

KHNPDCDRAIsPEm Resource

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Cc: Kent, Lauren; Junge, Michael; Ward, William; Lee, Samuel
Subject: APR1400 Design Certification Application RAI 315-8091 (18 - Human Factors Engineering)
Attachments: APR1400 DC RAI 315 COLP 8091.pdf

KHNP,

The attachment contains the subject request for additional information (RAI). This RAI was sent to you in draft form. Your licensing review schedule assumes technically correct and complete responses within 30 days of receipt of RAIs. However, KHNP requests, and we grant, 45 days to respond to this RAI. We may adjust the schedule accordingly.

Please submit your RAI response to the NRC Document Control Desk.

Thank you,

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Operating Company: Korea Hydro & Nuclear Power Co. Ltd.
Docket No. 52-046
Review Section: 18 - Human Factors Engineering
Application Section: 18.4

QUESTIONS

18-42

The first bullet of Criterion 9 in Section 5, "Task Analysis," of NUREG-0711 states, "the analysis establishes the time available using an analysis method and acceptance criteria consistent with the regulatory guidance associated with the actions. The basis for the time available is documented." Also, Section 1.2.2, "Review Elements," of NUREG-0711 states in part that the NRC staff accepts implementation plans for review when the results for an HFE element are not available for the review. Additionally, this section states, "to determine whether an implementation plan (IP) is acceptable, the NRC staff evaluates whether the IP is:... detailed, i.e., the IP describes the methodology in a step-by-step format to ensure that the applicant's design personnel can reliably use the IP, and that knowledgeable engineers will obtain consistent results from executing the methodology..."

Section 4.2.1, "Task Narrative", of the Task Analysis (TA) Implementation Plan (IP), APR1400-E-I-NR-14004, Rev. 0, discusses the information sources used to create the task narrative. Item 17 specifically discusses determining the "Time Available" (TmAv) and the importance of defining time zero for the event.

Section 4.3.1.1, "Time Available," discusses the time available as part of the "Task Timing Analysis" and how to identify the point in time when time available begins.

The information in these two sections is contradictory: it isn't clear if the SME should determine the "time available" from event initiation or from the HSI prompt. Note that Section 4.2, "Deterministically-Important Human Actions Analyses," of APR1400-E-I-NR-14006-P, "Treatment of Important Actions Implementation Plan" (TIHA IP), Rev. 0, Item 4 similarly discusses when the "time available" period should begin.

The "time available" information required to be documented in the TIHA results summary report is also extracted from the plant analyses in the DCD, which evaluates the time available from the event initiation.

Also, the qualifications of the "plant analyst" are not defined in APR1400-E-I-NR-14001-P, "Human Factors Engineering Program Plan."

1. Clarify whether or not the TmAv is determined from the event initiation, which is used in the plant analyses, or from the time of the HSI prompt.
2. If TmAv will be determined from the HSI prompt, provide detailed directions to the SME about how to determine this (e.g., state any documents that should be reviewed and any other resources that could be used).
3. If TmAv will be determined from the HSI prompt, clarify the qualifications and role of the "plant analyst."
4. Revise the submittal as necessary.

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18-43

The first bullet of Criterion 9 in Section 5, "Task Analysis," of NUREG-0711 states, "the analysis establishes the time available using an analysis method and acceptance criteria consistent with the regulatory guidance associated with the actions. The basis for the time available is documented."

Field description Item 6, "HFE PE [Program Element] Reference," of Section 4.2.1, "Task Narrative," of the TA IP describes how to correlate the task narrative being developed with other PEs and analyses; however, for important human actions, there is not clear direction for the SME to specifically document the basis for the value of TmAv that is documented in the task narrative.

1. Provide direction to the SME to document the basis for the value of the time available.
2. Revise the submittal as necessary.

18-44

The seventh bullet of Criterion 9 in Section 5, "Task Analysis," of NUREG-0711 states, "the analysis of the action sequence is conducted at a level of detail sufficient to identify individual task components, including cognitive elements such as diagnosis..." Additionally, it says, "the applicant should establish time estimates for individual task components and the basis for the estimates..."

Section 4.3.1.2.1, "Task Initiation Time," discusses determination of the time period between operator awareness of a plant condition to initiating response tasks. The first two paragraphs end with discussions of short task initiation times. The third period begins with a different, conservative task initiation time. The basis for these times is not documented in the TA IP.

1. Provide the basis for the task initiation times listed in the TA IP.
2. Revise the submittal as necessary.

18-45

Section 1.2.2, "Review Elements," of NUREG-0711 states in part that an acceptable implementation plan ensures that knowledgeable engineers will obtain consistent results from executing the methodology. Also, the third bullet of Criterion 9 in NUREG-0711 states that "techniques to minimize bias are used when estimates of time required are derived using methods that are dependent on expert judgment."

Section 4.3.1.2.2, "Subtask Time," describes determining the time required to complete all subtasks necessary to complete a specific task. The second to last paragraph discusses the process to determine the subtask time for non-standard, or unique subtasks, which may involve using SME judgments.

Using judgment may produce less consistent results than an empirical method. Additionally, information may be available from the reference plants or the predecessor plants.

1. Describe any conditions that may require judgment to be used instead of an empirical method, and describe how bias will be minimized when SME judgment is used.
2. Revise the submittal as necessary.

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18-46

Section 1.2.2, "Review Elements," of NUREG-0711 states in part that an acceptable implementation plan ensures that knowledgeable engineers will obtain consistent results from executing the methodology. Also, the third bullet of Criterion 9 in Section 5.4, "Review Criteria," in NUREG-0711 states that "techniques to minimize bias are used when estimates of time required are derived using methods that are dependent on expert judgment. Uncertainties in the analysis of time required are identified and assessed." Appendix 18-A, "Crediting Manual Operator Actions in Diversity and Defense-In-Depth Analyses," of NUREG-0800 provides additional guidance that specifically addresses DIHAs identified from DCD Tier 2 Chapter 7. Section 1.A, "Method," of Appendix 18-A states in part,

Methods that are dependent on expert judgment to derive time estimates for task components are potentially subject to bias. In addition, the uncertainties associated with estimates derived through these methods are difficult to quantify. Accordingly, these methods should be employed using structured approaches that minimize bias and help identify and assess uncertainties...Prior experience with tasks or subtasks similar to the actions...may provide valuable insights for the analysis/estimates of operator response times.

Section 4.3.1.2.3, "Task Characterization Time," describes time that is added at the task/subtask level at the discretion of the SME for specific, given reasons. Because the TA IP does not describe any techniques to minimize bias, or outline a structured approach, this method may produce inconsistent results.

1. Describe a method and/or a structured approach that will be used to determine the weighting factors or fixed amounts of time that will account for the task characterization time such that consistent results will be obtained, bias will be minimized and uncertainties are identified and assessed.
2. Revise the submittal as necessary.

18-47

Section 1.2.2, "Review Elements," of NUREG-0711 states in part that an acceptable implementation plan ensures that knowledgeable engineers will obtain consistent results from executing the methodology. Also, the third bullet of Criterion 9 in Section 5, "Task Analysis," in NUREG-0711 states that "techniques to minimize bias are used when estimates of time required are derived using methods that are dependent on expert judgment." Appendix 18-A, "Crediting Manual Operator Actions in Diversity and Defense-In-Depth Analyses," of NUREG-0800 provides additional guidance that specifically addresses DIHAs identified from DCD Tier 2 Chapter 7. Section 1.A, "Method," of Appendix 18-A states in part,

Methods that are dependent on expert judgment to derive time estimates for task components are potentially subject to bias. In addition, the uncertainties associated with estimates derived through these methods are difficult to quantify. Accordingly, these methods should be employed using structured approaches that minimize bias and help identify and assess uncertainties...Prior experience with tasks or subtasks similar to the actions...may provide valuable insights for the analysis/estimates of operator response times.

Section 4.3.1.2.4, "Administrative Time," describes the time included which is not directly related to the task. As described in the TA IP, these times may be adjusted based on SME experience and judgment and an explanation of their basis is recorded. In order to verify the above review criteria, staff needs more than the time adjustment basis.

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1. Describe a method and/or a structured approach that will be used by the SMEs to determine the administrative weighting factors such that consistent results will be obtained, bias will be minimized and uncertainties are identified and assessed.
2. Revise the submittal as necessary.

18-48

Section 1.2.2, "Review Elements," of NUREG-0711 states in part that an acceptable implementation plan ensures that knowledgeable engineers will obtain consistent results from executing the methodology. Also, the third bullet of Criterion 9 in Section 5, "Task Analysis," in NUREG-0711 states that "techniques to minimize bias are used when estimates of time required are derived using methods that are dependent on expert judgment." Appendix 18-A, "Crediting Manual Operator Actions in Diversity and Defense-In-Depth Analyses," of NUREG-0800 provides additional guidance that specifically addresses DIHAs identified from DCD Tier 2 Chapter 7. Section 1.A, "Method," of Appendix 18-A states in part,

Methods that are dependent on expert judgment to derive time estimates for task components are potentially subject to bias. In addition, the uncertainties associated with estimates derived through these methods are difficult to quantify. Accordingly, these methods should be employed using structured approaches that minimize bias and help identify and assess uncertainties...Prior experience with tasks or subtasks similar to the actions...may provide valuable insights for the analysis/estimates of operator response times.

Section 4.3.1.2.5, "Critical Function Time," describes the time spent maintaining situational awareness independent of and concurrent with performing specific tasks and how it is determined. The second paragraph describes specific factors used in this determination. The described time determination processes discuss the use of SME judgment.

1. Describe a method and/or a structured approach that will be used by the SMEs to establish the factors described in this section such that consistent results will be obtained, bias will be minimized and uncertainties are identified and assessed.
2. Revise the submittal as necessary.

18-49

Section 1.2.2, "Review Elements," of NUREG-0711 states in part that an acceptable implementation plan ensures that knowledgeable engineers will obtain consistent results from executing the methodology.

Section 4.3.2, "Time Margin," of the TA IP describes how the "Time Margin" is calculated including one time input which may not be available. When this occurs, the section states that SME's reach consensus on what to use. It is not clear how the SMEs reach this consensus, or why it would be necessary, considering that information about plant processes should be available in the APR1400 or reference plant documentation.

1. Describe why the analysis of PdTm would need to depend on SME judgment. If there is a reason for this, then describe how the SMEs will reach this consensus (for example, what information will they use) and how consistent results will be obtained.
2. Revise the submittal as necessary.

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18-50

The seventh bullet of Criterion 9 in Section 5, "Task Analysis," in NUREG-0711 states in part that the analysis of the action sequence is conducted at a level of detail sufficient to identify individual task components, including cognitive elements such as diagnosis and selection of appropriate response. Also, Section 1.2.2, "Review Elements," of NUREG-0711 states in part that to determine whether or not an implementation plan (IP) is acceptable, the staff evaluates whether the IP is detailed; i.e., the IP describes the methodology in a step-by-step format to ensure the applicant's design personnel can reliably use the IP.

Section 4.3, "Task Timing Analysis," of the TA IP says that, "[t]he analysis of the subtask sequences is conducted at a level of detail sufficient to identify individual task components..." as Criterion 9 expects. However, the TA IP lacks clear guidance to the SMEs performing the task analysis to incorporate any relevant standard or unique subtasks into the sequence of operator actions documented in the task narrative.

1. Provide a method, and/or step-by-step instructions for the SMEs to ensure that the subtasks and the subtask sequence documented in the task narrative will be analyzed at a level of detail sufficient to identify individual task components.
2. Additionally, describe how the SME should incorporate standard and unique subtasks into the subtask sequence for each task.
3. Revise the submittal as necessary.

18-51

The fourth bullet under Criterion 9 in Section 5, "Task Analysis," of NUREG-0711 states, "the sequence of actions uses only alarms, controls, and displays that would be available and operable during the assumed scenario(s)." Also, the fourth bullet under Section 1.B., "Review Criteria," in Appendix 18-A of NUREG-0800 states further that, for DIHAs identified from DCD Tier 2 Chapter 7, "operable means the main control room equipment that would still be available based on the defense-in-depth analysis of the postulated CCF associated with each event that is evaluated in the accident analysis section of the safety analysis report." Additionally, Section 1.2.2, "Review Elements," of NUREG-0711 states in part that to determine whether or not an implementation plan (IP) is acceptable, the staff evaluates whether the IP is detailed; i.e., the IP describes the methodology in a step-by-step format to ensure the applicant's design personnel can reliably use the IP.

Although Section 4.3, "Task Timing Analysis," contains a statement that aligns with the fourth bullet under Criterion 9 in Section 5 of NUREG-0711, the sections of the TA IP that tell the SME how to develop the task narrative and the HSI inventory for tasks related to important human actions do not contain any direction to consider this constraint. Furthermore, Table 4-1, "Key Available Information for Operators for DBEs with a CCF in Digital Safety I&C Systems," of the CCF Coping Analysis (APR1400-Z-A-NR-14019, Rev. 0) lists the alarms, controls, and indications that are available to the operator during a software CCF that occurs during an accident or transient. Additional information is also found in the DCD Tier 2, Chapter 15 analyses. The TA IP does not contain any direction to use these documents when the task narrative and HSI inventory are generated for tasks associated with important human actions.

1. Provide clear direction to the SMEs to only include the alarms, controls, and displays that would be available and operable when the task will be performed.

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2. Include any resources (e.g., the CCF Coping Analysis and DCD Tier 2, Chapter 15) that the SMEs can use to make sure that only the alarms, controls, and displays that would be available and operable during task performance are documented in the task analysis.
3. Revise the submittal as necessary.

18-52

The sixth bullet of Criterion 9 in Section 5, "Task Analysis," of NUREG-0711 states that "staffing for analysis is justified, and if credited manual actions require additional operators beyond the assumed staffing, the justification for timely availability of the additional staffing is provided and the estimate of time required includes any time needed for calling in additional personnel." Also, Section 1.2.2, "Review Elements," of NUREG-0711 states in part that an acceptable implementation plan is detailed to ensure that knowledgeable engineers will obtain consistent results from executing the methodology.

Section 4.3.1.2.2, "Subtask Time," in the TA IP describes the determination of the time required to complete subtasks. Item 7 of section 4.3.1.2.2 discusses physical transitions between two operator locations.

1. Item 7.a., Clarify if "from offsite" means the furthest distance an operator could be from the main control room while at the plant or if it means the furthest distance that an operator could be while off duty (for example, the operator is at home and needs to be called in).
2. If "from offsite" could mean "from home," then it would not be possible to obtain information about the associated transition time from a plant walkthrough. Describe how this time will be determined.
3. Describe how the SMEs will identify whether or not additional operators need to be called in to perform a task, and describe how the time required will account for the time for these operators to travel to the site.
4. Describe any assumptions that the SMEs should use to determine transition times and the basis for those assumptions, if applicable (e.g., assumptions about how long it would take for off-shift personnel to arrive at the plant if needed).
5. Revise the submittal as necessary.

18-53

The eighth bullet of Criterion 9 states, "the analysis identifies a time margin to be added to the time required and the basis for the adequacy of the margin." Additionally, Appendix 18-A, "Crediting Manual Operator Actions in Diversity and Defense-In-Depth Analyses," of NUREG-0800 also includes specific guidance for evaluating the time margin associated with manual operator actions that are credited in the coping analysis. Section 1.A, "Method," states in part, "the basis for the specific time margin used in the analysis should be justified and documented. Insights from the HFE program, especially the OER and human reliability analysis, should be used. The identification of potential errors, error detection methods, and error recovery paths in event trees may be used to provide estimates of how much margin should be added to the operator response time estimates."

Section 4.3.2, "Time Margin," of the TA IP describes how the "Time Margin" is calculated using the "Time Available" and the "Time Engaged". It also provides an arbitrary acceptable Time Margin without sufficient justification. Also, the guidance in Appendix 18-A of NUREG-0800 was not addressed for the time margin associated with deterministically important human actions credited in the CCF coping analysis submitted as part of DCD Chapter 7.

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1. Provide some basis to support the statements made in the last paragraph of this section regarding an acceptable Time Margin.
2. Describe how the guidance of Section 1.A in Appendix 18-A of NUREG-0800 regarding time margin for manual operator actions credited in the CCF Coping Analysis is satisfied.
3. Revise the submittal as necessary.

18-54

The eighth bullet of Section 1.B., "Review Criteria," in Appendix 18-A of NUREG-0800 states in part that "the analysis of the action sequence is conducted at a level of detail sufficient to identify...the associated performance shaping factors that affect time required and the potential for operator error." Note that Appendix 18-A specifically applies to DIHAs identified from the CCF Coping Analysis.

Item 22, "Performance-shaping factors," in Section 4.2.1, "Task Narrative," of the TA IP provides the applicants directions in addressing the shaping factors that affect the time required to execute tasks; however, there is no direction to identify and document factors that could contribute to operator error during the performance of manual operator actions credited for a software CCF during an accident or transient.

Revise the submittal to ensure that any performance shaping factors that affect the potential for operator error are identified and documented (for DIHAs identified in the CCF Coping Analysis).

18-55

The sixth bullet in Section 1.B., "Review Criteria," in Appendix 18-A of NUREG-0800 states, "The initial MCR operating staff size and composition assumed for the analysis of time required is the same as the minimum MCR staff defined in the Technical Specifications." This guidance is applicable to DIHAs identified from the CCF Coping Analysis.

Item 18, "Staff," in Section 4.2.1 of the TA IP describes how staff requirements are addressed in developing the Task Narrative. However, there is no direction for the SME to verify that the required number and qualification of operators aligns with the minimum number of staff defined in the Technical Specifications.

1. Provide direction to the SME to ensure that the initial MCR operating staff size and composition assumed for the analysis of time required is the same as the minimum MCR staff defined in the Technical Specifications.
2. Revise the submittal as necessary.

18-56

The first bullet of Criterion 9 in NUREG-0711 states, "the analysis establishes the time available using an analysis method and acceptance criteria consistent with the regulatory guidance associated with the actions. The basis for the time available is documented." Also, Section 1.2.2, "Review Elements," of NUREG-0711 states in part that the NRC staff accepts implementation plans for review when the results for an HFE element are not available for the review. Additionally, this section states, "to determine whether an implementation plan (IP) is acceptable, the NRC staff evaluates whether the IP is:... detailed, i.e., the IP describes the methodology in a step-by-step format to ensure that the applicant's design

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personnel can reliably use the IP, and that knowledgeable engineers will obtain consistent results from executing the methodology...”

Finally, the first bullet in Section 1.B., “Review Criteria,” in Appendix 18-A of NUREG-0800 states that for manual operator actions credited to mitigate the consequences of a software common cause failure during a postulated accident or transient, “The analysis establishes the time available using an analysis method and acceptance criteria consistent with the guidance of BTP 7-19. The basis for the time available is documented.”

Item 17, “Time Available,” in Section 4.2.1, “Task Narrative,” of the TA IP discusses the information sources used to create the task narrative. These information sources include DCD chapters and their associated technical reports submitted with the design certification application. The staff reviewed these documents to verify that they contained the time available for important human actions [emphasis added by staff using underline]:

- Section 5.4.2.6, “Steam Generator Tube Rupture,” of APR1400-Z-A-NR-14019, “CCF Coping Analysis,” Revision 0, subsection 5.4.2.6.2, “Analysis of Effects and Consequences,” subsection c., “Results,” states, “for offsite dose calculation, the manual actions are assumed to begin step by step according to appropriate operating procedures using available functions from 30 minutes after the event initiation.” The CCF Coping Analysis does not identify when these credited actions need to be completed by to avoid adverse consequences (i.e., the time available).
- Section 5.1, “Major Assumptions and Initial Conditions,” of the CCF Coping Analysis states, “It is assumed that no operator action is taken during the 30 minutes after event initiation. At 30 minutes after the event, the operators begin to perform manual controls of the plant under the appropriate recovery procedures....” For example, subsection 5.4.2.8.2, “Analysis of Effects and Consequences,” states that for a steam line break inside containment, it is assumed that at 30 minutes, operators actuate containment spray and close the main steam isolation valves. It isn’t clear if the CCF Coping Analysis assumes that these two manual actions occur at 30 minutes after event initiation, or if there is some delay associated with the operators beginning to take these actions at 30 minutes after event initiation and actually accomplishing them.
- The staff reviewed Table 15.6.3-3, “Sequence of Events for a Steam Generator Tube Rupture with a Loss of Offsite Power,” in DCD Chapter 15. The table shows that at 1800 seconds (30 minutes) after the event initiation, the “operator cools the NSSS using plant emergency procedure after isolation of affected steam generator or confirmation of isolation.” Section 15.6.3.1.3, “Core and System Performance,” in DCD Chapter 15 further states, “After 1800 seconds, the operator identifies and completes isolation of the affected SG.” Chapter 15 does not discuss what specifically these credited actions are and when these credited actions need to be completed before adverse consequences occur.
- The staff did not find the time available for any risk-important human actions in DCD Tier 2 Chapter 19.

The TIHA IP and the TA IP state that the values of “time available” will be extracted from the plant analyses. Because these analyses have been submitted for staff review, they do not need to be deferred to the COL applicant. Further, the staff did not determine that the time available was clearly documented in DCD Tier 2 Chapters 7, 15, and 19, and the CCF Coping Analysis.

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1. Submit the values of TmAv for all IHAs for staff review and the basis for the time available (for example, if it is assumed that operators can isolate a steam generator with a design basis tube rupture within 30 minutes from the time of the event initiation, document the basis for this assumption).
2. Revise the submittal (e.g., the coping analysis and DCD Chapter 15 sections, TIHA IP, and TA IP) as necessary.

18-57

Section 1.A, "Method," of Appendix 18-A of NUREG-0800 cautions that because the time intervals described in ANSI/ANS 58.8, "Time Response Design Criteria for Safety-Related Operator Actions," were validated using analog controls, the guidance may be not accurate for digital I&C systems.

Section 7.2, "Manual Operator Action Time Evaluation Methods," in APR1400-Z-J-NR-14002, "Diversity and Defense-in-Depth," Rev. 0, states, "Any operator action credited in the CCF Coping Analysis prior to 30 minutes is justified based on a reasonable HFE evaluation methodology. The starting time of operator actions is based on conservative application of HFE standards such as ANSI/ANS 58.8-1994." This report also describes justification for operator actions credited prior to 30 minutes in the CCF Coping Analysis and includes some assumptions that are not described in the TA IP (e.g., the time to execute all steps in the standard post-trip actions [SPTAs] is based on ANSI/ANS 58.8-1994). The CCF Coping Analysis, section 5.1(j) states that no actions are credited until 30 minutes after event initiation; therefore, it isn't clear why the Defense-in-Depth Report discusses actions credited prior to 30 minutes.

1. Align the information in Section 7.2 of APR1400-Z-J-NR-14002, "Diversity and Defense-in-Depth," and Section 5.1(j) in APR1400-Z-A-NR-14019, "CCF Coping Analysis," about the timing of operator actions so that the information in these reports is consistent.
2. Describe why the time intervals in ANSI/ANS 58.8-1994 are accurate for the APR1400.
3. Revise the submittal as necessary.



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