



Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-16-129

August 3, 2016

10 CFR 50.90

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 29, Response to Request for Additional Information**

- References:
1. Letter from TVA to NRC, CNL-15-169, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU)," dated September 21, 2015 (ML15282A152)
 2. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Request for Additional Information Related to License Amendment Request Regarding Extended Power Uprate (CAC Nos. MF6741, MF6742, and MF6743)," dated July 21, 2016 (ML16194A229)

By the Reference 1 letter, Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) for the Extended Power Uprate (EPU) of Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3. The proposed LAR modifies the renewed operating licenses to increase the maximum authorized core thermal power level from the current licensed thermal power of 3458 megawatts to 3952 megawatts. The Reference 2 letter provided an Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) related to probabilistic risk assessment. The due date for the response to NRC RAI APLA-RAI 09.01, provided by the Reference 2 letter, is August 12, 2016. The enclosure to this letter provides the response to NRC RAI APLA-RAI 09.01.

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TVA has reviewed the information supporting a finding of no significant hazards consideration and the environmental consideration provided to the NRC in the Reference 1 letter. The supplemental information provided in this submittal does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration. In addition, the supplemental information in this submittal does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed license amendment. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter to the Alabama State Department of Public Health.

There are no new regulatory commitments associated with this submittal. If there are any questions or if additional information is needed, please contact Edward D. Schrull at (423) 751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 3rd day of August 2016.

Respectfully,



J. W. Shea
Vice President, Nuclear Licensing

Enclosure: Response to NRC Request for Additional Information APLA-RAI 09.01

cc:

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
State Health Officer, Alabama Department of Public Health

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Response to NRC Request for Additional Information APLA-RAI 09.01

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APLA-RAI 09.01

In RAI No. APLA-RAI 09, dated April 14, 2016, the NRG staff requested the licensee to explain how several human error probabilities (HEPs) were quantified for both the extended power uprate (EPU) and CL TP in order to confirm the reasonableness of these calculations and to understand why the increase in some HEPs are much larger than others. In response to APLA-RAI 09 dated April 27, 2016, the licensee discussed the quantification of these HEPs for both the EPU and CLTP. The response stated for human failure event (HFE) HFFAOASD_RCIC that "the dependency levels are higher [a medium dependency was assigned for the CL TP case and a high dependency was assigned for the EPU case] for the abandonment action due to the longer execution time and stress levels." It is not clear why the HEP for HFFAOASD_RCIC is increased by only a factor of 1.15 at the CL TP level to the EPU level, while HEP for HFEs HFA_0002RPV_LVL and HFA_OHCIINIT30 are increased by much larger factors (i.e., a factor of 2.76 and 2.04, respectively).

The staff observed that the execution analysis in the Electric Power Research Institute (EPRI) human reliability analysis (HRA) calculation sheet for HFFAOASD_RCIC includes 9 procedure steps, with recovery considered only in procedure step 1. Procedure steps 2 through 9, which are considered "high" stress, did not credit recovery because of an assumption made for the HEP of each step (i.e., "it is better to use item Ref. 8a [that is a HEP value of 2×10^{-4}] even though it is for normal stress and then not credit a recovery step"). Not crediting recovery in procedure steps 2 through 9 for HFFAOASD_RCIC causes the HEPs associated with these steps to be the same between the CL TP and EPU. This results in a smaller increase in total HEP for HFFAOASD_RCIC, between the CLTP and EPU cases, than that had recovery been credited, potentially leading to underestimating the change in risk. When recovery is credited in each procedure step, the EPU HEP for HFFAOASD_RCIC could be 3 times larger (not 1.15 times larger as currently indicated by Attachment 44 of the EPU LAR) than that for the CL TP case. This issue may also apply to other HFEs considered in the EPU risk evaluation, such as those HFEs identified in Part 1 below.

The staff requests the licensee to address the following:

- a. Provide the detailed HRA calculation sheets (e.g., as generated by the EPRI HRA calculator) for the following HFEs for both the CL TP and EPU cases:*
 - HFA_0003PMP START ("Operator fails to restart RFW [reactor feedwater] after Level 8 trip")*
 - HFA_0071 L8RESTART ("Operator fails to restart RCIC [reactor core isolation cooling] after Level 8 trip")*

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- HFA_0073L8RESTART ("Operator fails to restart HPCI [high pressure coolant injection] after Level 8 trip")
 - HFFA_1 SHV0760540_35 ("Local action - close 1-SHV-076-0540 (2- and 3- for Units 2 and 3) within 35 minutes")
 - HFFA0268480CRSTIE ("Failure to transfer deenergized 480V board to alternate supply (fire)")
 - HFFAOASD_RCIC ("Operator fails to start RCIC")
- b. For each internal events and fire HFE considered in the EPU risk evaluation (i.e., HFEs in Tables 4-4 and 4-9 of Attachment 44 of the EPU LAR) that have a different dependency level between the CL TP and EPU cases, confirm that recovery is appropriately represented in the HFE's cognitive analysis and execution analysis such that the total HEP is realistically estimated for the CL TP and EPU cases. If it is not, then update the associated HEPs for the CL TP and EPU cases to appropriately address recovery, and provide the updated HEPs along with an explanation of how they were changed (provide sufficient detail and numerical values to understand the basis for the updated HEPs).
- c. If changes were made to the HEPs in Part b of this RAI, then provide:
1. Updated risk results in Sections 5.1 ("Internal Event Results"), 5.2 ("Fire Risk Results"), and 5.6 ("Total Risk") in Attachment 44 of the EPU LAR, as applicable. If Regulatory Guide (RG) 1.17 4 risk acceptance guidelines are exceeded, then please provide a detailed justification to support the conclusion that no "special circumstances" are created by the proposed EPU, include a discussion of which metrics are exceeded and the conservatisms in the analysis and the risk significance of these conservatisms.
 2. Updated risk results in Table 8-1 ("Summary Risk Results for the Combined Sensitivity Study") of the response to APLA-RAI 08, dated April 27, 2016. If RG 1.17 4 risk acceptance guidelines are exceeded, then provide a detailed justification to support the conclusion that no "special circumstances" are created by the proposed EPU, include a discussion of which metrics are exceeded and the conservatisms in the analysis and the risk significance of these conservatisms.

TVA Response:

Response to RAI 09.01 a.

The requested detailed Human Reliability Analysis (HRA) calculation sheets are provided in Attachment 1 of this RAI response. While the text of the HRA Calculator sheets was updated for clarity and to add more explanations, the selections made for the cognitive and execution evaluations and the associated HEPs were not altered. The human failure events (HFEs) included in this document are listed below.

HFA_0003PMP_START-CLTP
HFA_0003PMP_START-EPU
HFA_0071L8RESTART-CLTP
HFA_0071L8RESTART-EPU

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HFA_0073L8RESTART-CLTP
HFA_0073L8RESTART-EPU
HFFA_1SHV0760540_35-CLTP
HFFA_1SHV0760540_35-EPU
HFFA0268480CRSTIE-CLTP
HFFA0268480CRSTIE-EPU
HFFA0ASD_RCIC-CLTP
HFFA0ASD_RCIC-EPU

Response to RAI 09.01 b.

For the HFEs on the list in item a., there is no difference in Execution Recovery step assignment between the Current Licensed Thermal Power (CLTP) and Extended Power Uprate (EPU) cases; the Recovery is applied to particular steps of the procedure and does not change for the two cases. The assignment of recovery steps was reviewed and considered appropriate for the errors modeled.

The difference between the CLTP and EPU human error probabilities (HEPs) for these HFEs is therefore due to the timing differences from the Modular Accident Analysis Program (MAAP) runs for the two cases and the impact that has on the Cognitive portion of the HEP, if credited, and the dependency level for the recovery actions.

Application of recovery to the Execution steps is part of the analytical process of HRA. It is based upon the analyst's identification and evaluation of the steps that will be reviewed by another operator. A combination of operational and HRA experience and an understanding of the specific procedures is used to make these determinations.

When there are multiple Execution steps in an HFE, it is common for the analyst to apply recovery to combinations of steps rather than to each individual one, based on the analyst's knowledge of how the actions are taken and reviewed. In the case of the HFFA0ASD_RCIC action, it is considered likely that the operator will go through the steps to do the switch transfers and the check will happen afterwards.

An additional analytical variable is the selection of the type of Execution failure and associated HEP in HRA Calculator from Technique for Human Error Rate Prediction (THERP). In the case of HFFA0ASD_RCIC, the selection available did not match well the type of error being modeled and the variation in HEPs for these selections is significant.

The primary error for HFFA0ASD_RCIC is that the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. The error associated with THERP Table 20-12, Item 8c (Reference 1) is for both high stress and violation of a stereotype (this was incorrectly called "prototype" in the HFE). In this case, there is no stereotype violation, but the choices available to the analyst are limited. Selection of Item 8c would have resulted in an exceptionally high HEP of 1.3E-01. Therefore, the analyst elected to use Item 8a with a more appropriate HEP of 2.7E-04, even though it is for normal stress, and then not credit a recovery step that would have lowered the HEP even further.

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In summary, the analyst evaluated the Execution actions taken in HFFA0ASD_RCIC and determined that recovery would not have been applied for each individual switch action based on experience with such actions, and had to apply the most reasonable HEP from the THERP options provided in HRA Calculator, given that the error mode choices available did not completely match the situation.

In the set of HFEs whose different timing data led to a changed dependency level between the CLTP and EPU cases, HFE HFFA0ASD_RCIC was the only action with a combination of 1) recovery not applied to every step and 2) an execution failure mode applied that did not match well with the type of error.

For the HFEs cited for comparison in the RAI, HFA_0002RPV_LVL and HFA_0HCIINIT30, there is only one Execution step, so recovery was applied to that single action step. The analysis in these cases is much more straightforward.

The HFEs of Tables 4-4 and Table 4-9 of LAR Attachment 44 were reviewed. Those that have a difference between HEPs of the CLTP and EPU cases were categorized in three groups, as follows:

1. HFEs whose timing data differences between the CLTP and EPU cases did not lead to a change in the dependency level (as determined in the "Time Window" tab of the HRA Calculator).

For such HFEs, keeping the same HEP between the CLTP and EPU cases would be warranted because the dependency level stayed the same. However, a lower HEP was calculated in the CLTP case by either applying an additional cognitive recovery, or by lowering the cognitive dependency level of an already credited recovery. This was done to inject a reasonable conservatism in the delta risk evaluations, intended to take into account the added potential for recovery afforded by the additional time in the CLTP case.

2. HFEs whose timing data differences between the CLTP and EPU cases led to a change in the dependency level, which was carried over as-is in the cognitive and execution recoveries.

For these HFEs, the recoveries credited in the EPU case for the cognitive analysis and the execution analysis were carried over in the CLTP case, but with the lower dependence level granted by the additional time from the CLTP case. Recoveries were appropriately represented.

3. HFEs whose timing data differences between the CLTP and EPU cases led to a change in the dependency level, which was selectively carried over in the cognitive and execution recoveries.

A specific discussion is required for each of these HFEs, as follows.

In the EPU case, it was noted that for HFE HFA_0071L8RESTART, representing the failure of the operators to restart Reactor Core Isolation Cooling (RCIC) after its trip on Reactor Level L-8, the recovery step of the "skip a step in procedure" entry was assigned a complete level of dependency, while the recovery of another cognitive failure mechanism ("failure of attention") was assigned a medium level of dependency. In contrast, the same HFE in the

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CLTP case had these recovery steps both assigned to the low dependency level. This cognitive recovery dependency level for the EPU case is considered to be appropriate, because, in the relatively short time window of the human action, the operators may collectively make the mistake of skipping a step in the procedure. This can be explained as follows: the recovery step is stated as “when RPV level drops below minus 120.” RPV level could be recovered quickly with HPCI, but it may be difficult to turn level around with RCIC if level was not maintained and a step was skipped at a higher power level, leading to less available time to recover. At a lower power level, however, it would not be as significant since the operators would have more time to recover. The resulting HEP in the EPU case, 7.97E-03, is approximately 11 percent higher than the HEP obtained if the dependency level had been assigned to the medium level (7.13E-03), a moderate increase. Similarly, the EPU plant risk Core Damage Frequency (CDF), Large Early Release Frequency (LERF), and delta risk values (delta CDF, delta LERF), are slightly more conservative with this complete dependency level than if the medium level had been used. In particular, when, in the cutset files, an HEP of 7.13E-03 for HFA_0071L8RESTART is used in lieu of 7.93E-03, the CDF and LERF decreases slightly, by less than 1 percent. In summary, the EPU plant risk metrics presented in Attachment 44 of the EPU LAR are marginally more conservative with the 7.97E-03 value than with the lower value of 7.13E-03.

In the CLTP case, it was noted that for HFE HFA_0003PMP_START, representing the failure of the operators to restart a feedwater pump after its trip on Reactor Level L-8, the execution recoveries were left at the low dependency level used for the EPU case. A low dependency level is considered to be appropriate because feedwater is the normally operated system to provide both inventory and decay heat removal. As such, it could be expected that an error of execution to restart a feedwater pump would be promptly noticed and likely to be recovered. This is because if feedwater is available, RPV level could be recovered even faster than with HPCI or RCIC due to its larger makeup capability. With lower flow rate systems, it could be challenging to turn the level around within the recovery window if a step is missed, while a higher flow system (such as feedwater) can recover the RPV level more quickly. In that light, a low level of dependency is justified. If, however, a medium dependency level was used for the recovery of execution steps in the EPU case, the HEP of HFA_003PMP_START would increase from 1.14E-02 to 1.18E-02, a 3.5 percent increase. When this updated value is used in the cutset files of the EPU case, the CDF and LERF values are unchanged, thereby showing that increasing the execution recovery dependency level from low to medium has an insignificant effect on the risk results.

It was noted that for the failure to transfer a de-energized 480V board to alternate supply, represented with HFE HFA_0268480CRSTIE in the Internal Events PRA and HFFA_0268480CRSTIE in the Fire PRA, the execution recoveries were kept at a high level of dependencies in both the EPU and CLTP cases. This was done because the relatively complex actions modeled under these HFEs are performed locally and within a short time window. A lower recovery dependency level in the CLTP case would lead to an unrealistic value of the associated HEP.

Finally, it was noted that for HFEs HFA_0HCIINIT30 (operator failing to initiate high pressure injection within 30 min) and HFE HFA_0LPINIT10 (operator failing to initiate low pressure injection within 10 min), the execution recoveries were kept at a low level of dependencies in both the EPU and CLTP cases. This was done because these actions are intended to recover adequate reactor water level, a highly visible parameter that is constantly monitored by the operators. A low level of recovery dependency appropriately captures the likelihood that the operators would recover a failed injection. In contrast, selecting a higher level of

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recovery dependency for these actions would provide an unrealistically high HEP in both the CLTP and EPU cases.

It is concluded that the recovery analysis is appropriately represented in the HFEs cognitive analysis and execution analysis such that the total HEP is realistically estimated for both the CLTP and EPU cases.

Response to RAI 09.01 c.

No action is required for this request as no changes were made to HEPs in part b. of this RAI response.

Reference

1. NUREG/CR-1278, "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications," dated August 1983.

Attachment 1

Human Reliability Analysis Calculation Reports

HFA_0003PMP_START-CLTP, OPERATOR FAILS TO RESTART RFW AFTER LEVEL 8 TRIP

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J. Branch (Update for CLTP)			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary						
	P ₁	P ₂	P _{cog}	P _{exe}	Total HEP	Error Factor
Method	CBDTM	HCR/ORE	Maximum	THERP		
HEP	1.07E-03	2.44E-10	1.07E-03	8.82E-03	9.88E-03	5

RAW	FV	Risk Significant
1.03E+00	2.66E-06	NO

Identification and Definition
<p>In the event of a transient, operators are instructed to maintain water level between +2 in. and +51 in. (level 8) (EOI-1, RC/L-4). If water level reaches +55 in. and RFW is operating to provide injection, the pumps would be tripped and main turbine automatically trip (HPCI and RCIC trip at +51 in.). Without any other source of injection, the water level would then decrease. Operators are instructed to restart injection before water level decreases to +2 in. Failing this, the water level would continue to decrease eventually leading to core uncover and heatup.</p> <p>Several other steps in the EOI also instruct operators to restore Feedwater, CRD, HPCI, RCIC, or other pump to restore level (e.g., EOI-1, step RC/L-4; C-1, step C1-4).</p> <p>The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the RFW, HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased.</p> <p>This HFE has been updated for the current licensing thermal power (CLTP) case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for Tsw.</p> <p>(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.</p> <p>(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.</p> <p>MAAP 4.0.7 run (407_CLTP) Case 1 is a general transient scram with no injection. Time to core damage (Tsw): 407_CLTP: Tsw = 0.70 hrs or 42 min The CLTP modeling uses 42 minutes for HFEs in all general transient (GTRAN) sequences for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.</p>

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Cues and Indications	
Initial Cue	Low level in reactor pressure vessel (+2 in normal range)
Recovery Cue	
Cue Comments	EOI-1 Step RC/L-4 instructs operators to maintain water level between +2 in. and +51 in. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action. Thus the cue is taken as water level at +2 in.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	1-EOI-1 (RPV Control, Unit 1, Browns Ferry Nuclear Power Plant) Revision:
Cognitive Step Number	RC/L-4
Cognitive Instruction	Restore and maintain RPV level . . . with one of the following sources
Execution Procedure	1-EOI App 5D (Injection System Lineup HPCI) Revision:
Execution Instruction	
Job Performance Measure	JPM: Not Selected
Other Procedures	1-C-1 (Alternate Level Control, Unit 1, Browns Ferry Nuclear Power Plant) Revision: 0

Notes
Response begins with EOI-1, and transitions to C-1 when level cannot be maintained. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action.

Training	
Classroom Training	
Simulator Training	

Crew Member	Included	Total Available	Required for Execution	Notes
Reactor Operator	No	0	2	Assume that HPCI or RCIC restart would take precedence, but RFW would be restarted.

Notes

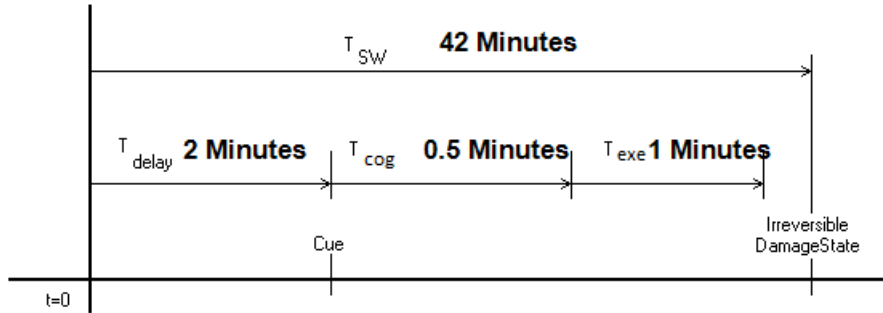
Assumptions
The first cue the operators receive to restart RFW, HPCI or RCIC is when the water level reaches +2 in. In reality, The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the RFW, HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased, thus pump restart would likely be initiated prior to water level dropping to +2 in.

Operator Interview Insights
During observation of a demonstration of a representative scenario using the Unit 3 simulator, it was clear that the operators would track RPV level carefully.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports



Timing Analysis



Time available for cognition and recovery	39 Minutes
Time available for recovery	38.5 Minutes
SPAR-H Available time (cognitive)	39 Minutes
SPAR-H Available time (execution) ratio	39.50 Minutes
EPRI Minimum level of dependence for recovery	LD

Notes

This HFE has been updated for the current licensing thermal power (CLTP) case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for Tsw.

(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.

(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.

MAAP 4.0.7 run (407_CLTP)

Case 1 is a general transient scram with no injection.

Time to core damage (Tsw):

407_CLTP: Tsw = 0.70 hrs or 42 min

The CLTP modeling uses 42 minutes for HFEs in all general transient (GTRAN) sequences for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.

The initiation time is taken as the time when Level 8 is reached since this HEP applies to a failure to restart RFW following a Level 8 trip. Thus, the time delay is time from L8 to +2 in. = 0.06 - 0.02 = 0.04 hours, or 2.4 minutes. The time delay would be shorter for scenarios that do not involve L8. For the CLTP case, however, the MAAP timing discussed above for Tsw was also used to re-evaluate Tdelay, due to impacts from changes in RPV power since these operator actions may be derived based on other parameters such as time for battery depletion, time for irreversible equipment failure, or depletion of inventory. This re-evaluation resulted in a value of 2 minutes.

The median response time would be very short, because operators are monitoring water level closely during any transient. Based on response for similar actions median response time is taken as 30 seconds to restore RFW (per 1-AOI-3-1 4.2.12, 1-AOI-100-1 and 1-OI-3) once low level is detected.

Cognitive Analysis

Pc Failure Mechanism	Branch	HEP
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ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	m	1.50E-02
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure	e	1.98E-03
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		1.70E-02
Notes		

Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes	[]	[]	[]	(a) 0.0e+000
			[]	(b) 0.0e+000
No	[]	[]	[]	(c) 1.5e-004
			[]	(d) 1.5e-003
			[]	(e) 5.0e-002
			[]	(f) 5.0e-001
			[]	(g) 1.0e+000

Pcb: Failure of Attention

Notes/Assumptions: Workload would be expected to be relatively high due to attempts to restore some source of HPI. Action primarily triggered based on monitoring RPV level, which is indicated by a variety of displays and meters.

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value	
Low	Check	Front	[]	(a) 0.0e+000	
		Back	[]	(b) 1.5e-004	
	Monitor	Front	[]	(c) 3.0e-003	
		Back	[]	(d) 1.5e-004	
	High	Check	Front	[]	(e) 3.0e-003
			Back	[]	(f) 3.0e-004
Monitor		Front	[]	(g) 6.0e-003	
		Back	[]	(h) 0.0e+000	
Check		Front	[]	(i) 0.0e+000	
		Back	[]	(j) 7.5e-004	
Monitor	Front	[]	(k) 1.5e-002		
	Back	[]	(l) 7.5e-004		
			[]	(m) 1.5e-002	
			[]	(n) 1.5e-003	
			[]	(o) 3.0e-002	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
Not easy	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	No

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pce: Skip a step in procedure

Notes/Assumptions: Since a transition among three procedures might be required, and the unit supervisor would be following multiple paths through the EOIs, this is treated as a case of multiple procedures. Placekeeping aids are used in the form of a bracket in which the unit supervisor initials the steps as they are reached.

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value
Obvious	Single	Yes	Yes	(a) 9.9e-004
		No	No	(b) 3.3e-003
	Multiple	No		(c) 3.0e-003
		Yes		(d) 1.0e-002
		Yes		(e) 2.0e-003
		No		(f) 4.3e-003
Hidden			(g) 6.0e-003	
			(h) 1.3e-002	
			(i) 1.0e-001	

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous			(c) 3.0e-002
	Yes		(d) 3.0e-003
	Yes		(e) 3.0e-002
	No		(f) 6.0e-003
	No		(g) 6.0e-002

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcg: Misinterpret decision logic

Notes/Assumptions: Logic is straightforward, and this is a well-practiced scenario.

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value
Yes	[]	[]	[]	(a) 1.6e-002
			[]	(b) 4.8e-002
			[]	(c) 5.9e-003
			[]	(d) 1.8e-002
			[]	(e) 2.0e-003
			[]	(f) 6.0e-003
No	[]	[]	[]	(g) 1.0e-002
			[]	(h) 3.1e-002
			[]	(i) 3.3e-004
			[]	(j) 1.0e-003
			[]	(k) 0.0e+000
			[]	(l) 0.0e+000

Pch: Deliberate violation

Notes/Assumptions: There is no reason to expect other than verbatim compliance with this instruction.

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes	[]	[]	[]	(a) 0.0e+000
			[]	(b) 5.0e-001
No	[]	[]	[]	(c) 1.0e+000
			[]	(d) 0.0e+000
			[]	(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	1.50E-02	X	-	-	-	-		LD	6.43E-02		9.65E-04
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0

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Pce	1.98E-03	X	-	-	-	-	-	LD	5.19E-02		1.03E-04
Pcf	n/a	-	-	-	-	-	-	N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-	-	N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-	-	N/A	1.00E+00		0.0
Final Pc (with recovery credited)											1.07E-03
Notes											
Self-review is credited because RPV level is continuously monitored											

Execution Performance Shaping Factors		
Environment	Lighting	Normal
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)	Main control room	Accessible
Equipment Accessibility (Execution)	Main control room	Accessible

Stress	
High	
Plant Response As Expected:	Yes
Workload:	High
Performance Shaping Factors:	Negative
Notes	
The workload is high and the PSFs are negative due to the fire	

Sigma Table				
Plant Type	Response Type	LB	Sigma	UB
BWR	CP1	0.4	0.7	1
	CP2	0.2	0.58	0.96
	CP3	0.59	0.75	0.91
PWR	CP1	0.26	0.57	0.88
	CP2	0.07	0.38	0.69
	CP3		0.77	
Sigma:	7.00E-01			
HEP:	2.44E-10			
Notes/Assumptions	The cue is to start HPCI when level reaches +2 in. Although the operators are prepared for this condition, it is still a response of type CP1.			

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered								
Procedure		Comment				Stress Factor	Override	
Step No.	Instruction / Comment	Error Type	THERP		HEP			
			Table	Item				
EOI-1 RC/L-04	Restore and maintain water lvl between +2 in and +51 in ... with ... RFW, Appx 5A	EOM	20-7b	1	4.3E-4	High		
	Comment	Operator must recognize low water level and the need to restore feedwater						
	Location:				Total Step HEP		2.15E-03	
1-EOI Appx 5A Step 4	DEPRESS 1-HS-46-8A(9A)(10A), RFPT 1A(1B)(1C) SPEED CONT RAISE/LOWE R, and VERIFY amber light is illuminated.	EOM	20-7b	1	4.3e-04	High		
	Location:				Total Step HEP		2.15E-03	
1-EOI Appx 5A Step 8	DEPRESS 1-HS-3-124A(150A)(175A), RFPT 1A(1B)(1C) TRIP RESET, and VERIFY that the turbine trip is RESET	EOM	20-7b	1	4.3e-04	High		
	Location:				Total Step HEP		2.15E-03	
1-EOI Appx 5A Step 10	PLACE 1-HS-46-112A(138A)(163A), RFPT	EOM	20-7b	1	4.3e-04	High		

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	1A(1B)(1C) START/LOCA L ENABLE, in START, AND VERIFY RFPT speed increases to approximately 600 rpm.						
	Location:					Total Step HEP	2.15E-03
1-EOI App 5A Step 12	SLOWLY ADJUST RFPT speed UNTIL fw flow to the RPV is indicated, using ANY of the following methods on Panel 1-9-5: 1- HS-46- 8A(9A)(10A) switch in MNL GVRNOR; 1- SIC-46- 8(9)(10) SPEED CNTRL in MNL; 1-LIC-46- 5, RX LVL CNTRL in MNL with 1- SIC-46- 8(9)(10) AUTO	EOM	20-7b	1	4.3e-04	High	
	Location:					Total Step HEP	2.15E-03
EOI-1 RC/L- 7,8	If RPV water lvl drops below -120 in. ... augment RPV	EOM	20-7b	1	4.3e-04	High	

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	water lvl ...						
	Location:					Total Step HEP	2.15E-03
1-EOI App 5A Step 13	ADJUST RFPT speed as necessary to control injection using the methods of step 12.	EOM	20-7b	1	4.3e-04	High	
	Location:					Total Step HEP	2.15E-03
1-EO1 Appx 5A Step 14	WHEN RPV level is approximately equal to desired level AND automatic level control is desired, THEN PLACE 1-LIC-46-5, REACTOR WATER LEVEL CONTROL, in AUTO with individual 1-SIC-46-8(9)(10), SPEED CONTROL in AUTO	EOM	20-7b	1	4.3e-04	High	
	Location:	Main control room				Total Step HEP	2.15E-03

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
EOI-1 RC/L-04		Restore and maintain water lvl between +2 in	2.15E-03				1.12E-04

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		and +51 in ... with ... RFW, Appx 5A					
	EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...		2.15E-03	LD	5.20E-02	
1-EOI Appx 5A Step 4		DEPRESS 1-HS-46-8A(9A)(10A), RFPT 1A(1B)(1C) SPEED CONT RAISE/LOWER, and VERIFY amber light is illuminated.	2.15E-03				2.15E-03
1-EOI Appx 5A Step 8		DEPRESS 1-HS-3-124A(150A)(175A), RFPT 1A(1B)(1C) TRIP RESET, and VERIFY that the turbine trip is RESET	2.15E-03				2.15E-03
1-EOI Appx 5A Step 10		PLACE 1-HS-46-112A(138A)(163A), RFPT 1A(1B)(1C) START/LOCAL ENABLE, in START, AND VERIFY RFPT speed increases to approximately 600 rpm.	2.15E-03				2.15E-03
1-EOI App 5A Step 12		SLOWLY ADJUST RFPT speed UNTIL fw flow to the RPV is indicated, using ANY of the	2.15E-03				1.12E-04

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		following methods on Panel 1-9-5: 1-HS-46-8A(9A)(10A) switch in MNL GVRNOR; 1-SIC-46-8(9)(10) SPEED CNTRL in MNL; 1-LIC-46-5, RX LVL CNTRL in MNL with 1-SIC-46-8(9)(10) AUTO					
	1-EOI App 5A Step 13	ADJUST RFPT speed as necessary to control injection using the methods of step 12.		2.15E-03	LD	5.20E-02	
1-EO1 Appx 5A Step 14		WHEN RPV level is approximately equal to desired level AND automatic level control is desired, THEN PLACE 1-LIC-46-5, REACTOR WATER LEVEL CONTROL, in AUTO with individual 1-SIC-46-8(9)(10), SPEED CONTROL in AUTO	2.15E-03				2.15E-03
Total Unrecovered:			1.29E-02	Total Recovered:			8.82E-03

HFA_0003PMP_START-EPU, OPERATOR FAILS TO RESTART RFW AFTER LEVEL 8 TRIP

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_2016 0708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J. Branch (Update for EPU)			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary						
	P ₁	P ₂	P _{cog}	P _{exe}	Total HEP	Error Factor
Method	CBDTM	HCR/ORE	Maximum	THERP		
HEP	2.63E-03	2.21E-09	2.63E-03	8.82E-03	1.14E-02	5

RAW	FV	Risk Significant
1.03E+00	2.66E-06	NO

Identification and Definition
<p>In the event of a transient, operators are instructed to maintain water level between +2 in. and +51 in. (level 8) (EOI-1, RC/L-4). If water level reaches +55 in. and RFW is operating to provide injection, the pumps would be tripped and main turbine automatically trip (HPCI and RCIC trip at +51 in.). Without any other source of injection, the water level would then decrease. Operators are instructed to restart injection before water level decreases to +2 in. Failing this, the water level would continue to decrease eventually leading to core uncover and heatup.</p> <p>Several other steps in the EOI also instruct operators to restore Feedwater, CRD, HPCI, RCIC, or other pump to restore level (e.g., EOI-1, step RC/L-4; C-1, step C1-4).</p> <p>The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the RFW, HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased.</p> <p>This HFE has been updated for the EPU case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for Tsw.</p> <p>(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.</p> <p>(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.</p> <p>MAAP 4.0.7 run of equivalent cases (407_EPU) Case 1 is a general transient scram with no injection. Time to core damage (Tsw): 407_EPU: Tsw = 0.59 hrs or 35.4 min A Tsw of 35 minutes typically used in the EPU Fire HRA for actions to initiate injection if all</p>

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injection is lost at the scram and there are no stuck open relief valves.

Cues and Indications	
Initial Cue	Low level in reactor pressure vessel (+2 in normal range)
Recovery Cue	
Cue Comments	EOI-1 Step RC/L-4 instructs operators to maintain water level between +2 in. and +51 in. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action. Thus the cue is taken as water level at +2 in.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	1-EOI-1 (RPV Control, Unit 1, Browns Ferry Nuclear Power Plant) Revision:
Cognitive Step Number	RC/L-4
Cognitive Instruction	Restore and maintain RPV level . . . with one of the following sources
Execution Procedure	1-EOI App 5D (Injection System Lineup HPCI) Revision:
Execution Instruction	
Job Performance Measure	JPM: Not Selected
Other Procedures	1-C-1 (Alternate Level Control, Unit 1, Browns Ferry Nuclear Power Plant) Revision: 0

Notes

Response begins with EOI-1, and transitions to C-1 when level cannot be maintained. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action.

Training	
Classroom Training	
Simulator Training	

Crew Member	Included	Total Available	Required for Execution	Notes
Reactor Operator	No	0	2	Assume that HPCI or RCIC restart would take precedence, but RFW would be restarted.

Notes

Assumptions

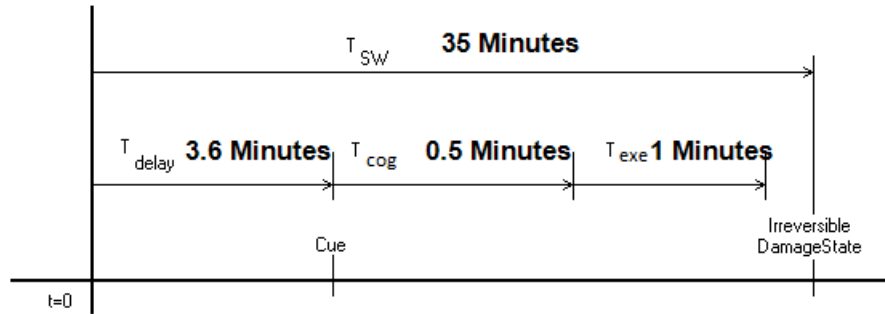
The first cue the operators receive to restart RFW, HPCI or RCIC is when the water level reaches +2 in. In reality, The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the RFW, HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased, thus pump restart would likely be initiated prior to water level dropping to +2 in.

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Operator Interview Insights

During observation of a demonstration of a representative scenario using the Unit 3 simulator, it was clear that the operators would track RPV level carefully.

Timing Analysis



Time available for cognition and recovery	30.4 Minutes
Time available for recovery	29.9 Minutes
SPAR-H Available time (cognitive)	30.4 Minutes
SPAR-H Available time (execution) ratio	30.90 Minutes
EPRI Minimum level of dependence for recovery	LD

Notes

This HFE has been updated for the EPU case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for T_{sw} .

(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.

(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.

MAAP 4.0.7 run of equivalent cases (407_EPU)

Case 1 is a general transient scram with no injection.

Time to core damage (T_{sw}):

407_EPU: $T_{\text{sw}} = 0.59$ hrs or 35.4 min

A T_{sw} of 35 minutes is typically used in the EPU Fire HRA for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.

The initiation time is taken as the time when Level 8 is reached since this HEP applies to a failure to restart RFW following a Level 8 trip. Thus, the nominal time delay is time from L8 to +2 in. = $0.06 - 0.02 = 0.04$ hours, or 2.4 minutes. For the EPU case, however, the MAAP timing discussed above for T_{sw} was also used to re-evaluate T_{delay} , due to impacts from changes in RPV power since these operator actions may be derived based on other parameters such as time for battery depletion, time for irreversible equipment failure, or depletion of inventory. This re-evaluation resulted in a value of 3.6 minutes.

The median response time would be very short, because operators are monitoring water level closely during any transient. Based on response for similar actions median response time is taken as 30 seconds to restore RFW (per 1-AOI-3-1 4.2.12, 1-AOI-100-1 and 1-OI-3) once low level is detected.

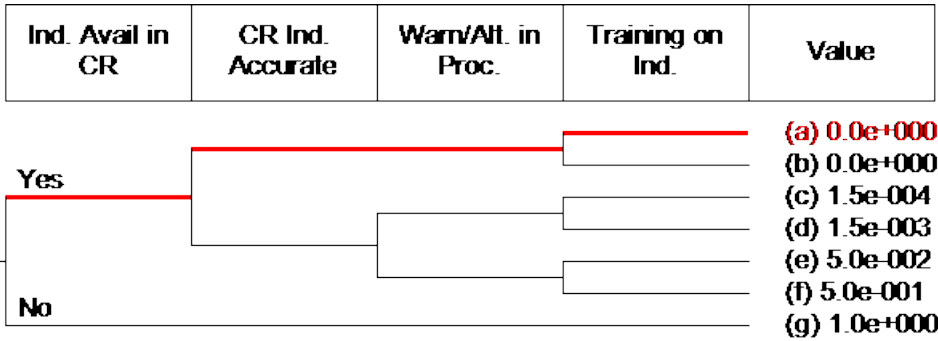
ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

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Cognitive Analysis		
Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	m	1.50E-02
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure	e	1.98E-03
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		1.70E-02
Notes		

Pca: Availability of Information

Notes/Assumptions:



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Pcb: Failure of Attention

Notes/Assumptions: Workload would be expected to be relatively high due to attempts to restore some source of HPI. Action primarily triggered based on monitoring RPV level, which is indicated by a variety of displays and meters.

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value
Low	Check	Front		(a) 0.0e+000
		Back		(b) 1.5e-004
	Monitor	Front		(c) 3.0e-003
		Back		(d) 1.5e-004
High	Check	Front		(e) 3.0e-003
		Back		(f) 3.0e-004
		Front		(g) 6.0e-003
		Back		(h) 0.0e+000
	Monitor	Front		(i) 0.0e+000
		Back		(j) 7.5e-004
		Front		(k) 1.5e-002
		Back		(l) 7.5e-004
				(m) 1.5e-002
				(n) 1.5e-003
				(o) 3.0e-002

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
Not easy	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

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Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value		
Yes				(a) 0.0e+000		
No	Yes			(b) 3.0e-003		
	No	Yes			(c) 1.0e-002	
		No	Yes			(d) 1.0e-001
			No			(e) 1.0e+000

Pce: Skip a step in procedure

Notes/Assumptions: Since a transition among three procedures might be required, and the unit supervisor would be following multiple paths through the EOIs, this is treated as a case of multiple procedures. Placekeeping aids are used in the form of a bracket in which the unit supervisor initials the steps as they are reached.

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value	
Obvious	Single	Yes	Yes	(a) 9.9e-004	
		No	No	(b) 3.3e-003	
	Multiple	Yes		(c) 3.0e-003	
				(d) 1.0e-002	
		No		(e) 2.0e-003	
	Hidden	Multiple	Yes		(f) 4.3e-003
			No		(g) 6.0e-003
		Single	Yes		(h) 1.3e-002
			No		(i) 1.0e-001

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Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous	Yes		(c) 3.0e-002
	No		(d) 3.0e-003
			(e) 3.0e-002
			(f) 6.0e-003
			(g) 6.0e-002

Pcg: Misinterpret decision logic

Notes/Assumptions: Logic is straightforward, and this is a well-practiced scenario.

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value	
Yes				(a) 1.6e-002	
				(b) 4.8e-002	
				(c) 5.9e-003	
	No				(d) 1.8e-002
					(e) 2.0e-003
					(f) 6.0e-003
				(g) 1.0e-002	
				(h) 3.1e-002	
				(i) 3.3e-004	
			(j) 1.0e-003		
			(k) 0.0e+000		
			(l) 0.0e+000		

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pch: Deliberate violation

Notes/Assumptions: There is no reason to expect other than verbatim compliance with this instruction.

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes				
				(a) 0.0e+000
				(b) 5.0e-001
No				(c) 1.0e+000
				(d) 0.0e+000
				(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	1.50E-02	X	-	-	-	-		MD	1.56E-01		2.34E-03
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pce	1.98E-03	X	-	-	-	-		MD	1.45E-01		2.87E-04
Pcf	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Final Pc (with recovery credited)											2.63E-03
Notes											
Self-review is credited because RPV level is continuously monitored											

Execution Performance Shaping Factors		
Environment	Lighting	Normal
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)	Main control room	Accessible
Equipment Accessibility (Execution)	Main control room	Accessible

Stress	
High	
Plant Response As Expected:	Yes
Workload:	High

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Performance Shaping Factors:	Negative
Notes	
The workload is high and the PSFs are negative due to the fire	

Sigma Table				
Plant Type	Response Type	LB	Sigma	UB
BWR	CP1	0.4	0.7	1
	CP2	0.2	0.58	0.96
	CP3	0.59	0.75	0.91
PWR	CP1	0.26	0.57	0.88
	CP2	0.07	0.38	0.69
	CP3		0.77	
Sigma:	7.00E-01			
HEP:	2.21E-09			
Notes/Assumptions	The cue is to start HPCI when level reaches +2 in. Although the operators are prepared for this condition, it is still a response of type CP1.			

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered								
Procedure		Comment				Stress Factor	Override	
Step No.	Instruction / Comment	Error Type	THERP		HEP			
			Table	Item				
EOI-1 RC/L-04	Restore and maintain water lvl between +2 in and +51 in ... with ... RFW, Appx 5A	EOM	20-7b	1	4.3E-4	High		
	Comment	Operator must recognize low water level and the need to restore feedwater						
	Location:				Total Step HEP		2.15E-03	
1-EOI Appx 5A Step 4	DEPRESS 1-HS-46-8A(9A)(10A), RFPT 1A(1B)(1C) SPEED CONT RAISE/LOWE R, and VERIFY amber light is illuminated.	EOM	20-7b	1	4.3e-04	High		
	Location:				Total Step HEP		2.15E-03	
1-EOI Appx 5A Step 8	DEPRESS 1-HS-3-124A(150A)(175A), RFPT 1A(1B)(1C) TRIP RESET, and VERIFY that the turbine trip is RESET	EOM	20-7b	1	4.3e-04	High		
	Location:				Total Step HEP		2.15E-03	
1-EOI Appx 5A Step 10	PLACE 1-HS-46-112A(138A)(163A), RFPT	EOM	20-7b	1	4.3e-04	High		

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	1A(1B)(1C) START/LOCA L ENABLE, in START, AND VERIFY RFPT speed increases to approximately 600 rpm.						
	Location:					Total Step HEP	2.15E-03
1-EOI App 5A Step 12	SLOWLY ADJUST RFPT speed UNTIL fw flow to the RPV is indicated, using ANY of the following methods on Panel 1-9-5: 1- HS-46- 8A(9A)(10A) switch in MNL GVRNOR; 1- SIC-46- 8(9)(10) SPEED CNTRL in MNL;1-LIC-46- 5, RX LVL CNTRL in MNL with 1- SIC-46- 8(9)(10) AUTO	EOM	20-7b	1	4.3e-04	High	
	Location:					Total Step HEP	2.15E-03
EOI-1 RC/L- 7,8	If RPV water lvl drops below -120 in. ... augment RPV	EOM	20-7b	1	4.3e-04	High	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	water lvl ...						
	Location:					Total Step HEP	2.15E-03
1-EOI App 5A Step 13	ADJUST RFPT speed as necessary to control injection using the methods of step 12.	EOM	20-7b	1	4.3e-04	High	
	Location:					Total Step HEP	2.15E-03
1-EO1 Appx 5A Step 14	WHEN RPV level is approximately equal to desired level AND automatic level control is desired, THEN PLACE 1-LIC-46-5, REACTOR WATER LEVEL CONTROL, in AUTO with individual 1-SIC-46-8(9)(10), SPEED CONTROL in AUTO	EOM	20-7b	1	4.3e-04	High	
	Location:	Main control room				Total Step HEP	2.15E-03

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
EOI-1 RC/L-04		Restore and maintain water lvl between +2 in	2.15E-03				1.12E-04

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		and +51 in ... with ... RFW, Appx 5A					
	EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...		2.15E-03	LD	5.20E-02	
1-EOI Appx 5A Step 4		DEPRESS 1-HS-46-8A(9A)(10A), RFPT 1A(1B)(1C) SPEED CONT RAISE/LOWER, and VERIFY amber light is illuminated.	2.15E-03				2.15E-03
1-EOI Appx 5A Step 8		DEPRESS 1-HS-3-124A(150A)(175A), RFPT 1A(1B)(1C) TRIP RESET, and VERIFY that the turbine trip is RESET	2.15E-03				2.15E-03
1-EOI Appx 5A Step 10		PLACE 1-HS-46-112A(138A)(163A), RFPT 1A(1B)(1C) START/LOCAL ENABLE, in START, AND VERIFY RFPT speed increases to approximately 600 rpm.	2.15E-03				2.15E-03
1-EOI App 5A Step 12		SLOWLY ADJUST RFPT speed UNTIL fw flow to the RPV is indicated, using ANY of the	2.15E-03				1.12E-04

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		following methods on Panel 1-9-5: 1-HS-46-8A(9A)(10A) switch in MNL GVRNOR; 1-SIC-46-8(9)(10) SPEED CNTRL in MNL; 1-LIC-46-5, RX LVL CNTRL in MNL with 1-SIC-46-8(9)(10) AUTO					
	1-EOI App 5A Step 13	ADJUST RFPT speed as necessary to control injection using the methods of step 12.		2.15E-03	LD	5.20E-02	
1-EO1 Appx 5A Step 14		WHEN RPV level is approximately equal to desired level AND automatic level control is desired, THEN PLACE 1-LIC-46-5, REACTOR WATER LEVEL CONTROL, in AUTO with individual 1-SIC-46-8(9)(10), SPEED CONTROL in AUTO	2.15E-03				2.15E-03
Total Unrecovered:			1.29E-02	Total Recovered:			8.82E-03

HFA_0071L8RESTART-CLTP, Operator fails to restart RCIC after Level 8 trip

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J. Branch (Update for CLTP)			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary				
	Pcog	Pexe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	2.73E-03	6.88E-03		
With Recovery	8.93E-05	6.88E-03	6.97E-03	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
<p>In the event of a transient, operators are instructed to maintain water level between +2 in. and +51 in. (level 8) (EOI-1, RC/L-4). If water level reaches +51 in. and either the HPCI or RCIC pump is operating to provide injection, the operating pump would be tripped. Without any other source of injection, the water level would then decrease. Operators are instructed to restart injection before water level decreases to +2 in. Failing this, the water level would continue to decrease eventually leading to core uncover and heatup.</p> <p>Several other steps in the EOI also instruct operators to restart a HPCI, RCIC, or other pump to restore level (e.g., EOI-1, step RC/L-7; C-1, step C1-4).</p> <p>The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the RFW, HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased.</p> <p>This HFE has been updated for the current licensing thermal power (CLTP) case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for Tsw.</p> <p>(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.</p> <p>(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.</p> <p>MAAP 4.0.7 run (407_CLTP) Case 1 is a general transient scram with no injection. Time to core damage (Tsw): 407_CLTP: Tsw = 0.70 hrs or 42 min The CLTP modeling uses 42 minutes for HFEs in all general transient (GTRAN) sequences for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.</p>

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Cues and Indications	
Initial Cue	Low level in reactor pressure vessel
Recovery Cue	
Cue Comments	EOI-1 Step RC/L-4 instructs operators to maintain water level between +2 in. and +51 in. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action. Thus the cue is taken as water level at +2 in.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	1-EOI-1 (RPV Control, Unit 1, Browns Ferry Nuclear Power Plant) Revision: 0
Cognitive Step Number	RC/L-4
Cognitive Instruction	Restore and maintain RPV level . . . with one of the following sources
Execution Procedure	Execution: Not Selected
Execution Instruction	
Job Performance Measure	JPM: Not Selected
Notes	
Response begins with EOI-1, and transitions to C-1 when level cannot be maintained. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action.	

Training	
Classroom Training	
Simulator Training	

Crew Member	Included	Total Available	Required for Execution	Notes
Shift Manager	No	1	1	---
Shift Supervisor	No	1	1	---
STA	No	1	1	---
Reactor Operator	No	1	2	---
Plant Operators	Yes	2	2	---
Chemist	Yes	2	0	---
Radcon Tech	Yes	2	0	---
Elect Maintenance	Yes	2	0	---
Mech Maintenance	Yes	2	0	---
Security	Yes	2	0	---
Industry Safety Tech	Yes	2	0	---
I&C Technicians	Yes	2	0	---
Notes				

Assumptions
The first cue the operators receive to restart HPCI or RCIC is when the water level reaches +2 in. In reality, The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased, thus pump restart would likely be initiated prior to water level dropping to

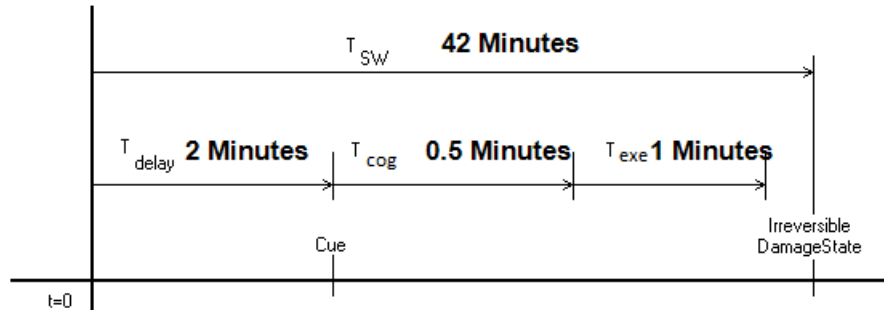
ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

+2 in.

Operator Interview Insights

During observation of a demonstration of a representative scenario using the Unit 3 simulator, it was clear that the operators would track RPV level carefully.

Timing Analysis



Time available for cognition and recovery	39 Minutes
Time available for recovery	38.5 Minutes
SPAR-H Available time (cognitive)	39 Minutes
SPAR-H Available time (execution) ratio	39.50 Minutes
EPRI Minimum level of dependence for recovery	LD

Notes

This HFE has been updated for the current licensing thermal power (CLTP) case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for T_{sw} .

(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.

(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.

MAAP 4.0.7 run (407_CLTP)

Case 1 is a general transient scram with no injection.

Time to core damage (T_{sw}):

407_CLTP: $T_{\text{sw}} = 0.70$ hrs or 42 min

The CLTP modeling uses 42 minutes for HFEs in all general transient (GTRAN) sequences for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.

The initiation time is taken as the time when Level 8 is reached since this HEP applies to a failure to restart RFW following a Level 8 trip. Thus, the time delay is time from L8 to +2 in. = $0.06 - 0.02 = 0.04$ hours, or 2.4 minutes. The time delay would be shorter for scenarios that do not involve L8. For the CLTP case, however, the MAAP timing discussed above for T_{sw} was also used to re-evaluate T_{delay} , due to impacts from changes in RPV power since these operator actions may be derived based on other parameters such as time for battery depletion, time for irreversible equipment failure, or depletion of inventory. This re-evaluation resulted in a value of 2 minutes.

The median response time would be very short, because operators are monitoring water level closely during any transient. Based on response for similar actions median response time is taken as 30 seconds to restore RFW (per 1-AOI-3-1 4.2.12, 1-AOI-100-1 and 1-OI-3) once low

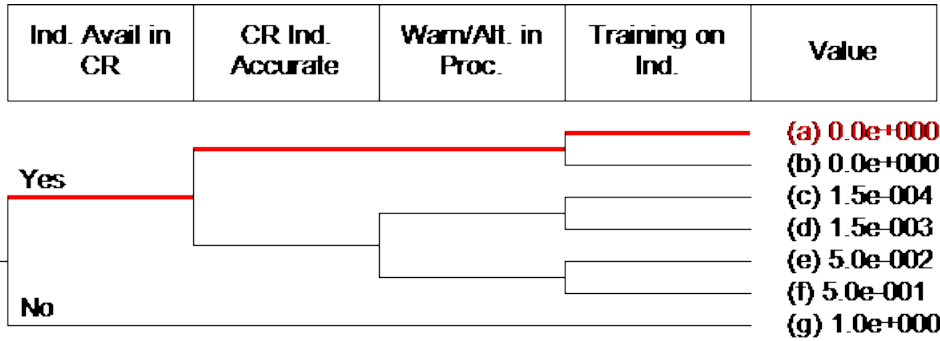
ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

level is detected.

Cognitive Analysis		
Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	l	7.50E-04
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure	e	1.98E-03
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		2.73E-03
Notes		

Pca: Availability of Information

Notes/Assumptions:



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Pcb: Failure of Attention

Notes/Assumptions: Workload would be expected to be relatively high due to attempts to restore some source of HPI. Action primarily triggered based on monitoring RPV level, which is indicated by a variety of displays and meters.

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value
Low	Check	Front		(a) 0.0e+000
		Back		(b) 1.5e-004
	Monitor	Front		(c) 3.0e-003
		Back		(d) 1.5e-004
High	Check	Front		(e) 3.0e-003
		Back		(f) 3.0e-004
	Monitor	Front		(g) 6.0e-003
		Back		(h) 0.0e+000
	Check	Front		(i) 0.0e+000
		Back		(j) 7.5e-004
Monitor	Front		(k) 1.5e-002	
	Back		(l) 7.5e-004	
				(m) 1.5e-002
				(n) 1.5e-003
				(o) 3.0e-002

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
Not easy	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

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Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	

Pce: Skip a step in procedure

Notes/Assumptions: Since a transition among three procedures might be required, and the unit supervisor would be following multiple paths through the EOIs, this is treated as a case of multiple procedures. Placekeeping aids are used in the form of a bracket in which the unit supervisor initials the steps as they are reached.

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value	
Obvious	Single	Yes	Yes	(a) 9.9e-004	
		No	No	(b) 3.3e-003	
	Multiple	Yes	No		(c) 3.0e-003
			No		(d) 1.0e-002
		No	Yes		(e) 2.0e-003
	Hidden	Multiple	No		(f) 4.3e-003
			No		(g) 6.0e-003
		Single	No		(h) 1.3e-002
			No		(i) 1.0e-001

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Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous	Yes		(c) 3.0e-002
	No		(d) 3.0e-003
	Yes		(e) 3.0e-002
	No		(f) 6.0e-003
			(g) 6.0e-002

Pcg: Misinterpret decision logic

Notes/Assumptions: Logic is straightforward, and this is a well-practiced scenario.

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value	
Yes				(a) 1.6e-002	
				(b) 4.8e-002	
					(c) 5.9e-003
					(d) 1.8e-002
					(e) 2.0e-003
					(f) 6.0e-003
No				(g) 1.0e-002	
				(h) 3.1e-002	
					(i) 3.3e-004
					(j) 1.0e-003
					(k) 0.0e+000
					(l) 0.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pch: Deliberate violation

Notes/Assumptions: There is no reason to expect other than verbatim compliance with this instruction.

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes				(a) 0.0e+000
No				(b) 5.0e-001
				(c) 1.0e+000
				(d) 0.0e+000
				(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	7.50E-04	-	-	X	-	-		LD	5.07E-02		3.80E-05
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pce	1.98E-03	X	X	-	-	-		LD	2.59E-02		5.13E-05
Pcf	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Final Pc (with recovery credited)											8.93E-05
Notes											

Execution Performance Shaping Factors		
Environment	Lighting	Normal
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)	Main control room	Accessible
Equipment Accessibility (Execution)	Main control room	Accessible

Stress	
Moderate	
Plant Response As Expected:	Yes
Workload:	High

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Performance Shaping Factors:	Optimal
Notes	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
EOI-1 RC/L-04	Restore and maintain water lvl between +2 in and +51 in ... with ... HPCI, Appx 5D	EOM	20-7b	1	4.3E-4	Moderate	
	Comment	Operator must recognize low water level and the need to restore HPCI injection					
	Location:				Total Step HEP		
1-EOI App 5C Step 3	VERIFY RESET and OPEN 1-FCV-71-9, RCIC TURB TRIP/THROTV LV	EOM	20-7b	1	4.3e-04	Moderate	
	Location:				Total Step HEP		
1-EOI App 5C Step 4	VERIFY 1-FIC-71-36A, RCIC SYSTEM FLOW/CONT ROL, controller in AUTO with setpoint at 600 gpm	EOM	20-7b	1	4.3e-04	Moderate	
	Location:				Total Step HEP		
1-EOI App 5C Step 5a	OPEN the following valves: 1-FCV-71-39, RCIC PUMP INJECTION	EOM	20-7b	1	4.3e-04	Moderate	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	VALVE						
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 5b	OPEN the following valves:1-FCV-71-34, RCIC PUMP MIN FLOW VALVE	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 5c	OPEN the following valves:1-FCV-71-25, RCIC LUBE OIL COOLING WTR VLV.	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 6	PLACE 1-HS-71-31A, RCIC VACUUM PUMP, handswitch in START.	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 7	OPEN 1-FCV-71-8, RCIC TURBINE STEAM SUPPLY VLV, to start RCIC turbine	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C	CHECK proper	EOM	20-7b	1	4.3e-04	Moderate	

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Step 8	RCIC operation by observing the following:							
	Comment	Operator instructed to check a) RCIC turbine speed > 2100 rpm, b) RCIC flow stabilizes and is controlled at 600 gpm; c) 1-FCV-71-40 red light illuminated, d) 1-FCV-71-34 closes as flow rises above 120 gpm.						
	Location:					Total Step HEP	8.60E-04	

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
EOI-1 RC/L-04		Restore and maintain water lvl between +2 in and +51 in ... with ... HPCI, Appx 5D	8.60E-04				8.60E-04
	EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...		8.60E-04	CD	1.00E+00	
1-EOI App 5C Step 3		VERIFY RESET and OPEN 1-FCV-71-9, RCIC TURB TRIP/THROTVLV	8.60E-04				8.60E-04
1-EOI App 5C Step 4		VERIFY 1-FIC-71-36A, RCIC SYSTEM FLOW/CONTROL, controller in AUTO with setpoint at 600 gpm	8.60E-04				8.60E-04
1-EOI App 5C Step 5a		OPEN the following valves: 1-FCV-71-39, RCIC PUMP	8.60E-04				8.60E-04

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

		INJECTION VALVE					
	1-EOI App 5C Step 8	CHECK proper RCIC operation by observing the following:		8.60E-04	CD	1.00E+00	
1-EOI App 5C Step 5b		OPEN the following valves:1-FCV-71-34, RCIC PUMP MIN FLOW VALVE	8.60E-04				8.60E-04
	1-EOI App 5C Step 8	CHECK proper RCIC operation by observing the following:		8.60E-04	CD	1.00E+00	
1-EOI App 5C Step 5c		OPEN the following valves:1-FCV-71-25, RCIC LUBE OIL COOLING WTR VLV.	8.60E-04				8.60E-04
	1-EOI App 5C Step 8	CHECK proper RCIC operation by observing the following:		8.60E-04	CD	1.00E+00	
1-EOI App 5C Step 6		PLACE 1-HS-71-31A, RCIC VACUUM PUMP, handswitch in START.	8.60E-04				8.60E-04
1-EOI App 5C Step 7		OPEN 1-FCV-71-8, RCIC TURBINE STEAM SUPPLY VLV, to start RCIC turbine	8.60E-04				8.60E-04
	1-EOI App 5C Step 8	CHECK proper RCIC operation by observing the		8.60E-04	CD	1.00E+00	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

		following:					
Total Unrecovered:		6.88E-03	Total Recovered:				6.88E-03

HFA_0071L8RESTART-EPU, Operator fails to restart RCIC after Level 8 trip

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J. Branch (Update for EPU)			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary				
	Pcog	Pexe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	2.73E-03	6.88E-03		
With Recovery	1.10E-03	6.88E-03	7.97E-03	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
<p>In the event of a transient, operators are instructed to maintain water level between +2 in. and +51 in. (level 8) (EOI-1, RC/L-4). If water level reaches +51 in. and either the HPCI or RCIC pump is operating to provide injection, the operating pump would be tripped. Without any other source of injection, the water level would then decrease. Operators are instructed to restart injection before water level decreases to +2 in. Failing this, the water level would continue to decrease eventually leading to core uncover and heatup.</p> <p>Several other steps in the EOI also instruct operators to restart a HPCI, RCIC, or other pump to restore level (e.g., EOI-1, step RC/L-7; C-1, step C1-4).</p> <p>The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the RFW, HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased.</p> <p>This HFE has been updated for the EPU case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for Tsw.</p> <p>(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.</p> <p>(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.</p> <p>MAAP 4.0.7 run of equivalent cases (407_EPU) Case 1 is a general transient scram with no injection. Time to core damage (Tsw): 407_EPU: Tsw = 0.59 hrs or 35.4 min A Tsw of 35 minutes typically used in the EPU Fire HRA for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.</p>

Cues and Indications

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Initial Cue	Low level in reactor pressure vessel
Recovery Cue	
Cue Comments	EOI-1 Step RC/L-4 instructs operators to maintain water level between +2 in. and +51 in. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action. Thus the cue is taken as water level at +2 in.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	1-EOI-1 (RPV Control, Unit 1, Browns Ferry Nuclear Power Plant) Revision: 0
Cognitive Step Number	RC/L-4
Cognitive Instruction	Restore and maintain RPV level . . . with one of the following sources
Execution Procedure	Execution: Not Selected
Execution Instruction	
Job Performance Measure	JPM: Not Selected
Notes	
Response begins with EOI-1, and transitions to C-1 when level cannot be maintained. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action.	

Training	
Classroom Training	
Simulator Training	

Crew Member	Included	Total Available	Required for Execution	Notes
Shift Manager	No	1	1	---
Shift Supervisor	No	1	1	---
STA	No	1	1	---
Reactor Operator	No	1	2	---
Plant Operators	Yes	2	2	---
Chemist	Yes	2	0	---
Radcon Tech	Yes	2	0	---
Elect Maintenance	Yes	2	0	---
Mech Maintenance	Yes	2	0	---
Security	Yes	2	0	---
Industry Safety Tech	Yes	2	0	---
I&C Technicians	Yes	2	0	---
Notes				

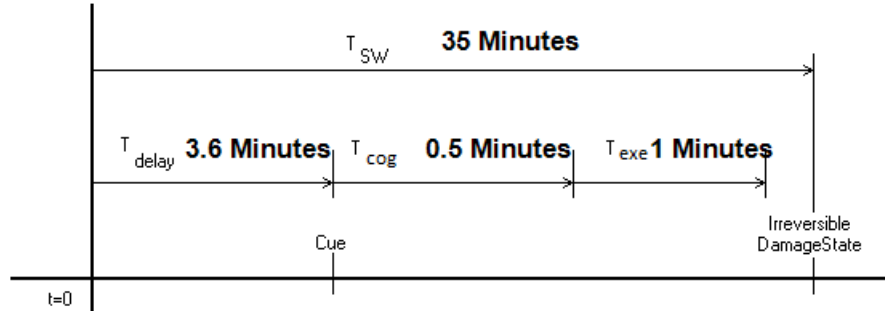
Assumptions
The first cue the operators receive to restart HPCI or RCIC is when the water level reaches +2 in. In reality, The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased, thus pump restart would likely be initiated prior to water level dropping to +2 in.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Operator Interview Insights

During observation of a demonstration of a representative scenario using the Unit 3 simulator, it was clear that the operators would track RPV level carefully.

Timing Analysis



Time available for cognition and recovery	30.4 Minutes
Time available for recovery	29.9 Minutes
SPAR-H Available time (cognitive)	30.4 Minutes
SPAR-H Available time (execution) ratio	30.90 Minutes
EPRI Minimum level of dependence for recovery	LD

Notes

This HFE has been updated for the EPU case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for T_{sw}.

(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.

(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.

MAAP 4.0.7 run of equivalent cases (407_EPU)

Case 1 is a general transient scram with no injection.

Time to core damage (T_{sw}):

407_EPU: T_{sw} = 0.59 hrs or 35.4 min

A T_{sw} of 35 minutes is typically used in the EPU Fire HRA for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.

The initiation time is taken as the time when Level 8 is reached since this HEP applies to a failure to restart RFW following a Level 8 trip. Thus, the nominal time delay is time from L8 to +2 in. = 0.06 - 0.02 = 0.04 hours, or 2.4 minutes. For the EPU case, however, the MAAP timing discussed above for T_{sw} was also used to re-evaluate T_{delay}, due to impacts from changes in RPV power since these operator actions may be derived based on other parameters such as time for battery depletion, time for irreversible equipment failure, or depletion of inventory. This re-evaluation resulted in a value of 3.6 minutes.

The median response time would be very short, because operators are monitoring water level closely during any transient. Based on response for similar actions (see HFA_OLPIINIT30), median response time is taken as 30 seconds to restore HPCI or RCIC once low level is detected.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Cognitive Analysis		
Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	l	7.50E-04
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure	e	1.98E-03
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		2.73E-03
Notes		

Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes	_____	_____	_____	(a) 0.0e+000
			_____	(b) 0.0e+000
No	_____	_____	_____	(c) 1.5e-004
			_____	(d) 1.5e-003
			_____	(e) 5.0e-002
			_____	(f) 5.0e-001
			_____	(g) 1.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcb: Failure of Attention

Notes/Assumptions: Workload would be expected to be relatively high due to attempts to restore some source of HPI. Action primarily triggered based on monitoring RPV level, which is indicated by a variety of displays and meters.

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value
Low	Check	Front		(a) 0.0e+000
		Back		(b) 1.5e-004
	Monitor	Front		(c) 3.0e-003
		Back		(d) 1.5e-004
High	Check	Front		(e) 3.0e-003
		Back		(f) 3.0e-004
	Monitor	Front		(g) 6.0e-003
		Back		(h) 0.0e+000
	Check	Front		(i) 0.0e+000
		Back		(j) 7.5e-004
Monitor	Front		(k) 1.5e-002	
	Back		(l) 7.5e-004	
				(m) 1.5e-002
				(n) 1.5e-003
				(o) 3.0e-002

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
Not easy	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value	
Yes				(a) 0.0e+000	
No	Yes			(b) 3.0e-003	
	No	Yes		(c) 1.0e-002	
		No	Yes		(d) 1.0e-001
			No		(e) 1.0e+000

Pce: Skip a step in procedure

Notes/Assumptions: Since a transition among three procedures might be required, and the unit supervisor would be following multiple paths through the EOIs, this is treated as a case of multiple procedures. Placekeeping aids are used in the form of a bracket in which the unit supervisor initials the steps as they are reached.

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value		
Obvious	Single	Yes	Yes	(a) 9.9e-004		
		No	No	(b) 3.3e-003		
	Multiple	Yes			(c) 3.0e-003	
					(d) 1.0e-002	
		No			(e) 2.0e-003	
					(f) 4.3e-003	
		Hidden	No			(g) 6.0e-003
						(h) 1.3e-002
						(i) 1.0e-001

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous	Yes		(c) 3.0e-002
	No		(d) 3.0e-003
			(e) 3.0e-002
			(f) 6.0e-003
			(g) 6.0e-002

Pcg: Misinterpret decision logic

Notes/Assumptions: Logic is straightforward, and this is a well-practiced scenario.

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value	
Yes				(a) 1.6e-002	
				(b) 4.8e-002	
				(c) 5.9e-003	
				(d) 1.8e-002	
No				(e) 2.0e-003	
				(f) 6.0e-003	
					(g) 1.0e-002
					(h) 3.1e-002
					(i) 3.3e-004
					(j) 1.0e-003
					(k) 0.0e+000
					(l) 0.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pch: Deliberate violation

Notes/Assumptions: There is no reason to expect other than verbatim compliance with this instruction.

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes				
				(a) 0.0e+000
				(b) 5.0e-001
No				(c) 1.0e+000
				(d) 0.0e+000
				(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	7.50E-04	-	-	X	-	-		MD	1.44E-01		1.08E-04
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pce	1.98E-03	X	X	-	-	-		CD	5.00E-01		9.90E-04
Pcf	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Final Pc (with recovery credited)											1.10E-03
Notes											

Execution Performance Shaping Factors		
Environment	Lighting	Normal
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)	Main control room	Accessible
Equipment Accessibility (Execution)	Main control room	Accessible

Stress	
Moderate	
Plant Response As Expected:	Yes
Workload:	High

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Performance Shaping Factors:	Optimal
Notes	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
EOI-1 RC/L-04	Restore and maintain water lvl between +2 in and +51 in ... with ... HPCI, Appx 5D	EOM	20-7b	1	4.3E-4	Moderate	
	Comment	Operator must recognize low water level and the need to restore HPCI injection					
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 3	VERIFY RESET and OPEN 1-FCV-71-9, RCIC TURB TRIP/THROTV LV	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 4	VERIFY 1-FIC-71-36A, RCIC SYSTEM FLOW/CONT ROL, controller in AUTO with setpoint at 600 gpm	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 5a	OPEN the following valves: 1-FCV-71-39, RCIC PUMP INJECTION	EOM	20-7b	1	4.3e-04	Moderate	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	VALVE						
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 5b	OPEN the following valves:1-FCV-71-34, RCIC PUMP MIN FLOW VALVE	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 5c	OPEN the following valves:1-FCV-71-25, RCIC LUBE OIL COOLING WTR VLV.	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 6	PLACE 1-HS-71-31A, RCIC VACUUM PUMP, handswitch in START.	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C Step 7	OPEN 1-FCV-71-8, RCIC TURBINE STEAM SUPPLY VLV, to start RCIC turbine	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5C	CHECK proper	EOM	20-7b	1	4.3e-04	Moderate	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Step 8	RCIC operation by observing the following:							
	Comment	Operator instructed to check a) RCIC turbine speed > 2100 rpm, b) RCIC flow stabilizes and is controlled at 600 gpm; c) 1-FCV-71-40 red light illuminated, d) 1-FCV-71-34 closes as flow rises above 120 gpm.						
	Location:				Total Step HEP		8.60E-04	

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
EOI-1 RC/L-04		Restore and maintain water lvl between +2 in and +51 in ... with ... HPCI, Appx 5D	8.60E-04				8.60E-04
	EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...		8.60E-04	CD	1.00E+00	
1-EOI App 5C Step 3		VERIFY RESET and OPEN 1-FCV-71-9, RCIC TURB TRIP/THROTVLV	8.60E-04				8.60E-04
1-EOI App 5C Step 4		VERIFY 1-FIC-71-36A, RCIC SYSTEM FLOW/CONTROL, controller in AUTO with setpoint at 600 gpm	8.60E-04				8.60E-04
1-EOI App 5C Step 5a		OPEN the following valves: 1-FCV-71-39, RCIC PUMP	8.60E-04				8.60E-04

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

		INJECTION VALVE					
	1-EOI App 5C Step 8	CHECK proper RCIC operation by observing the following:		8.60E-04	CD	1.00E+00	
1-EOI App 5C Step 5b		OPEN the following valves:1-FCV-71-34, RCIC PUMP MIN FLOW VALVE	8.60E-04				8.60E-04
	1-EOI App 5C Step 8	CHECK proper RCIC operation by observing the following:		8.60E-04	CD	1.00E+00	
1-EOI App 5C Step 5c		OPEN the following valves:1-FCV-71-25, RCIC LUBE OIL COOLING WTR VLV.	8.60E-04				8.60E-04
	1-EOI App 5C Step 8	CHECK proper RCIC operation by observing the following:		8.60E-04	CD	1.00E+00	
1-EOI App 5C Step 6		PLACE 1-HS-71-31A, RCIC VACUUM PUMP, handswitch in START.	8.60E-04				8.60E-04
1-EOI App 5C Step 7		OPEN 1-FCV-71-8, RCIC TURBINE STEAM SUPPLY VLV, to start RCIC turbine	8.60E-04				8.60E-04
	1-EOI App 5C Step 8	CHECK proper RCIC operation by observing the		8.60E-04	CD	1.00E+00	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

		following:					
Total Unrecovered:			6.88E-03	Total Recovered:			6.88E-03

HFA_0073L8RESTART-CLTP, Operator fails to restart HPCI after Level 8 trip

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J. Branch (Update for CLTP)			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary				
	Pcog	Pexe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	2.73E-03	4.30E-03		
With Recovery	8.93E-05	4.30E-03	4.39E-03	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
<p>In the event of a transient, operators are instructed to maintain water level between +2 in. and +51 in. (level 8) (EOI-1, RC/L-4). If water level reaches +51 in. and either the HPCI or RCIC pump is operating to provide injection, the operating pump would be tripped. Without any other source of injection, the water level would then decrease. Operators are instructed to restart injection before water level decreases to +2 in. Failing this, the water level would continue to decrease eventually leading to core uncover and heatup.</p> <p>Several other steps in the EOI also instruct operators to restart a HPCI, RCIC, or other pump to restore level (e.g., EOI-1, step RC/L-7; C-1, step C1-4).</p> <p>The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the RFW, HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased.</p> <p>This HFE has been updated for the current licensing thermal power (CLTP) case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for Tsw.</p> <p>(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.</p> <p>(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.</p> <p>MAAP 4.0.7 run (407_CLTP) Case 1 is a general transient scram with no injection. Time to core damage (Tsw): 407_CLTP: Tsw = 0.70 hrs or 42 min The CLTP modeling uses 42 minutes for HFEs in all general transient (GTRAN) sequences for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.</p>

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Cues and Indications	
Initial Cue	Low level in reactor pressure vessel
Recovery Cue	
Cue Comments	EOI-1 Step RC/L-4 instructs operators to maintain water level between +2 in. and +51 in. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action. Thus the cue is taken as water level at +2 in.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	1-EOI-1 (RPV Control, Unit 1, Browns Ferry Nuclear Power Plant) Revision: 0
Cognitive Step Number	RC/L-4
Cognitive Instruction	Restore and maintain RPV level . . . with one of the following sources
Execution Procedure	Execution: Not Selected
Execution Instruction	
Job Performance Measure	JPM: Not Selected
Notes	
Response begins with EOI-1, and transitions to C-1 when level cannot be maintained. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action.	

Training	
Classroom Training	
Simulator Training	

Crew Member	Included	Total Available	Required for Execution	Notes
Shift Manager	No	1	1	---
Shift Supervisor	No	1	1	---
STA	No	1	1	---
Reactor Operator	No	1	2	---
Plant Operators	Yes	2	2	---
Chemist	Yes	2	0	---
Radcon Tech	Yes	2	0	---
Elect Maintenance	Yes	2	0	---
Mech Maintenance	Yes	2	0	---
Security	Yes	2	0	---
Industry Safety Tech	Yes	2	0	---
I&C Technicians	Yes	2	0	---
Notes				

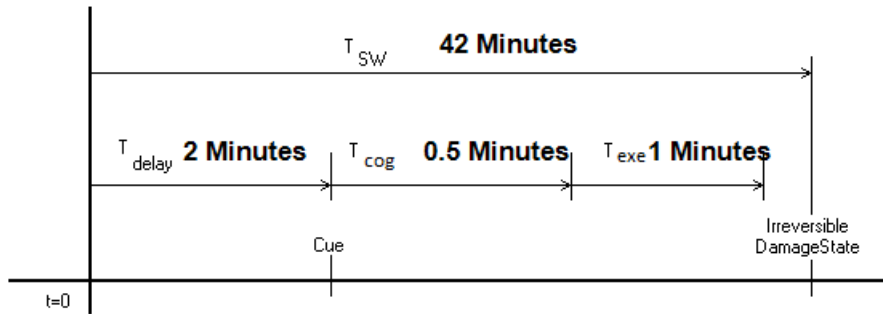
Assumptions
The first cue the operators receive to restart HPCI or RCIC is when the water level reaches +2 in. In reality, The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased, thus pump restart would likely be initiated prior to water level dropping to +2 in.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Operator Interview Insights

During observation of a demonstration of a representative scenario using the Unit 3 simulator, it was clear that the operators would track RPV level carefully.

Timing Analysis



Time available for cognition and recovery	39 Minutes
Time available for recovery	38.5 Minutes
SPAR-H Available time (cognitive)	39 Minutes
SPAR-H Available time (execution) ratio	39.50 Minutes
EPRI Minimum level of dependence for recovery	LD

Notes

This HFE has been updated for the current licensing thermal power (CLTP) case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for T_{sw} .

- (a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.
- (b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.

MAAP 4.0.7 run (407_CLTP)

Case 1 is a general transient scram with no injection.

Time to core damage (T_{sw}):

407_CLTP: $T_{\text{sw}} = 0.70$ hrs or 42 min

The CLTP modeling uses 42 minutes for HFEs in all general transient (GTRAN) sequences for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.

The initiation time is taken as the time when Level 8 is reached since this HEP applies to a failure to restart RFW following a Level 8 trip. Thus, the time delay is time from L8 to +2 in. = $0.06 - 0.02 = 0.04$ hours, or 2.4 minutes. The time delay would be shorter for scenarios that do not involve L8. For the CLTP case, however, the MAAP timing discussed above for T_{sw} was also used to re-evaluate T_{delay} , due to impacts from changes in RPV power since these operator actions may be derived based on other parameters such as time for battery depletion, time for irreversible equipment failure, or depletion of inventory. This re-evaluation resulted in a value of 2 minutes.

The median response time would be very short, because operators are monitoring water level closely during any transient. Based on response for similar actions median response time is taken as 30 seconds to restore RFW (per 1-AOI-3-1 4.2.12, 1-AOI-100-1 and 1-OI-3) once low level is detected.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Cognitive Analysis		
Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	l	7.50E-04
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure	e	1.98E-03
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		2.73E-03
Notes		

Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes	[]	[]	[]	(a) 0.0e+000
			[]	(b) 0.0e+000
No	[]	[]	[]	(c) 1.5e-004
			[]	(d) 1.5e-003
			[]	(e) 5.0e-002
			[]	(f) 5.0e-001
			[]	(g) 1.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcb: Failure of Attention

Notes/Assumptions: Workload would be expected to be relatively high due to attempts to restore some source of HPI. Action primarily triggered based on monitoring RPV level, which is indicated by a variety of displays and meters.

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value
Low	Check	Front		(a) 0.0e+000
		Back		(b) 1.5e-004
	Monitor	Front		(c) 3.0e-003
		Back		(d) 1.5e-004
High	Check	Front		(e) 3.0e-003
		Back		(f) 3.0e-004
	Monitor	Front		(g) 6.0e-003
		Back		(h) 0.0e+000
	Check	Front		(i) 0.0e+000
		Back		(j) 7.5e-004
Monitor	Front		(k) 1.5e-002	
	Back		(l) 7.5e-004	
				(m) 1.5e-002
				(n) 1.5e-003
				(o) 3.0e-002

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
Not easy	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	

Pce: Skip a step in procedure

Notes/Assumptions: Since a transition among three procedures might be required, and the unit supervisor would be following multiple paths through the EOIs, this is treated as a case of multiple procedures. Placekeeping aids are used in the form of a bracket in which the unit supervisor initials the steps as they are reached.

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value	
Obvious	Single	Yes	Yes	(a) 9.9e-004	
		No	No	(b) 3.3e-003	
	Multiple	Yes			(c) 3.0e-003
					(d) 1.0e-002
		No			(e) 2.0e-003
	Hidden	Multiple	Yes		(f) 4.3e-003
			No		(g) 6.0e-003
		Single	Yes		(h) 1.3e-002
			No		(i) 1.0e-001

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous	Yes		(c) 3.0e-002
	No		(d) 3.0e-003
			(e) 3.0e-002
			(f) 6.0e-003
			(g) 6.0e-002

Pcg: Misinterpret decision logic

Notes/Assumptions: Logic is straightforward, and this is a well-practiced scenario.

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value
Yes				(a) 1.6e-002
				(b) 4.8e-002
				(c) 5.9e-003
				(d) 1.8e-002
				(e) 2.0e-003
No				(f) 6.0e-003
				(g) 1.0e-002
				(h) 3.1e-002
				(i) 3.3e-004
				(j) 1.0e-003
				(k) 0.0e+000
			(l) 0.0e+000	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pch: Deliberate violation

Notes/Assumptions: There is no reason to expect other than verbatim compliance with this instruction.

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes				
				(a) 0.0e+000
				(b) 5.0e-001
No				(c) 1.0e+000
				(d) 0.0e+000
				(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	7.50E-04	-	-	X	-	-		LD	5.07E-02		3.80E-05
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pce	1.98E-03	X	X	-	-	-		LD	2.59E-02		5.13E-05
Pcf	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Final Pc (with recovery credited)											8.93E-05
Notes											

Execution Performance Shaping Factors		
Environment	Lighting	Normal
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)	Main control room	Accessible
Equipment Accessibility (Execution)	Main control room	Accessible

Stress	
Moderate	
Plant Response As Expected:	Yes
Workload:	High

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Performance Shaping Factors:	Optimal
Notes	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
EOI-1 RC/L-04	Restore and maintain water lvl between +2 in and +51 in ... with ... HPCI, Appx 5D	EOM	20-7b	1	4.3E-4	Moderate	
	Comment:	Operator must recognize low water level and the need to restore HPCI injection					
	Location:						
1-EOI Appx 5D Step 7	PLACE 1-HS-73-47A, HPCI AUXILIARY OIL PUMP, handswitch in start	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI Appx 5D Step 8	PLACE 1-HS-73-10A, HPCI STEAM PACKING EXHAUSTER, handswitch in start	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI Appx 5D Step 9	Open the following valves 1-FCV-73-30, 1FCV-73-44	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5D Step 10	OPEN 1-FCV-73-16, HPCI TURBINE STEAM	EOM	20-7b	1	4.3e-04	Moderate	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	SUPPLY VLV, to start HPCI turbine						
	Location:					Total Step HEP	8.60E-04
EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5D Step 11	CHECK proper HPCI operation by observing the following ...	EOM	20-7b	1	4.3e-04	Moderate	
	Comment	Operator instructed to a) check HPCI turbine speed, b) 1-FCV-73-45 red light illuminated, c) HPCI flow at 5000 gpm, d) 1-FCV-73-30 closes as HPCI flow exceeds 1200 gpm.					
	Location:					Total Step HEP	8.60E-04

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
EOI-1 RC/L-04		Restore and maintain water lvl between +2 in and +51 in ... with ... HPCI, Appx 5D	8.60E-04				8.60E-04
	EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...		8.60E-04	CD	1.00E+00	
1-EOI Appx 5D Step 7		PLACE 1-HS-73-47A, HPCI AUXILIARY OIL PUMP, handswitch in start	8.60E-04				8.60E-04
1-EOI Appx		PLACE 1-HS-73-	8.60E-04				8.60E-04

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

5D Step 8		10A, HPCI STEAM PACKING EXHAUSTER, handswitch in start					
1-EOI Appx 5D Step 9		Open the following valves 1-FCV-73-30, 1FCV-73-44	8.60E-04				8.60E-04
	1-EOI App 5D Step 11	CHECK proper HPCI operation by observing the following ...		8.60E-04	CD	1.00E+00	
1-EOI App 5D Step 10		OPEN 1-FCV-73-16, HPCI TURBINE STEAM SUPPLY VLV, to start HPCI turbine	8.60E-04				8.60E-04
	1-EOI App 5D Step 11	CHECK proper HPCI operation by observing the following ...		8.60E-04	CD	1.00E+00	
Total Unrecovered:			4.30E-03	Total Recovered:			4.30E-03

HFA_0073L8RESTART-EPU, Operator fails to restart HPCI after Level 8 trip

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J. Branch (Update for EPU)			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary				
	Pcog	Pexe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	2.73E-03	4.30E-03		
With Recovery	2.51E-04	4.30E-03	4.55E-03	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
<p>In the event of a transient, operators are instructed to maintain water level between +2 in. and +51 in. (level 8) (EOI-1, RC/L-4). If water level reaches +51 in. and either the HPCI or RCIC pump is operating to provide injection, the operating pump would be tripped. Without any other source of injection, the water level would then decrease. Operators are instructed to restart injection before water level decreases to +2 in. Failing this, the water level would continue to decrease eventually leading to core uncover and heatup.</p> <p>Several other steps in the EOI also instruct operators to restart a HPCI, RCIC, or other pump to restore level (e.g., EOI-1, step RC/L-7; C-1, step C1-4).</p> <p>The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the RFW, HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased.</p> <p>This HFE has been updated for the EPU case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for Tsw.</p> <p>(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.</p> <p>(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.</p> <p>MAAP 4.0.7 run of equivalent cases (407_EPU) Case 1 is a general transient scram with no injection. Time to core damage (Tsw): 407_EPU: Tsw = 0.59 hrs or 35.4 min A Tsw of 35 minutes typically used in the EPU Fire HRA for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.</p>

Cues and Indications

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Initial Cue	Low level in reactor pressure vessel
Recovery Cue	
Cue Comments	EOI-1 Step RC/L-4 instructs operators to maintain water level between +2 in. and +51 in. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action. Thus the cue is taken as water level at +2 in.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	1-EOI-1 (RPV Control, Unit 1, Browns Ferry Nuclear Power Plant) Revision: 0
Cognitive Step Number	RC/L-4
Cognitive Instruction	Restore and maintain RPV level . . . with one of the following sources
Execution Procedure	Execution: Not Selected
Execution Instruction	
Job Performance Measure	JPM: Not Selected
Notes	
Response begins with EOI-1, and transitions to C-1 when level cannot be maintained. Although operators would likely attempt to restart injection prior to water level dropping to +2 in., it is assumed that the operators allow the level to decrease to the procedural minimum before taking action.	

Training	
Classroom Training	
Simulator Training	

Crew Member	Included	Total Available	Required for Execution	Notes
Shift Manager	No	1	1	---
Shift Supervisor	No	1	1	---
STA	No	1	1	---
Reactor Operator	No	1	2	---
Plant Operators	Yes	2	2	---
Chemist	Yes	2	0	---
Radcon Tech	Yes	2	0	---
Elect Maintenance	Yes	2	0	---
Mech Maintenance	Yes	2	0	---
Security	Yes	2	0	---
Industry Safety Tech	Yes	2	0	---
I&C Technicians	Yes	2	0	---
Notes				

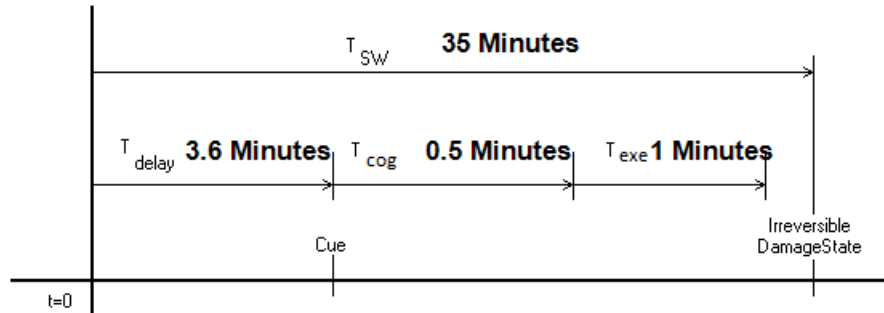
Assumptions
The first cue the operators receive to restart HPCI or RCIC is when the water level reaches +2 in. In reality, The operators monitor RPV level very closely during a transient. They would be anticipating tripping of the HPCI or RCIC turbine at Level 8 and restarting the pumps again if the water level decreased, thus pump restart would likely be initiated prior to water level dropping to +2 in.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Operator Interview Insights

During observation of a demonstration of a representative scenario using the Unit 3 simulator, it was clear that the operators would track RPV level carefully.

Timing Analysis



Time available for cognition and recovery	30.4 Minutes
Time available for recovery	29.9 Minutes
SPAR-H Available time (cognitive)	30.4 Minutes
SPAR-H Available time (execution) ratio	30.90 Minutes
EPRI Minimum level of dependence for recovery	LD

Notes

This HFE has been updated for the EPU case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for T_{sw} .

(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.

(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.

MAAP 4.0.7 run of equivalent cases (407_EPU)

Case 1 is a general transient scram with no injection.

Time to core damage (T_{sw}):

407_EPU: $T_{sw} = 0.59$ hrs or 35.4 min

A T_{sw} of 35 minutes is typically used in the EPU Fire HRA for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.

The initiation time is taken as the time when Level 8 is reached since this HEP applies to a failure to restart RFW following a Level 8 trip. Thus, the nominal time delay is time from L8 to +2 in. = $0.06 - 0.02 = 0.04$ hours, or 2.4 minutes. For the EPU case, however, the MAAP timing discussed above for T_{sw} was also used to re-evaluate T_{delay} , due to impacts from changes in RPV power since these operator actions may be derived based on other parameters such as time for battery depletion, time for irreversible equipment failure, or depletion of inventory. This re-evaluation resulted in a value of 3.6 minutes.

The median response time would be very short, because operators are monitoring water level closely during any transient. Based on response for similar actions (see HFA_OLPIINIT30), median response time is taken as 30 seconds to restore HPCI or RCIC once low level is detected.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Cognitive Analysis		
Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	l	7.50E-04
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure	e	1.98E-03
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		2.73E-03
Notes		

Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes	_____	_____	_____	(a) 0.0e+000
			_____	(b) 0.0e+000
No	_____	_____	_____	(c) 1.5e-004
			_____	(d) 1.5e-003
			_____	(e) 5.0e-002
			_____	(f) 5.0e-001
			_____	(g) 1.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcb: Failure of Attention

Notes/Assumptions: Workload would be expected to be relatively high due to attempts to restore some source of HPI. Action primarily triggered based on monitoring RPV level, which is indicated by a variety of displays and meters.

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value
Low	Check	Front		(a) 0.0e+000
		Back		(b) 1.5e-004
	Monitor	Front		(c) 3.0e-003
		Back		(d) 1.5e-004
High	Check	Front		(e) 3.0e-003
		Back		(f) 3.0e-004
	Monitor	Front		(g) 6.0e-003
		Back		(h) 0.0e+000
	Check	Front		(i) 0.0e+000
		Back		(j) 7.5e-004
Monitor	Front		(k) 1.5e-002	
	Back		(l) 7.5e-004	
				(m) 1.5e-002
				(n) 1.5e-003
				(o) 3.0e-002

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
Not easy	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	

Pce: Skip a step in procedure

Notes/Assumptions: Since a transition among three procedures might be required, and the unit supervisor would be following multiple paths through the EOIs, this is treated as a case of multiple procedures. Placekeeping aids are used in the form of a bracket in which the unit supervisor initials the steps as they are reached.

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value
Obvious <hr/> Hidden	Single	Yes	Yes	(a) 9.9e-004
		No	No	(b) 3.3e-003
	Multiple	Yes		(c) 3.0e-003
		No		(d) 1.0e-002
		Yes		(e) 2.0e-003
		No		(f) 4.3e-003
				(g) 6.0e-003
				(h) 1.3e-002
				(i) 1.0e-001

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous	Yes		(c) 3.0e-002
	No		(d) 3.0e-003
	Yes		(e) 3.0e-002
	No		(f) 6.0e-003
			(g) 6.0e-002

Pcg: Misinterpret decision logic

Notes/Assumptions: Logic is straightforward, and this is a well-practiced scenario.

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value	
Yes				(a) 1.6e-002	
				(b) 4.8e-002	
				(c) 5.9e-003	
				(d) 1.8e-002	
No				(e) 2.0e-003	
				(f) 6.0e-003	
					(g) 1.0e-002
					(h) 3.1e-002
				(i) 3.3e-004	
				(j) 1.0e-003	
					(k) 0.0e+000
					(l) 0.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pch: Deliberate violation

Notes/Assumptions: There is no reason to expect other than verbatim compliance with this instruction.

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes				
				(a) 0.0e+000
				(b) 5.0e-001
No				(c) 1.0e+000
				(d) 0.0e+000
				(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	7.50E-04	-	-	X	-	-		MD	1.44E-01		1.08E-04
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pce	1.98E-03	X	X	-	-	-		MD	7.23E-02		1.43E-04
Pcf	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Final Pc (with recovery credited)											2.51E-04
Notes											

Execution Performance Shaping Factors		
Environment	Lighting	Normal
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)	Main control room	Accessible
Equipment Accessibility (Execution)	Main control room	Accessible

Stress	
Moderate	
Plant Response As Expected:	Yes
Workload:	High

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Performance Shaping Factors:	Optimal
Notes	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
EOI-1 RC/L-04	Restore and maintain water lvl between +2 in and +51 in ... with ... HPCI, Appx 5D	EOM	20-7b	1	4.3E-4	Moderate	
	Comment	Operator must recognize low water level and the need to restore HPCI injection					
	Location:					Total Step HEP	8.60E-04
1-EOI Appx 5D Step 7	PLACE 1-HS-73-47A, HPCI AUXILIARY OIL PUMP, handswitch in start	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI Appx 5D Step 8	PLACE 1-HS-73-10A, HPCI STEAM PACKING EXHAUSTER, handswitch in start	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI Appx 5D Step 9	Open the following valves 1-FCV-73-30, 1FCV-73-44	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5D Step 10	OPEN 1-FCV-73-16, HPCI TURBINE STEAM	EOM	20-7b	1	4.3e-04	Moderate	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	SUPPLY VLV, to start HPCI turbine						
	Location:					Total Step HEP	8.60E-04
EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...	EOM	20-7b	1	4.3e-04	Moderate	
	Location:					Total Step HEP	8.60E-04
1-EOI App 5D Step 11	CHECK proper HPCI operation by observing the following ...	EOM	20-7b	1	4.3e-04	Moderate	
	Comment	Operator instructed to a) check HPCI turbine speed, b) 1-FCV-73-45 red light illuminated, c) HPCI flow at 5000 gpm, d) 1-FCV-73-30 closes as HPCI flow exceeds 1200 gpm.					
	Location:					Total Step HEP	8.60E-04

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
EOI-1 RC/L-04		Restore and maintain water lvl between +2 in and +51 in ... with ... HPCI, Appx 5D	8.60E-04				8.60E-04
	EOI-1 RC/L-7,8	If RPV water lvl drops below -120 in. ... augment RPV water lvl ...		8.60E-04	CD	1.00E+00	
1-EOI Appx 5D Step 7		PLACE 1-HS-73-47A, HPCI AUXILIARY OIL PUMP, handswitch in start	8.60E-04				8.60E-04
1-EOI Appx		PLACE 1-HS-73-	8.60E-04				8.60E-04

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

5D Step 8		10A, HPCI STEAM PACKING EXHAUSTER, handswitch in start					
1-EOI Appx 5D Step 9		Open the following valves 1-FCV-73-30, 1FCV-73-44	8.60E-04				8.60E-04
	1-EOI App 5D Step 11	CHECK proper HPCI operation by observing the following ...		8.60E-04	CD	1.00E+00	
1-EOI App 5D Step 10		OPEN 1-FCV-73- 16, HPCI TURBINE STEAM SUPPLY VLV, to start HPCI turbine	8.60E-04				8.60E-04
	1-EOI App 5D Step 11	CHECK proper HPCI operation by observing the following ...		8.60E-04	CD	1.00E+00	
Total Unrecovered:			4.30E-03	Total Recovered:			4.30E-03

HFFA_1SHV0760540_35-CLTP, Local action - close 1-SHV-076-0540 (2- and 3- for Units 2 and 3) within 35 minutes

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J BRANCH			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary				
	Pcog	Pexe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	0.00E+00	2.55E-02		
With Recovery	0.00E+00	3.78E-03	3.78E-03	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
This action supports the MCR Abandonment HRA.
This action is a general action to read and properly follow a step in the SSI that directs the operator to go to a valve and manually manipulate it. It models the operator missing the step and the proper selection of the valve.

Cues and Indications	
Initial Cue	Direction from fire procedure
Recovery Cue	
Cue Comments	Clarity of Cues and Indications are modeled explicitly in CBDTM.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	SSI-16 (Area 16 Fire Procedure) Revision: Draft
Cognitive Step Number	TYPICAL
Cognitive Instruction	[6] PROCEED TO Unit 1 Reactor Building EL 565 AND VERIFY CLOSED the following valves:
Execution Procedure	SSI-16 (Area 16 Fire Procedure) Revision: Draft
Execution Instruction	A. RHR HX 1A RHRSW INLET VLV, 1 SHV 023 0031 (R2 U-Line)
Job Performance Measure	JPM: Not Selected

Notes
The SSI-16 fire procedure will be used in conjunction with the EOIs. All necessary cognitive and execution steps are in the fire procedure and in some instances the SSI-16 cognitive and execution steps override the EOIs. This is due to the adverse effects the fire could have on equipment control.
The above cognitive and execution steps are typical and do not necessarily represent the specific use of this action. They are included just to show the nature of the guiding procedures.

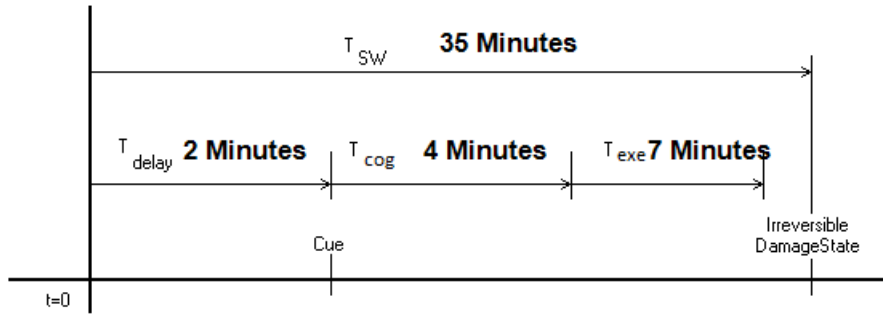
ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

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Assumptions
The operators have abandoned the MCR.

Operator Interview Insights

Timing Analysis



Time available for cognition and recovery	26 Minutes
Time available for recovery	22 Minutes
SPAR-H Available time (cognitive)	26 Minutes
SPAR-H Available time (execution) ratio	4.14 Minutes
EPRI Minimum level of dependence for recovery	MD

Notes

Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for T_{sw} .

(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.

(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.

NOTE: THE EPU Case timing was used as a bounding case for the CLTP case of this HFE. MAAP 4.0.7 run of equivalent cases (407_EPU)

Case 1 is a general transient scram with no injection.

Time to core damage (T_{sw}):

407_EPU: $T_{sw} = 0.59$ hrs or 35.4 min

A T_{sw} of 35 minutes is typically used for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.

T_{delay} is estimated as 2 min for the immediate post scram actions.

The shift supervisor directs the operators to perform their attachments immediately after scrambling the reactor.

T_{cog} is based on approximately 4 minutes to get to the proper step in the fire procedure.

Execution timing T_{exe} is estimated to be 2 min for manipulating the breaker + 5 min for travel to the board = 7 min total.

Cognitive Analysis		
Pc Failure Mechanism	Branch	HEP

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	i	0.00E+00
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure		n/a
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		0.00E+00

Notes

The shift supervisor is already in the fire procedure. Missing a step in that procedure is covered by the execution analysis. This cognitive section is added for completeness and the Pce is not included.

Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes	[]	[]	[]	(a) 0.0e+000
			[]	(b) 0.0e+000
No	[]	[]	[]	(c) 1.5e-004
			[]	(d) 1.5e-003
			[]	(e) 5.0e-002
			[]	(f) 5.0e-001
			[]	(g) 1.0e+000

Pcb: Failure of Attention

Notes/Assumptions:

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value	
Low	Check	Front	[]	(a) 0.0e+000	
		Back	[]	(b) 1.5e-004	
	Monitor	Front	[]	(c) 3.0e-003	
		Back	[]	(d) 1.5e-004	
	High	Check	Front	[]	(e) 3.0e-003
			Back	[]	(f) 3.0e-004
Monitor		Front	[]	(g) 6.0e-003	
		Back	[]	(h) 0.0e+000	
Check		Front	[]	(i) 0.0e+000	
		Back	[]	(j) 7.5e-004	
Monitor	Front	[]	(k) 1.5e-002		
	Back	[]	(l) 7.5e-004		
High	Monitor	Front	[]	(m) 1.5e-002	
		Back	[]	(n) 1.5e-003	
			[]	(o) 3.0e-002	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
Not easy	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	No

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pce: Skip a step in procedure

Notes/Assumptions:

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value
Obvious	Single	Yes	Yes	(a) 9.9e-004
		No	No	(b) 3.3e-003
	Multiple	Yes		(c) 3.0e-003
		No		(d) 1.0e-002
Hidden	Single	Yes		(e) 2.0e-003
		No		(f) 4.3e-003
	Multiple	Yes		(g) 6.0e-003
		No		(h) 1.3e-002
				(i) 1.0e-001

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value	
Standard	Yes		(a) 0.0e+000	
	No	Yes	(b) 3.0e-003	
Ambiguous		No	(c) 3.0e-002	
	Yes		(d) 3.0e-003	
	No			(e) 3.0e-002
				(f) 6.0e-003
				(g) 6.0e-002

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcg: Misinterpret decision logic

Notes/Assumptions:

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value
Yes			_____	(a) 1.6e-002
			_____	(b) 4.8e-002
			_____	(c) 5.9e-003
			_____	(d) 1.8e-002
			_____	(e) 2.0e-003
			_____	(f) 6.0e-003
No			_____	(g) 1.0e-002
			_____	(h) 3.1e-002
			_____	(i) 3.3e-004
			_____	(j) 1.0e-003
			_____	(k) 0.0e+000
			_____	(l) 0.0e+000

Pch: Deliberate violation

Notes/Assumptions:

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
No			_____	(a) 0.0e+000
			_____	(b) 5.0e-001
			_____	(c) 1.0e+000
			_____	(d) 0.0e+000
			_____	(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-			1.00E+00		0.0
Pcb	n/a	-	-	-	-	-			1.00E+00		0.0
Pcc	n/a	-	-	-	-	-			1.00E+00		0.0
Pcd	n/a	-	-	-	-	-			1.00E+00		0.0
Pce	n/a	-	-	-	-	-			1.00E+00		0.0

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcf	n/a	-	-	-	-	-			1.00E+00		0.0
Pcg	n/a	-	-	-	-	-			1.00E+00		0.0
Pch	n/a	-	-	-	-	-			1.00E+00		0.0
Final Pc (with recovery credited)											0.00E+00
Notes											
Not needed.											

Execution Performance Shaping Factors		
Environment	Lighting	Portable
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)		
Equipment Accessibility (Execution)	Reactor building	Accessible

Stress	
High	
Plant Response As Expected:	Yes
Workload:	N/A
Performance Shaping Factors:	N/A
Notes	
The stress is high due to MCR abandonment and the presence of a fire.	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
1	Operator manipulates valve	EOM	20-7b	2	1.3E-3	High	
		EOC	20-13	2	3.80E-03		
	Location:	Reactor building				Total Step HEP	2.55E-02
1r	Operator detects selection of wrong valve	EOM	20-7b	2	1.3E-3	High	
	Location:	Alternate Shutdown Panel				Total Step HEP	6.50E-03

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
1		Operator manipulates valve	2.55E-02				3.78E-03
	1r	Operator detects selection of wrong valve		6.50E-03	MD	1.48E-01	
Total Unrecovered:			2.55E-02	Total Recovered:			3.78E-03

HFFA_1SHV0760540_35-EPU, Local action - close 1-SHV-076-0540 (2- and 3- for Units 2 and 3) within 35 minutes

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J BRANCH			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary				
	Pcog	Pexe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	0.00E+00	2.55E-02		
With Recovery	0.00E+00	3.78E-03	3.78E-03	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
This action supports the MCR Abandonment HRA.
This action is a general action to read and properly follow a step in the SSI that directs the operator to go to a valve and manually manipulate it. It models the operator missing the step and the proper selection of the valve.

Cues and Indications	
Initial Cue	Direction from fire procedure
Recovery Cue	
Cue Comments	Clarity of Cues and Indications are modeled explicitly in CBDTM.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	SSI-16 (Area 16 Fire Procedure) Revision: Draft
Cognitive Step Number	TYPICAL
Cognitive Instruction	[6] PROCEED TO Unit 1 Reactor Building EL 565 AND VERIFY CLOSED the following valves:
Execution Procedure	SSI-16 (Area 16 Fire Procedure) Revision: Draft
Execution Instruction	A. RHR HX 1A RHR SW INLET VLV, 1 SHV 023 0031 (R2 U-Line)
Job Performance Measure	JPM: Not Selected

Notes
The SSI-16 fire procedure will be used in conjunction with the EOIs. All necessary cognitive and execution steps are in the fire procedure and in some instances the SSI-16 cognitive and execution steps override the EOIs. This is due to the adverse effects the fire could have on equipment control.
The above cognitive and execution steps are typical and do not necessarily represent the specific use of this action. They are included just to show the nature of the guiding procedures.

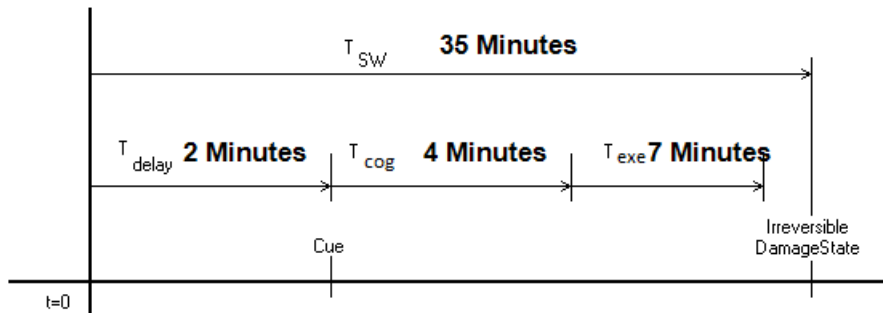
ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

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Assumptions
The operators have abandoned the MCR.

Operator Interview Insights

Timing Analysis



Time available for cognition and recovery	26 Minutes
Time available for recovery	22 Minutes
SPAR-H Available time (cognitive)	26 Minutes
SPAR-H Available time (execution) ratio	4.14 Minutes
EPRI Minimum level of dependence for recovery	MD

Notes	
<p>This HFE has been evaluated for the EPU case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for T_{sw}.</p> <p>(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.</p> <p>(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.</p> <p>MAAP 4.0.7 run of equivalent cases (407_EPU) Case 1 is a general transient scram with no injection. Time to core damage (T_{sw}): 407_EPU: $T_{\text{sw}} = 0.59$ hrs or 35.4 min A T_{sw} of 35 minutes is typically used in the EPU Fire HRA for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.</p> <p>T_{delay} is estimated as 2 min for the immediate post scram actions. The shift supervisor directs the operators to perform their attachments immediately after scrambling the reactor.</p> <p>T_{cog} is based on approximately 4 minutes to get to the proper step in the fire procedure.</p> <p>Execution timing T_{exe} is estimated to be 2 min for manipulating the breaker + 5 min for travel to the board = 7 min total.</p>	

Cognitive Analysis		
Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcb: Failure of Attention	i	0.00E+00
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure		n/a
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		0.00E+00
Notes		
The shift supervisor is already in the fire procedure. Missing a step in that procedure is covered by the execution analysis. This cognitive section is added for completeness and the Pce is not included.		

Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes	[]	[]	[]	(a) 0.0e+000
			[]	(b) 0.0e+000
No	[]	[]	[]	(c) 1.5e-004
			[]	(d) 1.5e-003
			[]	(e) 5.0e-002
			[]	(f) 5.0e-001
			[]	(g) 1.0e+000

Pcb: Failure of Attention

Notes/Assumptions:

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value
Low	Check	Front	[]	(a) 0.0e+000
		Back	[]	(b) 1.5e-004
	Monitor	Front	[]	(c) 3.0e-003
		Back	[]	(d) 1.5e-004
		Front	[]	(e) 3.0e-003
		Back	[]	(f) 3.0e-004
High	Check	Front	[]	(g) 6.0e-003
		Back	[]	(h) 0.0e+000
	Monitor	Front	[]	(i) 0.0e+000
		Back	[]	(j) 7.5e-004
		Front	[]	(k) 1.5e-002
		Back	[]	(l) 7.5e-004
	Monitor	Front	[]	(m) 1.5e-002
	Monitor	Back	[]	(n) 1.5e-003
			[]	(o) 3.0e-002

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
Not easy	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	No

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pce: Skip a step in procedure

Notes/Assumptions:

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value
Obvious	Single	Yes	Yes	(a) 9.9e-004
		No	No	(b) 3.3e-003
	Multiple	Yes		(c) 3.0e-003
		No		(d) 1.0e-002
Hidden	Single	Yes		(e) 2.0e-003
		No		(f) 4.3e-003
	Multiple	Yes		(g) 6.0e-003
		No		(h) 1.3e-002
				(i) 1.0e-001

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value	
Standard	Yes		(a) 0.0e+000	
	No	Yes	(b) 3.0e-003	
Ambiguous		No	(c) 3.0e-002	
	Yes		(d) 3.0e-003	
	No			(e) 3.0e-002
				(f) 6.0e-003
				(g) 6.0e-002

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcg: Misinterpret decision logic

Notes/Assumptions:

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value
Yes	[]	[]	[]	(a) 1.6e-002
			[]	(b) 4.8e-002
			[]	(c) 5.9e-003
			[]	(d) 1.8e-002
			[]	(e) 2.0e-003
			[]	(f) 6.0e-003
No	[]	[]	[]	(g) 1.0e-002
			[]	(h) 3.1e-002
			[]	(i) 3.3e-004
			[]	(j) 1.0e-003
			[]	(k) 0.0e+000
			[]	(l) 0.0e+000

Pch: Deliberate violation

Notes/Assumptions:

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
No	[]	[]	[]	(a) 0.0e+000
			[]	(b) 5.0e-001
			[]	(c) 1.0e+000
			[]	(d) 0.0e+000
			[]	(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-			1.00E+00		0.0
Pcb	n/a	-	-	-	-	-			1.00E+00		0.0
Pcc	n/a	-	-	-	-	-			1.00E+00		0.0
Pcd	n/a	-	-	-	-	-			1.00E+00		0.0
Pce	n/a	-	-	-	-	-			1.00E+00		0.0

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcf	n/a	-	-	-	-	-			1.00E+00		0.0
Pcg	n/a	-	-	-	-	-			1.00E+00		0.0
Pch	n/a	-	-	-	-	-			1.00E+00		0.0
Final Pc (with recovery credited)											0.00E+00
Notes											
Not needed.											

Execution Performance Shaping Factors		
Environment	Lighting	Portable
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)		
Equipment Accessibility (Execution)	Reactor building	Accessible

Stress	
High	
Plant Response As Expected:	Yes
Workload:	N/A
Performance Shaping Factors:	N/A
Notes	
The stress is high due to MCR abandonment and the presence of a fire.	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
1	Operator manipulates valve	EOM	20-7b	2	1.3E-3	High	
		EOC	20-13	2	3.80E-03		
	Location:	Reactor building				Total Step HEP	2.55E-02
1r	Operator detects selection of wrong valve	EOM	20-7b	2	1.3E-3	High	
	Location:	Alternate Shutdown Panel				Total Step HEP	6.50E-03

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
1		Operator manipulates valve	2.55E-02				3.78E-03
	1r	Operator detects selection of wrong valve		6.50E-03	MD	1.48E-01	
Total Unrecovered:			2.55E-02	Total Recovered:			3.78E-03

HFFA0268480CRSTIE-CLTP, FAILURE TO TRANSFER DEENERGIZED 480V BOARD TO ALTERNATE SUPPLY (FIRE)

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J BRANCH			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary				
	Pcog	Pexe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	6.00E-03	1.95E-02		
With Recovery	8.88E-04	9.81E-03	1.07E-02	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
<p>This HFE was evaluated for non-EPU conditions</p> <p>*** NOTE: This event is used in the rule file. If you change the HEP, change the rule file! ***</p> <p>In the event of a transient with unavailability of power from one of the 480V RMOV boards, the operators might need to take action to restore power to the board by connecting to the alternate supply. This analysis specifically addresses failure to restore power to 480V RMOV board 1A from shutdown board 1B. The analysis is applicable to analogous cases for the other 480V RMOV boards.</p> <p>The operators would normally be alerted to the lack of power most directly by an alarm on undervoltage for the affected board. The alarm response procedure directs the operators to verify the low voltage, and to check for any specific problems, such as evidence of a fire. They are then directed to the operating instruction to make the actual connection to the alternate supply. However, in a fire scenario the alarm may be unavailable.</p> <p>During talkthrough of a relevant scenario using the Unit 3 simulator, the operators indicated that they would recognize and respond to the undervoltage. Many cues would be available due to failures of equipment supplied by the board. After seeing these failures, the operator would check the board instrumentation and detect the board failure. Depending on the specific initiating event and any other failures that might have occurred, it is likely that response would be somewhat delayed while the operators dealt with actions called for in the EOIs.</p> <p>The limiting case of interest with respect to restoring power is one in which no source of high pressure injection is available immediately following the trip. Injection would need to be restored within about 37 min to prevent core damage.</p>

Cues and Indications	
Initial Cue	No voltage on RMOV boards
Recovery Cue	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Cue Comments	This cue does not credit any alarms because alarm circuits are not routed for fire scenarios. Many cues would be available due to failures of equipment supplied by the board. After seeing these failures, the operator would check the board instrumentation and detect the board failure.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	1-ARP-9-8C (Alarm Response Procedure for Panel Panel 1-9-8, 1-XA-55-8C) Revision:
Cognitive Step Number	17-D
Cognitive Instruction	REFER TO 0-OI-57B to re-energize the board
Execution Procedure	0-OI-57B (480V/240V AC Electrical System) Revision:
Execution Instruction	
Job Performance Measure	JPM: Not Selected
Other Procedures	FIRE-TBD (Fire Procedure (future)) Revision:
Notes	
Alarm response procedure would provide direction to restore power, with specific steps covered in the operating instruction.	

Training	
Classroom Training	
Simulator Training	

Crew Member	Included	Total Available	Required for Execution	Notes
Plant Operators	Yes	2	2	---
Reactor Operator	Yes	2	1	---
Shift Manager	No	1	0	
Shift Supervisor	No	1	0	
STA	No	1	0	
Chemist	No	1	0	
Radcon Tech	No	1	0	
Elect Maintenance	No	1	0	
Mech Maintenance	No	1	0	
Security	No	1	0	
Industry Safety Tech	No	1	0	
Notes				

Assumptions
Instructions for the operator actions on which this HFE is based will be incorporated in the fire procedures of the area where they will be credited. These operator actions will be demonstrated feasible and reliable as part of the NFPA-805 transition.
It is assumed that the relevant procedures will be changed so the required actions can be performed without relying on an annunciator.

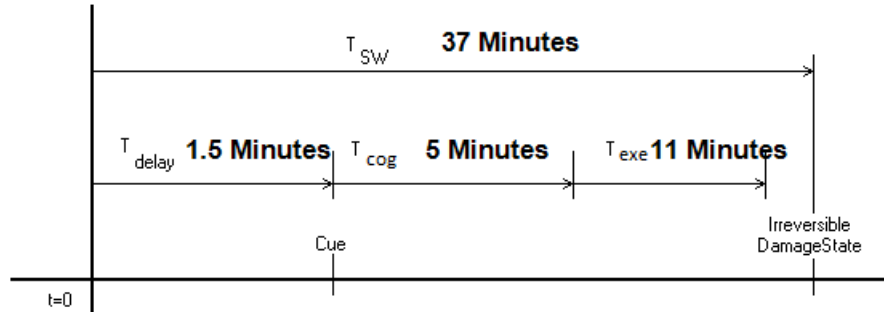
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Operator Interview Insights

During talkthrough of a relevant scenario using the Unit 3 simulator, the operators indicated that they would recognize and respond to the undervoltage. It would take about 10 min to complete the action.

See operator questionnaire "HFFA0268480CRSTIE" for more insight.

Timing Analysis



Time available for cognition and recovery	24.5 Minutes
Time available for recovery	19.5 Minutes
SPAR-H Available time (cognitive)	24.5 Minutes
SPAR-H Available time (execution) ratio	2.77 Minutes
EPRI Minimum level of dependence for recovery	MD

Notes

System time window is based on success criteria CASE05C (Success Criteria Notebook, Table 6-3, entry for RVD). The analysis showed that initiation of cooling within 30 min of the loss of high pressure injection (at the time of the reactor scram) was successful in preventing core damage. 7 minutes is added to this time based on MAAP run CASE01 with CLTP conditions

The median response time could be very short, but might be extended due to other early responses. Execution requires local action by two different operators.

Cognitive Analysis

Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	h	0.00E+00
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure	g	6.00E-03
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		6.00E-03

Notes

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Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes				(a) 0.0e+000
				(b) 0.0e+000
No				(c) 1.5e-004
				(d) 1.5e-003
				(e) 5.0e-002
				(f) 5.0e-001
				(g) 1.0e+000

Pcb: Failure of Attention

Notes/Assumptions: Workload would be expected to be relatively high, but response should be triggered by alarm, and does not require monitoring over time.

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value	
Low	Check	Front		(a) 0.0e+000	
		Back		(b) 1.5e-004	
	Monitor	Front		(c) 3.0e-003	
		Back		(d) 1.5e-004	
	High	Check	Front		(e) 3.0e-003
			Back		(f) 3.0e-004
Monitor		Front		(g) 6.0e-003	
		Back		(h) 0.0e+000	
Check		Front		(i) 0.0e+000	
		Back		(j) 7.5e-004	
Monitor	Front		(k) 1.5e-002		
	Back		(l) 7.5e-004		
High	Monitor	Front		(m) 1.5e-002	
		Back		(n) 1.5e-003	
				(o) 3.0e-002	

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Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
Not easy	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	No

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Pce: Skip a step in procedure

Notes/Assumptions: As the operators are in the fire procedures and the ARP's, multiple procedures always apply to fire scenarios. The step in the ARP is not graphically distinct, but there is a checkbox as a placekeeping aid.

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value
Obvious	Single	Yes	Yes	(a) 9.9e-004
		No	No	(b) 3.3e-003
	Multiple	No		(c) 3.0e-003
		Yes		(d) 1.0e-002
		Yes		(e) 2.0e-003
		No		(f) 4.3e-003
Hidden			(g) 6.0e-003	
			(h) 1.3e-002	
			(i) 1.0e-001	

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous	No		(c) 3.0e-002
	Yes		(d) 3.0e-003
	Yes		(e) 3.0e-002
	No		(f) 6.0e-003
	No		(g) 6.0e-002

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Pcg: Misinterpret decision logic

Notes/Assumptions: Logic is straightforward, and should lead to a clear decision to restore power.

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value
Yes				(a) 1.6e-002
				(b) 4.8e-002
				(c) 5.9e-003
				(d) 1.8e-002
				(e) 2.0e-003
				(f) 6.0e-003
No				(g) 1.0e-002
				(h) 3.1e-002
				(i) 3.3e-004
				(j) 1.0e-003
				(k) 0.0e+000
				(l) 0.0e+000

Pch: Deliberate violation

Notes/Assumptions: There is no reason to expect other than verbatim compliance with this instruction.

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes				(a) 0.0e+000
				(b) 5.0e-001
				(c) 1.0e+000
				(d) 0.0e+000
				(e) 0.0e+000
No				

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	n/a	-	-	-	-	-		HD	1.00E+00		0.0
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0

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Pce	6.00E-03	X	-	-	-	-		MD	1.48E-01		8.88E-04
Pcf	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Final Pc (with recovery credited)											8.88E-04
Notes											
Due to the relatively short time available for recovery, high dependence is applied as suggested for the default case.											

Execution Performance Shaping Factors		
Environment	Lighting	Portable
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Complex
Equipment Accessibility (Cognitive)	Main control room	Accessible
Equipment Accessibility (Execution)	RMOV board room	Accessible

Stress	
High	
Plant Response As Expected:	Yes
Workload:	High
Performance Shaping Factors:	Negative
Notes	
Negative PSF is that this is a relatively complex action (i.e., it is not a single step or series of simple steps).	

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Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
8.10[4]	CLOSE emergency feeder breaker from 480V SHUTDOWN	EOM	20-7b	2	1.3e-03	High	
		EOC	20-12	1a	0.00E+00		
	Location:					Total Step HEP	6.50E-03
8.10[7.7]-4	VERIFY bus voltage greater than 432 volts	EOM	20-7b	2	1.3e-03	High	
		Comment	This step would verify that the alignment had been made properly.				
	Location:					Total Step HEP	6.50E-03
8.10[7.2]	PLACE and HOLD ALTERNATE FEEDER BREAKER SWITCH in CLOSE while 2nd op completes Step 8.10[7.3]	EOM	20-7b	2	1.3e-03	High	
		EOC	20-12	1a	0.00E+00		
	Location:					Total Step HEP	6.50E-03
8.10[7.7]-7.2	VERIFY bus voltage greater than 432 volts	EOM	20-7b	2	1.3e-03	High	
		Comment	This step would verify that the alignment had been made properly.				
	Location:					Total Step HEP	6.50E-03
8.10[7.3]	PLACE NORMAL FEEDER BREAKER CONTROL SWITCH in trip	EOM	20-7b	2	1.3e-03	High	
		EOC	20-12	1a	0.00E+00		
	Location:					Total Step HEP	6.50E-03
8.10[7.7]-7.3	VERIFY bus	EOM	20-7b	2	1.3e-03	High	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	voltage greater than 432 volts						
	Comment	This step would verify that the alignment had been made properly.					
	Location:					Total Step HEP	6.50E-03

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
8.10[4]		CLOSE emergency feeder breaker from 480V SHUTDOWN	6.50E-03				3.27E-03
	8.10[7.7]-4	VERIFY bus voltage greater than 432 volts		6.50E-03	HD	5.03E-01	
8.10[7.2]		PLACE and HOLD ALTERNATE FEEDER BREAKER SWITCH in CLOSE while 2nd op completes Step 8.10[7.3]	6.50E-03				3.27E-03
	8.10[7.7]-7.2	VERIFY bus voltage greater than 432 volts		6.50E-03	HD	5.03E-01	
8.10[7.3]		PLACE NORMAL FEEDER BREAKER CONTROL SWITCH in trip	6.50E-03				3.27E-03
	8.10[7.7]-7.3	VERIFY bus voltage greater than 432 volts		6.50E-03	HD	5.03E-01	
Total Unrecovered:			1.95E-02	Total Recovered:			9.81E-03

HFFA0268480CRSTIE-EPU, FAILURE TO TRANSFER DEENERGIZED 480V BOARD TO ALTERNATE SUPPLY (FIRE)

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/7/2016
	Name			Date
Analyst	J BRANCH			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/7/2016

HEP Summary				
	Pcog	PeXe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	6.00E-03	1.95E-02		
With Recovery	3.02E-03	9.81E-03	1.28E-02	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
<p>*** NOTE: This event is used in the rule file. If you change the HEP, change the rule file! ***</p> <p>In the event of a transient with unavailability of power from one of the 480V RMOV boards, the operators might need to take action to restore power to the board by connecting to the alternate supply. This analysis specifically addresses failure to restore power to 480V RMOV board 1A from shutdown board 1B. The analysis is applicable to analogous cases for the other 480V RMOV boards.</p> <p>The operators would normally be alerted to the lack of power most directly by an alarm on undervoltage for the affected board. The alarm response procedure directs the operators to verify the low voltage, and to check for any specific problems, such as evidence of a fire. They are then directed to the operating instruction to make the actual connection to the alternate supply. However, in a fire scenario the alarm may be unavailable.</p> <p>During talkthrough of a relevant scenario using the Unit 3 simulator, the operators indicated that they would recognize and respond to the undervoltage. Many cues would be available due to failures of equipment supplied by the board. After seeing these failures, the operator would check the board instrumentation and detect the board failure. Depending on the specific initiating event and any other failures that might have occurred, it is likely that response would be somewhat delayed while the operators dealt with actions called for in the EOIs.</p> <p>The limiting case of interest with respect to restoring power is one in which no source of high pressure injection is available immediately following the trip. Injection would need to be restored within about 30 min to prevent core damage.</p>

Cues and Indications	
Initial Cue	No voltage on RMOV boards
Recovery Cue	
Cue Comments	This cue does not credit any alarms because alarm circuits are not routed for fire scenarios.

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	Many cues would be available due to failures of equipment supplied by the board. After seeing these failures, the operator would check the board instrumentation and detect the board failure.
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	1-ARP-9-8C (Alarm Response Procedure for Panel Panel 1-9-8, 1-XA-55-8C) Revision:
Cognitive Step Number	17-D
Cognitive Instruction	REFER TO 0-OI-57B to re-energize the board
Execution Procedure	0-OI-57B (480V/240V AC Electrical System) Revision:
Execution Instruction	
Job Performance Measure	JPM: Not Selected
Other Procedures	FIRE-TBD (Fire Procedure (future)) Revision:
Notes	
Alarm response procedure would provide direction to restore power, with specific steps covered in the operating instruction.	

Training	
Classroom Training	
Simulator Training	

Crew Member	Included	Total Available	Required for Execution	Notes
Plant Operators	Yes	2	2	---
Reactor Operator	Yes	2	1	---
Shift Manager	No	1	0	
Shift Supervisor	No	1	0	
STA	No	1	0	
Chemist	No	1	0	
Radcon Tech	No	1	0	
Elect Maintenance	No	1	0	
Mech Maintenance	No	1	0	
Security	No	1	0	
Industry Safety Tech	No	1	0	
Notes				

Assumptions
<p>Instructions for the operator actions on which this HFE is based will be incorporated in the fire procedures of the area where they will be credited.</p> <p>These operator actions will be demonstrated feasible and reliable as part of the NFPA-805 transition.</p> <p>It is assumed that the relevant procedures will be changed so the required actions can be performed without relying on an annunciator.</p>

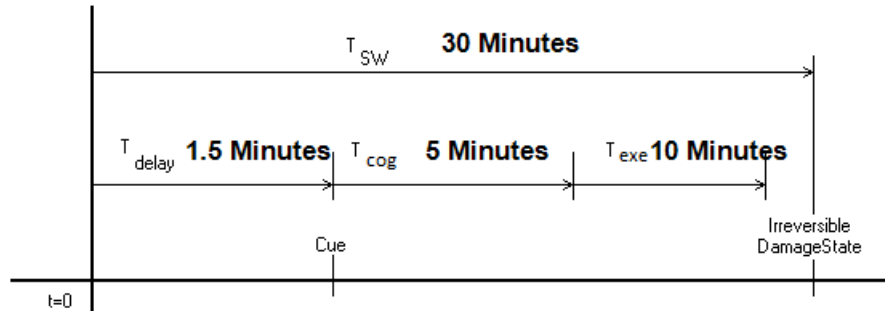
Operator Interview Insights
During talkthrough of a relevant scenario using the Unit 3 simulator, the operators indicated that they would recognize and respond to the undervoltage. It would take about 10 min to complete

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the action.

See operator questionnaire "HFFA0268480CRSTIE" for more insight.

Timing Analysis



Time available for cognition and recovery	18.5 Minutes
Time available for recovery	13.5 Minutes
SPAR-H Available time (cognitive)	18.5 Minutes
SPAR-H Available time (execution) ratio	2.35 Minutes
EPRI Minimum level of dependence for recovery	MD

Notes

System time window is based on success criteria CASE05C (Success Criteria Notebook, Table 6-3, entry for RVD). The analysis showed that initiation of cooling within 30 min of the loss of high pressure injection (at the time of the reactor scram) was successful in preventing core damage.

The median response time could be very short, but might be extended due to other early responses. Execution requires local action by two different operators.

Cognitive Analysis

Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	h	0.00E+00
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure	g	6.00E-03
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		6.00E-03

Notes

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Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes	[]	[]	[]	(a) 0.0e+000
			[]	(b) 0.0e+000
No	[]	[]	[]	(c) 1.5e-004
			[]	(d) 1.5e-003
			[]	(e) 5.0e-002
			[]	(f) 5.0e-001
			[]	(g) 1.0e+000

Pcb: Failure of Attention

Notes/Assumptions: Workload would be expected to be relatively high, but response should be triggered by alarm, and does not require monitoring over time.

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value
Low	Check	Front	[]	(a) 0.0e+000
		Back	[]	(b) 1.5e-004
	Monitor	Front	[]	(c) 3.0e-003
		Back	[]	(d) 1.5e-004
		Front	[]	(e) 3.0e-003
		Back	[]	(f) 3.0e-004
High	Check	Front	[]	(g) 6.0e-003
		Back	[]	(h) 0.0e+000
	Monitor	Front	[]	(i) 0.0e+000
		Back	[]	(j) 7.5e-004
		Front	[]	(k) 1.5e-002
		Back	[]	(l) 7.5e-004
[]	Monitor	Front	[]	(m) 1.5e-002
		Back	[]	(n) 1.5e-003
[]	[]	[]	[]	(o) 3.0e-002

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Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
Not easy	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	No

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Pce: Skip a step in procedure

Notes/Assumptions: As the operators are in the fire procedures and the ARP's, multiple procedures always apply to fire scenarios. The step in the ARP is not graphically distinct, but there is a checkbox as a placekeeping aid.

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value
Obvious	Single	Yes	Yes	(a) 9.9e-004
		No	No	(b) 3.3e-003
	Multiple	No		(c) 3.0e-003
		Yes		(d) 1.0e-002
		Yes		(e) 2.0e-003
		No		(f) 4.3e-003
Hidden			(g) 6.0e-003	
			(h) 1.3e-002	
			(i) 1.0e-001	

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous	No	Yes	(c) 3.0e-002
	Yes		(d) 3.0e-003
	Yes		(e) 3.0e-002
	No		(f) 6.0e-003
	No		(g) 6.0e-002

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcg: Misinterpret decision logic

Notes/Assumptions: Logic is straightforward, and should lead to a clear decision to restore power.

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value
Yes				(a) 1.6e-002
				(b) 4.8e-002
				(c) 5.9e-003
				(d) 1.8e-002
				(e) 2.0e-003
				(f) 6.0e-003
No				(g) 1.0e-002
				(h) 3.1e-002
				(i) 3.3e-004
				(j) 1.0e-003
				(k) 0.0e+000
				(l) 0.0e+000

Pch: Deliberate violation

Notes/Assumptions: There is no reason to expect other than verbatim compliance with this instruction.

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes				(a) 0.0e+000
				(b) 5.0e-001
				(c) 1.0e+000
				(d) 0.0e+000
				(e) 0.0e+000
No				

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	n/a	-	-	-	-	-		HD	1.00E+00		0.0
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0

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Pce	6.00E-03	X	-	-	-	-		HD	5.03E-01		3.02E-03
Pcf	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Final Pc (with recovery credited)											3.02E-03
Notes											
Due to the relatively short time available for recovery, high dependence is applied as suggested for the default case.											

Execution Performance Shaping Factors		
Environment	Lighting	Portable
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Complex
Equipment Accessibility (Cognitive)	Main control room	Accessible
Equipment Accessibility (Execution)	RMOV board room	Accessible

Stress	
High	
Plant Response As Expected:	Yes
Workload:	High
Performance Shaping Factors:	Negative
Notes	
Negative PSF is that this is a relatively complex action (i.e., it is not a single step or series of simple steps).	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
8.10[4]	CLOSE emergency feeder breaker from 480V SHUTDOWN	EOM	20-7b	2	1.3e-03	High	
		EOC	20-12	1a	0.00E+00		
	Location:					Total Step HEP	6.50E-03
8.10[7.7]-4	VERIFY bus voltage greater than 432 volts	EOM	20-7b	2	1.3e-03	High	
		Comment	This step would verify that the alignment had been made properly.				
	Location:					Total Step HEP	6.50E-03
8.10[7.2]	PLACE and HOLD ALTERNATE FEEDER BREAKER SWITCH in CLOSE while 2nd op completes Step 8.10[7.3]	EOM	20-7b	2	1.3e-03	High	
		EOC	20-12	1a	0.00E+00		
	Location:					Total Step HEP	6.50E-03
8.10[7.7]-7.2	VERIFY bus voltage greater than 432 volts	EOM	20-7b	2	1.3e-03	High	
		Comment	This step would verify that the alignment had been made properly.				
	Location:					Total Step HEP	6.50E-03
8.10[7.3]	PLACE NORMAL FEEDER BREAKER CONTROL SWITCH in trip	EOM	20-7b	2	1.3e-03	High	
		EOC	20-12	1a	0.00E+00		
	Location:					Total Step HEP	6.50E-03
8.10[7.7]-7.3	VERIFY bus	EOM	20-7b	2	1.3e-03	High	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	voltage greater than 432 volts						
	Comment	This step would verify that the alignment had been made properly.					
	Location:					Total Step HEP	6.50E-03

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
8.10[4]		CLOSE emergency feeder breaker from 480V SHUTDOWN	6.50E-03				3.27E-03
	8.10[7.7]-4	VERIFY bus voltage greater than 432 volts		6.50E-03	HD	5.03E-01	
8.10[7.2]		PLACE and HOLD ALTERNATE FEEDER BREAKER SWITCH in CLOSE while 2nd op completes Step 8.10[7.3]	6.50E-03				3.27E-03
	8.10[7.7]-7.2	VERIFY bus voltage greater than 432 volts		6.50E-03	HD	5.03E-01	
8.10[7.3]		PLACE NORMAL FEEDER BREAKER CONTROL SWITCH in trip	6.50E-03				3.27E-03
	8.10[7.7]-7.3	VERIFY bus voltage greater than 432 volts		6.50E-03	HD	5.03E-01	
Total Unrecovered:			1.95E-02	Total Recovered:			9.81E-03

HFFA0ASD_RCIC-CLTP , OPERATOR FAILS TO START RCIC

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J BRANCH			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary				
	Pcog	Pexe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	0.00E+00	4.10E-02		
With Recovery	0.00E+00	2.99E-02	2.99E-02	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
This action is to protect prevent inadvertent RCIC start, protect RCIC components and the RCIC board by placing the component breakers in EMERG, and then start RCIC from the alternate shutdown panel once the necessary SSI steps have been performed.

Cues and Indications	
Initial Cue	Direction from fire procedure
Recovery Cue	
Cue Comments	
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	SSI-16 (Area 16 Fire Procedure) Revision: Draft
Cognitive Step Number	TYPICAL
Cognitive Instruction	[9] DIRECT Unit Operator to perform the following: [9.1] HOLD RCIC TURB TRIP/THROT VALVE RESET, 1 HS 71 9D, in OPEN.
Execution Procedure	SSI-16 (Area 16 Fire Procedure) Revision: Draft
Execution Instruction	Unit operator instructions: [9.1] HOLD RCIC TURB TRIP/THROT VALVE RESET, 1 HS 71 9D, in OPEN. [9.2] WHEN 1 FCV 71 9 is OPEN, THEN RELEASE RCIC TURB TRIP/THROT VALVE RESET, 1 HS 71 9D. Field operator instructions: PLACE RCIC PUMP DISCHARGE VALVE EMER TRANS SWITCH in EMERG. PLACE RCIC PUMP INJECTION VALVE EMER TRANS SWITCH in EMERG. PLACE RCIC TURB STM SUPPLY EMER TRANS SWITCH in EMERG. PLACE RCIC CST 1 SUCT VALVE EMER TRANS SWITCH in EMERG. PLACE RCIC PUMP TEST BYP VALVE EMER TRANS SWITCH in

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

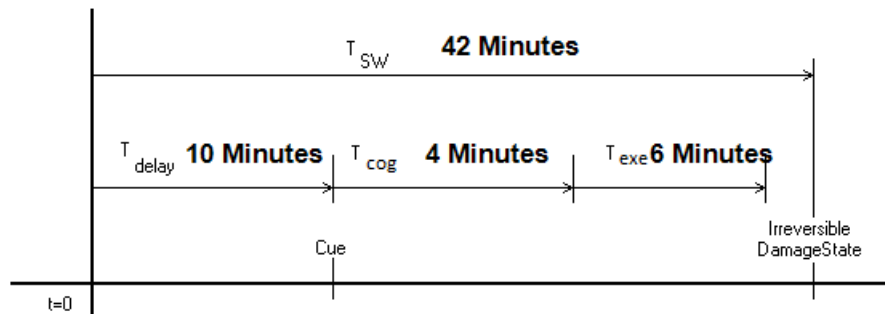
	EMERG. PLACE RCIC SUPP POOL OUTBD SUCT EMER TRANS SWITCH in EMERG. PLACE RCIC SUPP POOL INBD SUCT EMER TRANS SWITCH in EMERG. PLACE RCIC LUBE OIL CLR COOLING WATER VALVE EMER TRANS SWITCH in EMERG
Job Performance Measure	JPM: Not Selected
Notes	
The SSI gives instructions to the Unit operator to prevent spurious RCIC start until the field operator can protect RCIC components from MRC damage by placing them in EMERG at the 250v dc RCIC board. The steps to start RCIC are early in the SSI and the steps to place the components in EMERG are at the beginning of the attachment given to the field operator.	

Dependencies (Related Human Interactions)
HFFA1ASD_RCICISO

Assumptions
The operators have abandoned the MCR.

Operator Interview Insights
Operator interview needed

Timing Analysis



Time available for cognition and recovery	26 Minutes
Time available for recovery	22 Minutes
SPAR-H Available time (cognitive)	26 Minutes
SPAR-H Available time (execution) ratio	4.67 Minutes
EPRI Minimum level of dependence for recovery	MD

Notes

This HFE has been updated for the current licensing thermal power (CLTP) case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for T_{sw} .

(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.

(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.

MAAP 4.0.7 run (407_CLTP)
Case 1 is a general transient scram with no injection.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Time to core damage (Tsw):
 407_CLTP: Tsw = 0.70 hrs or 42 min
 The CLTP modeling uses 42 minutes for HFEs in all general transient (GTRAN) sequences for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.

A delay time of 10 minutes is the time to abandon the MCR and get to the respective stations.

It is assumed to take the operators 4 minutes to get to the proper steps in the SSI.

The following timing is used for the execution:

Reset and Open the Turbine trip throttle valve 6 min

Cognitive Analysis		
Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	h	0.00E+00
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure		n/a
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		0.00E+00
Notes		
The shift supervisor is already in the fire procedure. Missing a step in that procedure is covered by the execution analysis. This cognitive section is added for completeness and the Pce is not included. No cognitive impact was assessed for this HFE due to straightforward direction from the procedure.		

Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes	_____	_____	_____	(a) 0.0e+000
				(b) 0.0e+000
No	_____	_____	_____	(c) 1.5e-004
				(d) 1.5e-003
				(e) 5.0e-002
				(f) 5.0e-001
				(g) 1.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcb: Failure of Attention

Notes/Assumptions:

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value
Low	Check	Front		(a) 0.0e+000
		Back		(b) 1.5e-004
	Monitor	Front		(c) 3.0e-003
		Back		(d) 1.5e-004
High	Check	Front		(e) 3.0e-003
		Back		(f) 3.0e-004
		Front		(g) 6.0e-003
		Back		(h) 0.0e+000
	Monitor	Front		(i) 0.0e+000
		Back		(j) 7.5e-004
		Front		(k) 1.5e-002
		Back		(l) 7.5e-004
				(m) 1.5e-002
				(n) 1.5e-003
				(o) 3.0e-002

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
Not easy	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	

Pce: Skip a step in procedure

Notes/Assumptions:

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value	
Obvious	Single	Yes	Yes	(a) 9.9e-004	
		No	No	(b) 3.3e-003	
	Multiple	Yes			(c) 3.0e-003
					(d) 1.0e-002
		No			(e) 2.0e-003
					(f) 4.3e-003
	Hidden				(g) 6.0e-003
					(h) 1.3e-002
				(i) 1.0e-001	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous	Yes		(c) 3.0e-002
	No		(d) 3.0e-003
	Yes		(e) 3.0e-002
	No		(f) 6.0e-003
			(g) 6.0e-002

Pcg: Misinterpret decision logic

Notes/Assumptions:

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value	
Yes				(a) 1.6e-002	
				(b) 4.8e-002	
					(c) 5.9e-003
					(d) 1.8e-002
					(e) 2.0e-003
					(f) 6.0e-003
No				(g) 1.0e-002	
				(h) 3.1e-002	
					(i) 3.3e-004
					(j) 1.0e-003
					(k) 0.0e+000
					(l) 0.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pch: Deliberate violation

Notes/Assumptions:

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes				(a) 0.0e+000
No				(b) 5.0e-001
				(c) 1.0e+000
				(d) 0.0e+000
				(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pce	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcf	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Final Pc (with recovery credited)											
0.00E+00											
Notes											
Not needed											

Execution Performance Shaping Factors		
Environment	Lighting	Portable
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)	Alternate Shutdown Panel	Accessible
Equipment Accessibility (Execution)	Alternate Shutdown Panel	Accessible

Stress	
High	
Plant Response As Expected:	Yes
Workload:	High
Performance Shaping Factors:	Negative

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Notes
Stress is high due to the presence of a fire.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
1	Open the RCIC TURB TRIPO/THRO T valve	EOM	20-7b	2	1.3E-3	High	
		EOC	20-12	4	1.30E-03		
	Location:	Alternate Shutdown Panel				Total Step HEP	1.30E-02
1r	Detect Failure to Open the TRIP/THROTT LE Valve	EOM	20-7b	1	4.3E-4	High	
		Comment	This would be most directly observed by lack of injection flow				
	Location:	Alternate Shutdown Panel				Total Step HEP	2.15E-03
2	PLACE RCIC PUMP DISCHARGE VALVE EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		
	Comment	<p>This step and the steps following are listed together in a well defined section of a procedure. Once the operator locates this section of the procedure they will be focused on a short list.</p> <p>The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.</p>					
	Location:	Alternate Shutdown Panel					
3	PLACE RCIC PUMP INJECTION VALVE EMER	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	TRANS SWITCH in EMERG						
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03
4	PLACE RCIC TURB STM SUPPLY EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	3.50E-03
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03
5		EOM	20-7b	1	4.3E-4	High	3.50E-03
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03
	PLACE RCIC PUMP TEST	EOM	20-7b	1	4.3E-4	High	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

	BYP VALVE EMER TRANS SWITCH in EMERG	EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel			Total Step HEP		
7	PLACE RCIC SUPP POOL OUTBD SUCT EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel			Total Step HEP	3.50E-03	
8	PLACE RCIC SUPP POOL INBD SUCT EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case.					

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

		Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03
9	PLACE RCIC LUBE OIL CLR COOLING WATER VALVE EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
1		Open the RCIC TURB TRIPO/THROT valve	1.30E-02				1.88E-03
	1r	Detect Failure to Open the TRIP/THROTTLE Valve		2.15E-03	MD	1.45E-01	
2		PLACE RCIC PUMP DISCHARGE VALVE EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

3		PLACE RCIC PUMP INJECTION VALVE EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
4		PLACE RCIC TURB STM SUPPLY EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
5			3.50E-03				3.50E-03
6		PLACE RCIC PUMP TEST BYP VALVE EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
7		PLACE RCIC SUPP POOL OUTBD SUCT EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
8		PLACE RCIC SUPP POOL INBD SUCT EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
9		PLACE RCIC LUBE OIL CLR COOLING WATER VALVE EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
Total Unrecovered:			4.10E-02	Total Recovered:			2.99E-02

HFFA0ASD_RCIC-EPU, OPERATOR FAILS TO START RCIC

Plant	Data File	File Size	File Date	Record Date
	BFN_APLA-RAI 09.01 Response_20160708.hra	1331200	7/8/2016	7/8/2016
	Name			Date
Analyst	J BRANCH			7/6/2016
Reviewer	E. Collins, JENSEN HUGHES			7/8/2016

HEP Summary				
	Pcog	PeXe	Total HEP	Error Factor
Method	CBDTM	THERP	CBDTM+THERP	
Without Recovery	0.00E+00	4.10E-02		
With Recovery	0.00E+00	3.45E-02	3.45E-02	5

RAW	FV	Risk Significant
0.00E+00	0.00E+00	N/A

Identification and Definition
This action is to protect prevent inadvertent RCIC start, protect RCIC components and the RCIC board by placing the component breakers in EMERG, and then start RCIC from the alternate shutdown panel once the necessary SSI steps have been performed.

Cues and Indications	
Initial Cue	Direction from fire procedure
Recovery Cue	
Cue Comments	
Degree of Clarity	Clarity of Cues and Indications are modeled explicitly in CBDTM

Procedures	
Cognitive Procedure	SSI-16 (Area 16 Fire Procedure) Revision: Draft
Cognitive Step Number	TYPICAL
Cognitive Instruction	[9] DIRECT Unit Operator to perform the following: [9.1] HOLD RCIC TURB TRIP/THROT VALVE RESET, 1 HS 71 9D, in OPEN.
Execution Procedure	SSI-16 (Area 16 Fire Procedure) Revision: Draft
Execution Instruction	Unit operator instructions: [9.1] HOLD RCIC TURB TRIP/THROT VALVE RESET, 1 HS 71 9D, in OPEN. [9.2] WHEN 1 FCV 71 9 is OPEN, THEN RELEASE RCIC TURB TRIP/THROT VALVE RESET, 1 HS 71 9D. Field operator instructions: PLACE RCIC PUMP DISCHARGE VALVE EMER TRANS SWITCH in EMERG. PLACE RCIC PUMP INJECTION VALVE EMER TRANS SWITCH in EMERG. PLACE RCIC TURB STM SUPPLY EMER TRANS SWITCH in EMERG. PLACE RCIC CST 1 SUCT VALVE EMER TRANS SWITCH in EMERG. PLACE RCIC PUMP TEST BYP VALVE EMER TRANS SWITCH in

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

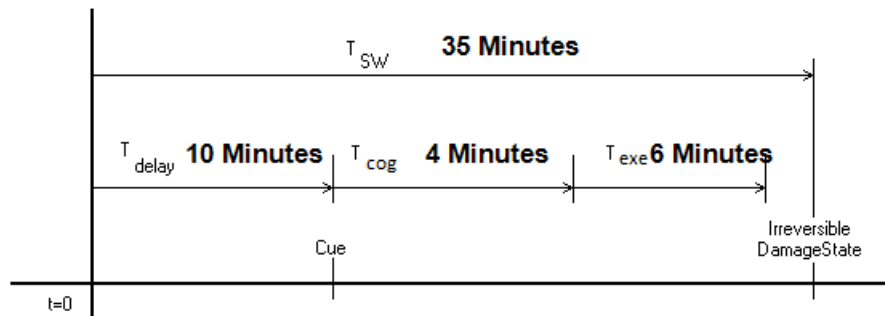
	EMERG. PLACE RCIC SUPP POOL OUTBD SUCT EMER TRANS SWITCH in EMERG. PLACE RCIC SUPP POOL INBD SUCT EMER TRANS SWITCH in EMERG. PLACE RCIC LUBE OIL CLR COOLING WATER VALVE EMER TRANS SWITCH in EMERG
Job Performance Measure	JPM: Not Selected
Notes	
The SSI gives instructions to the Unit operator to prevent spurious RCIC start until the field operator can protect RCIC components from MRC damage by placing them in EMERG at the 250v dc RCIC board. The steps to start RCIC are early in the SSI and the steps to place the components in EMERG are at the beginning of the attachment given to the field operator.	

Dependencies (Related Human Interactions)
HFFA1ASD_RCICISO

Assumptions
The operators have abandoned the MCR

Operator Interview Insights
Operator interview needed

Timing Analysis



Time available for cognition and recovery	19 Minutes
Time available for recovery	15 Minutes
SPAR-H Available time (cognitive)	19 Minutes
SPAR-H Available time (execution) ratio	3.50 Minutes
EPRI Minimum level of dependence for recovery	MD

Notes

This HFE has been updated for the EPU case. Attachment 44 to the LAR on Probabilistic Risk Assessment, pg. Att 44-72, discusses the following MAAP runs that were reviewed to identify the appropriate estimate for the time to core damage for T_{sw} .

(a) Browns Ferry Nuclear Plant Unit 1 PSA MAAP Thermal Hydraulic Calculations, Rev. 2, July 2008.

(b) NDN-000-999-2008-0006, "BFN Probabilistic Risk Assessment – Thermal Hydraulics Analysis," Rev. 4, August 2015.

MAAP 4.0.7 run of equivalent cases (407_EPU)
Case 1 is a general transient scram with no injection.
Time to core damage (T_{sw}):

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

407_EPU: Tsw = 0.59 hrs or 35.4 min

A Tsw of 35 minutes is typically used in the EPU Fire HRA for actions to initiate injection if all injection is lost at the scram and there are no stuck open relief valves.

A delay time of 10 minutes is the time to abandon the MCR and get to the respective stations.

It is assumed to take the operators 4 minutes to get to the proper steps in the SSI.

The following timing is used for the execution:

Reset and Open the Turbine trip throttle valve 6 min

Cognitive Analysis		
Pc Failure Mechanism	Branch	HEP
Pca: Availability of Information	a	0.00E+00
Pcb: Failure of Attention	h	0.00E+00
Pcc: Misread/miscommunicate data	a	0.00E+00
Pcd: Information misleading	a	0.00E+00
Pce: Skip a step in procedure		n/a
Pcf: Misinterpret Instructions	a	0.00E+00
Pcg: Misinterpret decision logic	k	0.00E+00
Pch: Deliberate violation	a	0.00E+00
Initial Pc(without recovery credited)		0.00E+00
Notes		
The shift supervisor is already in the fire procedure. Missing a step in that procedure is covered by the execution analysis. This cognitive section is added for completeness and the Pce is not included. No cognitive impact was assessed for this HFE due to straightforward direction from the procedure.		

Pca: Availability of Information

Notes/Assumptions:

Ind. Avail in CR	CR Ind. Accurate	Warn/Alt. in Proc.	Training on Ind.	Value
Yes	_____	_____	_____	(a) 0.0e+000
				(b) 0.0e+000
No	_____	_____	_____	(c) 1.5e-004
				(d) 1.5e-003
				(e) 5.0e-002
				(f) 5.0e-001
				(g) 1.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcb: Failure of Attention

Notes/Assumptions:

Low vs. Hi Workload	Check vs. Monitor	Front vs. Back Panel	Alarmed vs. Not Alarmed	Value
Low	Check	Front		(a) 0.0e+000
		Back		(b) 1.5e-004
	Monitor	Front		(c) 3.0e-003
		Back		(d) 1.5e-004
High	Check	Front		(e) 3.0e-003
		Back		(f) 3.0e-004
		Front		(g) 6.0e-003
		Back		(h) 0.0e+000
	Monitor	Front		(i) 0.0e+000
		Back		(j) 7.5e-004
		Front		(k) 1.5e-002
		Back		(l) 7.5e-004
				(m) 1.5e-002
				(n) 1.5e-003
				(o) 3.0e-002

Pcc: Misread/miscommunicate data

Notes/Assumptions:

Ind. Easy to Locate	Good/Bad Indicator	Formal Communication	Value
Easy	Good	Yes	(a) 0.0e+000
		No	(b) 3.0e-003
Not easy	Bad	Yes	(c) 1.0e-003
		No	(d) 4.0e-003
	Good	Yes	(e) 3.0e-003
		No	(f) 6.0e-003
	Bad	Yes	(g) 4.0e-003
		No	(h) 7.0e-003

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcd: Information misleading

Notes/Assumptions:

All Cues as Stated	Warning of Differences	Specific Training	General Training	Value
Yes				(a) 0.0e+000
No	Yes			(b) 3.0e-003
	No	Yes		(c) 1.0e-002
		No	Yes	
			No	

Pce: Skip a step in procedure

Notes/Assumptions:

Obvious vs. Hidden	Single vs. Multiple	Graphically Distinct	Placekeeping Aids	Value	
Obvious	Single	Yes	Yes	(a) 9.9e-004	
		No	No	(b) 3.3e-003	
	Multiple	Yes		(c) 3.0e-003	
		No		(d) 1.0e-002	
	Hidden	Single	Yes		(e) 2.0e-003
			No		(f) 4.3e-003
		Multiple	Yes		(g) 6.0e-003
			No		(h) 1.3e-002
				(i) 1.0e-001	

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pcf: Misinterpret Instructions

Notes/Assumptions:

Standard or Ambiguous Wording	All Required Information	Training on Step	Value
Standard	Yes	Yes	(a) 0.0e+000
	No	No	(b) 3.0e-003
Ambiguous	Yes		(c) 3.0e-002
	No		(d) 3.0e-003
	Yes		(e) 3.0e-002
	No		(f) 6.0e-003
			(g) 6.0e-002

Pcg: Misinterpret decision logic

Notes/Assumptions:

NOT Statement	AND or OR Statement	BOTH AND & OR	Practiced Scenario	Value
Yes				(a) 1.6e-002
				(b) 4.8e-002
				(c) 5.9e-003
				(d) 1.8e-002
				(e) 2.0e-003
				(f) 6.0e-003
No				(g) 1.0e-002
				(h) 3.1e-002
				(i) 3.3e-004
				(j) 1.0e-003
				(k) 0.0e+000
				(l) 0.0e+000

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Pch: Deliberate violation

Notes/Assumptions:

Belief in Adequacy of Instruction	Adverse Consequence if Comply	Reasonable Alternative	Policy of "Verbatim" Compliance	Value
Yes				(a) 0.0e+000
No				(b) 5.0e-001
				(c) 1.0e+000
				(d) 0.0e+000
				(e) 0.0e+000

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
Pca	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcb	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcc	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcd	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pce	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcf	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pcg	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Pch	n/a	-	-	-	-	-		N/A	1.00E+00		0.0
Final Pc (with recovery credited)											
0.00E+00											
Notes											
Not needed											

Execution Performance Shaping Factors		
Environment	Lighting	Portable
	Heat/Humidity	Normal
	Radiation	Non Radiation Area
	Atmosphere	Normal
Complexity of Response	Execution	Simple
Equipment Accessibility (Cognitive)	Alternate Shutdown Panel	Accessible
Equipment Accessibility (Execution)	Alternate Shutdown Panel	Accessible

Stress	
High	
Plant Response As Expected:	Yes
Workload:	High
Performance Shaping Factors:	Negative

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Notes
Stress is high due to the presence of a fire.

ALPA-RAI-09.01 (1) Response – HRA Calculator Reports

Execution Unrecovered							
Procedure		Comment				Stress Factor	Override
Step No.	Instruction / Comment	Error Type	THERP		HEP		
			Table	Item			
1	Open the RCIC TURB TRIPO/THRO T valve	EOM	20-7b	2	1.3E-3	High	
		EOC	20-12	4	1.30E-03		
	Location:	Alternate Shutdown Panel				Total Step HEP	1.30E-02
1r	Detect Failure to Open the TRIP/THROTT LE Valve	EOM	20-7b	1	4.3E-4	High	
		Comment	This would be most directly observed by lack of injection flow				
	Location:	Alternate Shutdown Panel				Total Step HEP	2.15E-03
2	PLACE RCIC PUMP DISCHARGE VALVE EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		
	Comment	<p>This step and the steps following are listed together in a well defined section of a procedure. Once the operator locates this section of the procedure they will be focused on a short list.</p> <p>The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.</p>					
Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03	
3	PLACE RCIC PUMP INJECTION VALVE EMER	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		

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	TRANS SWITCH in EMERG						
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03
4	PLACE RCIC TURB STM SUPPLY EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	3.50E-03
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03
5		EOM	20-7b	1	4.3E-4	High	3.50E-03
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03
	PLACE RCIC PUMP TEST	EOM	20-7b	1	4.3E-4	High	

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	BYP VALVE EMER TRANS SWITCH in EMERG	EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel			Total Step HEP		
7	PLACE RCIC SUPP POOL OUTBD SUCT EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel			Total Step HEP	3.50E-03	
8	PLACE RCIC SUPP POOL INBD SUCT EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case.					

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		Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03
9	PLACE RCIC LUBE OIL CLR COOLING WATER VALVE EMER TRANS SWITCH in EMERG	EOM	20-7b	1	4.3E-4	High	
		EOC	20-12	8a	2.70E-04		
	Comment	The primary error here is the operator fails to make the proper switch transfer. The stress level is high and the operator is assumed to be using portable lighting. However, the Item Ref. 8c is for both high stress and violates a prototype. The prototype violation is the major criteria affecting the failure probability for this type of error and there is no prototype violation in this case. Therefore, it is better to use item Ref. 8a even though it is for normal stress and then not credit a recovery step.					
	Location:	Alternate Shutdown Panel				Total Step HEP	3.50E-03

Execution Recovered							
Critical Step No.	Recovery Step No.	Action	HEP (Crit)	HEP (Rec)	Dep.	Cond. HEP (Rec)	Total for Step
1		Open the RCIC TURB TRIPO/THROT valve	1.30E-02				6.51E-03
	1r	Detect Failure to Open the TRIP/THROTTLE Valve		2.15E-03	HD	5.01E-01	
2		PLACE RCIC PUMP DISCHARGE VALVE EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03

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3		PLACE RCIC PUMP INJECTION VALVE EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
4		PLACE RCIC TURB STM SUPPLY EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
5			3.50E-03				3.50E-03
6		PLACE RCIC PUMP TEST BYP VALVE EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
7		PLACE RCIC SUPP POOL OUTBD SUCT EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
8		PLACE RCIC SUPP POOL INBD SUCT EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
9		PLACE RCIC LUBE OIL CLR COOLING WATER VALVE EMER TRANS SWITCH in EMERG	3.50E-03				3.50E-03
Total Unrecovered:			4.10E-02	Total Recovered:			3.45E-02

