.1 of NUREG-1921, and will be updated in the next PRA update to use the latest approved HRA methodologies.

DCD Section 19.1.6.3.1.3 will be revised to include additional detail on the LPSD internal fire HRA (see Attachment 2).

Also, the HRA for full power and LPSD internal fire PRAs will be updated using the latest industry accepted methodologies (e.g., ASEP, THERP, etc.)

Impact on DCD

The DCD will be revised to include additional detail on the full power and LPSD internal fire HRA as shown in the Attachments 1 and 2, respectively.

Impact on PRA

The fire HRA will be revised for both the full power and LPSD internal fire analyses using the latest plant procedures available, and using the latest applicable HRA approved methods.

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 Environment Report.

In the next step, Task 6, a fire ignition frequency is estimated for each identified ignition source and each fire compartment. This task is conducted in accordance with the methodology and information provided in Task 6 of NUREG/CR-6850 (Reference 6). Deviations from the methodology of NUREG/CR-6850 have been necessary as a result of further clarifications documented in Supplement 1 of NUREG/CR-6850 (Reference 41). Furthermore, the generic fire frequencies provided in NUREG/CR-6850 are not used in this analysis; rather, the updated generic fire frequencies from EPRI 1016735 (Reference 43) are used.

The text is inserted as shown in A

Task 7 screens fire compartments from further detailed analysis. There are no set screening criteria for fire-induced CDF or LRF. Rather, the criteria chosen are with the intent of achieving Capability Category II in accordance with Table 4-2.8-4(c) of the ASME/ANS PRA Standard, which suggests that the criteria should not screen the highest-risk fire areas, and the sum of the CDF and LRF contributors for all screened compartments is less than 10 percent of the total fire CDF and LRF. The process is iterative in that performing detailed analysis decreases the overall CDF and LRF, resulting in the need to perform detailed analysis on additional fire compartments.

Based on initial screening quantifications, detailed analysis was performed on 38 fire compartments, including the MCR, reactor containment building, and turbine building. The results of the fire compartment screening are listed in Table 19.1-45. Unscreened fire compartments are evaluated, resulting in the development of two or more unique fire scenarios. In total, there are 481 single compartment analysis (SCA) scenarios developed, of which 128 are the result of detailed analysis; the remaining 353 scenarios are the screened fire compartment full-room burnout scenarios. The CDF sum of all screened fire compartments is 1.6×10^{-7}/year, which is less than 10 percent of the total fire CDF of 1.9×10^{-6}/year (and 10 percent of the total single-compartment CDF of 1.6×10^{-6}/year). The LRF sum of all screened fire compartments is 1.1×10^{-8}/year, which is less than 10 percent of the total fire LRF of 1.7×10^{-7}/year (and less than 10 percent of the total single-compartment LRF of 1.5×10^{-7}/year). In addition, the highest unscreened CDF and LRF scenario (both are the complete room burnout of the AAC Building, FN-N00) resulted in about 0.6 percent (9.2×10^{-9}/year) of the total CDF, and about 0.7 percent (1.0×10^{-9}/year) of the total LRF. This indicates that the highest-risk fire areas are not screened.

No fire modeling is performed due to lack of sufficient data related to the relational location of the ignition sources and their targets (including intervening combustibles). Therefore,

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Prior to the initial quantification used to support the Task 7 quantitative screening analysis, the impacts of fires on human actions were initially all evaluated using the Screening HRA Quantification method detailed in Section 5.1 of NUREG-1921 (Reference 42). The NUREG-1921 screening process method assigns screening values by addressing the conditions that can influence crew performance during fires, ensuring that the time available to perform the necessary action is appropriately considered (given the other on going activities in the accident sequence), and ensuring that potential dependencies among HFEs modeled in a given accident sequence are addressed.

The NUREG-1921 screening process assign an HFE to one of four "Sets" for a given fire scenario based on screening criteria. In addition, the analysis must ensure that potential dependencies across HFEs in the models are addressed; that is, that the fire effects and the addition of any new fire-related HFEs to the model do not significantly alter the dependencies among the internal events HFEs and their associated HEPs.

In addition, the impacts of fires of local manual operator actions is addressed. Local operator actions are initially placed into an HEP Set as described above, and then an assessment is made to determine if fire scenarios result in any other impact on local operator actions. If a fire scenario places no additional restrictions on the local operator action, then the HEP value remains as assigned. However, local operator actions which require the operator to perform the task inside the same fire compartment as the postulated fire are assumed to fail. This is based on the assumption that even though the fire may be extinguished prior to the action taking place, the equipment required to perform the action is damaged beyond repair at least for the duration of the mission time.

In addition, local operator actions which require the operator to travel through the same fire compartment as the postulated fire to get to the local area(s) where the action(s) are to take place are assumed to fail. An exception is granted for local manual actions which do not need to be performed within the first 8 hours. The basis for this exception is that by 8 hours: 1) the fire will likely have been extinguished for several hours, 2) smoke removal equipment should have cleared the area of smoke or other combustion products which the operator must pass through, and 3) cleanup in the area should have been ongoing for several hours leaving a path for the operator.

After the initial Task 7 quantification, detailed HEP analysis was performed on the top 10 HFEs when ranked by Fussell-Vesely (F-V) importance. F-V is the appropriate risk metric to use as high F-V HFEs drive the CDF and LRF results. Having a more realistic HEP for these high F-V HFEs will have the most impact on estimating a more realistic CDF and LRF. HFEs with a low F-V importance will not affect the CDF and LRF very much, and thus their recalculation will likely not add any realism to the analysis. These 10 HEPs were incorporated in the final quantification.

Multiple compartment analysis (MCA) considers the potential for fire propagation from one fire compartment to an adjacent compartment via a failed fire barrier. Screening was performed to eliminate non-minimal MCA scenarios or scenarios deemed unlikely to occur due to lack of a credible fire spreading mechanism. Potential MCA compartments were screened if:

a. The exposed compartment has no PRA-credited equipment, since the resulting cutsets will be non-minimal to the exposing single-compartment scenario, or

b. When the exposing compartment is at a higher elevation than the exposed compartment, and there are no doors, dampers, or penetration seals in the barrier between the two compartments, and there are no oil fires in the exposing compartment since the potential for the hot gas layer descending below the fire source through a solid rated fire barrier is considered incredible. Note that oil fires are explicitly excluded in this screening process, since the potential to spread the fire via draindown to the lower elevation compartment is potentially credible and cannot be excluded without further detailed analysis.

c. In addition, potential scenarios involving either the main turbine building (fire compartment F000-TB) or the containment building (fire compartment F000-C01) were screened due to the size and geometry of the compartment, which preclude the formation of a hot gas layer or oil fire spread (see Key Assumptions in Subsection 19.1.6.3.1.2).

The potential for failure of barriers was evaluated in accordance with the methodology in NUREC/CR-6850, and considering Key Assumptions in Subsection 19.1.6.3.1.2). Risk-significant barriers can be identified by reviewing the importance analysis for the basic events associated with the barrier failures. Specifically, the RAW value of the barrier failure basic event enumerates the risk impact of the failed barrier, and helps identify which barriers are important to fire risk.

The text is inserted as shown in A

The LPSD Fire Level 2 analysis follows a similar approach as described for the LPSD internal events (Subsection 19.1.6.4.1), with some differences noted here. POS 1-4A and 13-15 are treated similar to the internal events LPSD Level 2.

For POS 4B-12A, as for the internal events LPSD Level 2, the single-compartment Level 1 fire scenarios are evaluated in detail for contribution to LRF. The only exception is the

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Task 12, Human Reliability Analysis (HRA), calculates the LPSD fire human failure event (HFE) probabilities. This task modified the existing internal events LPSD HFE probabilities to incorporate the postulated effects a fire may have on the ability of the operators to execute an action in the context of a fire. The existing LPSD HFE probabilities were calculated as described in DCD Section 19.1.6.1.1.6, and the LPSD HRA was conducted by modifying the these HFEs for fire scenarios by applying a systematic set of adjustments. NUREG-1921 (Reference 42) provides detailed guidance for PRA/HRA analysts to either re-evaluate HFEs completed for an internal events model given the additional presence of a fire, or to create completely new HFEs which are unique only to fire scenarios. NUREG-1921 goes beyond the guidance provided in NUREG/CR-6850 which developed only high level guidance on identifying and incorporating HFEs into the fire PRA. Throughout the analysis, ongoing feasibility of the action is considered. Feasibility analysis in the fire HRA assesses whether the operator action can be accomplished in the context associated with the response to a fire-induced initiating event. For example, if modifications made to the HFE resulted in an insufficient time to complete the analysis, the HFE was set to 1.0

The LPSD Fire Level 2 analysis follows a similar approach as described for the LPSD internal events (Subsection 19.1.6.4.1), with some differences noted here. POS 1-4A and 13-15 are treated similar to the internal events LPSD Level 2.