KHNPDCDRAIsPEm Resource

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Sent: Wednesday, September 06, 2017 7:45 PM
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Subject: APR1400 Design Certification Application RAI 553-9084 [18 - Human Factors Engineering]
Attachments: APR1400 DC RAI 553 HOIB 9084.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.

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

Thank you,

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REQUEST FOR ADDITIONAL INFORMATION 553-9084

Issue Date: 09/06/2017
Application Title: APR1400 Design Certification Review – 52-046
Operating Company: Korea Hydro & Nuclear Power Co. Ltd.
Docket No. 52-046
Review Section: 18 - Human Factors Engineering
Application Section:

QUESTIONS

Regulatory Basis

This regulatory basis applies to all questions in this request for additional information (RAI). Title 10 of the Code of Federal Regulations (10 CFR), Section 52.47(a)(8) requires an applicant for a design certification to provide a final safety analysis report (FSAR) that must include the information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). Specifically, Three Mile Island requirements in 10 CFR 50.34(f)(2)(iii) requires an applicant to "Provide, for Commission review, a control room design that reflects state-of-the-art human factor principles prior to committing to fabrication or revision of fabricated control room panels and layouts." Chapter 18, "Human Factors Engineering," of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Revision 3; and NUREG-0711, "Human Factors Engineering Program Review Model," Revision 3; identify criteria the staff uses to evaluate whether an applicant meets this requirement.

18-133

Acceptance Criteria

NUREG-0711, Criterion 7.4(1), states: "The applicant should identify risk-important HAs [human actions] from the PRA/HRA [Probabilistic Risk Assessment/Human Reliability Analysis]."

NUREG-0711, Section 7.1, "Background," provides additional context for this review criterion and states,

> *The PRA and HRA should begin early in the design process to provide insights and guidance for both systems design and for HFE* [human factors engineering] *purposes. Thus, the applicant should use, as appropriate, the first version of the PRA/HRA (depending on the amount of design information available) to identify the important HAs, so that they can be considered in the early HFE design elements. The analyses should be updated iteratively as the design progresses (including the final PRA/HRA) to ensure the actual important HAs are captured and considered. At the very least, the initial PRA/HRA, and the set of important HAs, should be finalized when the design of the plant and HSI* [human-system interface] *are complete.*

Section 7.1 also states,

> *HRA is an integral part of a completed PRA. Applicants submit PRAs in accordance with the NRC's current requirements. An HRA evaluates the potential for, and mechanisms of human error that might affect plant safety. Thus, it is an essential feature in assuring the HFE program goal of generating a design to minimize personnel errors, support their detection, and ensure recovery capability. The HRA is an integrated activity supporting both the HFE design and PRA activities. The robustness and quality of the HRA largely depends on the analyst's understanding of the causes, modes and probabilities of human error, the personnel tasks to be performed, information about those tasks, and any task-specific factors that may influence the human performance of them. Analysts should employ the descriptions and analyses of personnel functions and tasks, along with the operational characteristics of the HSIs. The HRA provides valuable insights into the desirable characteristics of the HSI design. Consequently, the HFE design should pay special attention to those plant scenarios, risk-important HAs, and HSIs that the PRA/HRA highlights as vital to plant safety and reliability."*

Application

- DCD Tier 2, Rev. 1, Section 18.6.1, "Objectives and Scope," says, "The scope of IHAs [important human actions] includes risk-important human actions (RIHAs) identified by the PRA (DCD Chapter 19)…"

- DCD Tier 2, Rev. 1, Section 18.6.2, "TIHA Methodology," says, "Since RIHAs and associated HFE characteristics are clearly identified in the PRA documentation, they are extracted from the PRA for inclusion in the TIHA results summary report (ReSR), without additional HFE judgment or evaluation."

- APR1400-E-I-NR-14006, "Treatment of Important Human Actions Implementation Plan" (TIHA IP), Revision 1, Section 4.1, "Risk-Important Human Actions," reiterates the statement from DCD Tier 2, Section 18.6.2, that RIHAs and the HFE characteristics are clearly identified in the PRA documentation, and therefore no analysis is required during the process of identifying RIHAs for the HFE program. The staff notes that a revision was included in the TIHA IP, Rev 1 regarding the need for PRA knowledge.

Following the June 21, 2017, meeting on Chapter 18 with the Advisory Committee on Reactor Safeguards (ACRS) APR1400 Subcommittee, the staff considered the following issues with the treatment of important human actions described in the application:

- The combined license (COL) applicant will be performing the activities described in the TIHA IP. The COL applicant develops a site-specific PRA and HRA. NUREG-0711, Section 7.1, "Background," says, "The analyses should be updated iteratively as the design progresses (including the final PRA/HRA) to ensure the actual important HAs are captured and considered. At the very least, the initial PRA/HRA, and the set of important HAs, should be finalized when the design of the plant and HSI are complete." Because the COL applicant will perform the activities described in the TIHA IP, the COL's site-specific PRA and HRA are more appropriate for use than the design-specific PRA.

- The TIHA IP, Rev 1, contains Appendices B, "Preliminary TIHA output for Deterministically-Identified Important Human Actions [DIHAs]," and C "Preliminary TIHA output for RIHA's," which list “preliminary output” for the IHAs. However, the TIHA IP does not explain how these appendices are to be used, and also, the information in Appendix B may change because the APR1400 PRA is still being revised for the design certification. Information in Appendix C may also change when the DCD is revised. Repeating information in multiple sections of the application can cause confusion and introduce errors if one section is updated and the other is not.

- The COL applicant needs to complete Table 4-1, “TIHA Output for RIHAs,” in the TIHA IP, which requires identification of the RIHAs as well as the HFE characteristics associated with each IHA that is documented in the human reliability analyses. To correctly identify these HFE characteristics and the risk-important human actions, personnel who have been involved in the development of the site-specific HRA and PRA need to be working with the HFE design team to complete Table 4-1. Personnel who are SMEs in the technical discipline(s) identified in the TIHA IP, Rev 1, Section 4.1, must have the qualifications listed in APR1400-E-I-NR-14001-P, Rev 1, “Human Factors Engineering Program Plan,” Section 5, “Implementation Team.” The staff found that the qualifications for the SMEs who must complete Table 4-1 of the TIHA IP do not include PRA and HRA knowledge. Therefore, the staff thinks these SMEs will need to coordinate with other personnel who do have knowledge of the APR1400 PRA and HRA in order to complete Table 4-1 of the TIHA IP.

- Some aspects of the site-specific PRA (including the quantification of seismic risk) will likely not be determined until fuel load, which occurs after the control room has been constructed. The application does not address whether or how any RIHAs identified as a result of quantifying the seismic PRA will be addressed in the HFE design program.

Questions

Please explain the following and revise the application (i.e., the TIHA IP and DCD Tier 2, Section 18.6) as needed based on the responses:

a. Explain why the site-specific PRA and HRA that will be developed by the COL applicant will not be used to complete Table 4-1 of the TIHA IP. Or, revise the application such that the site-specific PRA and HRA will be used to complete Table 4-1 of the TIHA IP.

b. Explain why PRA and HRA knowledge is not needed to complete Table 4-1 of the TIHA IP, or revise the application to clarify that SMEs with the technical discipline identified in the TIHA IP, Section 4.1, will coordinate with personnel who have knowledge of the PRA and HRA to complete Table 4-1 of the TIHA IP.

c. Remove Appendices B and C from the TIHA IP.

d. Explain how IHAs that result from the quantification of the site-specific seismic PRA are included in the HFE design program.

18-134

Acceptance Criteria

NUREG-0800, Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria," Appendix A, "Information on Prior Design Certification Reviews," says, "Tier 1 information includes…iii. Inspections, tests, analyses, and acceptance criteria (ITAAC)…"

SECY-92-053, "Use of Design Acceptance Criteria During 10 CFR Part 52 Design Certification Reviews," says, "The DAC [design acceptance criteria] are a set of prescribed limits, parameters, procedures, and attributes upon which the NRC relies, in a limited number of technical areas, in making a final safety determination to support a design certification. The DAC are to be objective (measurable, testable, or subject to analysis using pre-approved methods), and must be verified as a part of the ITAAC [inspections, tests, analyses, and acceptance criteria] performed to demonstrate that the as built facility conforms to the certified design. That is, the acceptance criteria for DAC become the acceptance criteria for ITAAC, which are part of the design certification."

SECY-17-0075, "Planned Improvements in Design Certification Tiered Information Designations," dated July 24, 2017 (ADAMS Accession No. ML16196A321), explains that Tier 2* information must be demonstrated to have the same safety significance as Tier 1, and Tier 2* should be applied only when an applicant determines the additional flexibility for making changes could be beneficial.

Application

KHNP is using design acceptance criteria (DAC) for Chapter 18. HFE implementation plans describing activities that will be performed to develop an APR1400 control room design that reflects state-of-the-art human factors principles have been provided in lieu of a control room design that reflects state-of-the-art human factors principles. In order to develop a control room design that reflects state-of-the-art human factors principles, the COL applicant will need to perform the activities described in each of the HFE implementation plans.

DCD Tier 2, Rev. 1, Section 14.3.2.9, "ITAAC for Human Factors Engineering," and DCD Tier 1, Rev. 1, Section 2.9, "Human Factors Engineering," describe the HFE-related ITAAC for the APR1400. ITAAC 1 in Table 2.9-1, "Human Factors Engineering ITAAC" (shown below) contains the design ITAAC only for the integrated systems validation (ISV), which is one of the major verification and validation (V&V) activities described in APR1400-E-I-NR-14008-P, "Human Factors Verification and Validation Implementation Plan" (V&V IP), Rev. 1.

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. The control room design incorporates HFE principles that minimize the potential for operator error.	1. An Integrated System Validation Test will be performed in accordance with the Verification and Validation Implementation Plan. [Design ITAAC]	1. An Integrated System Validation Report exists and concludes that acceptance criteria associated with each test scenario are satisfied upon initial performance of the scenarios or upon remediation of failures.

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
2. The as-built control room HSIs are consistent with the final validated design specifications.	2. An inspection of the as-built control room HSIs will be performed.	2. The as-built control room HSIs conform to the validated design with no configuration deviations.

ITAAC 1 is limited to only verifying completion of the ISV scenarios, and there are no other HFE ITAAC in the application to verify the completion of the other HFE activities in accordance with their implementation plans. Also, ITAAC 1 is limited to the ISV and excludes the other V&V activities described in the V&V IP. The staff thinks that ITAAC should be included to verify the HFE activities that will be completed in accordance with the implementation plans (the staff notes an ITAAC is not specifically required for implementation of the HFE Program Plan because the information in the HFE Program Plan is used to perform the activities in the other HFE implementation plans).

Additionally, because KHNP has used DAC, the staff is using information in the HFE implementation plans to make a final safety determination to support a design certification. Some portions of the HFE implementation plans contain the acceptance criteria for the DAC, which would be acceptance criteria for HFE ITAAC. Additionally, APR1400-E-I-NR-14010-P, Rev. 1, "Human Factors Verification and Validation Scenarios" (the scenarios document), says that it contains the scenarios that will be used to perform the activities described in the V&V IP. The V&V IP, Section 4.1.4, "Scenario Definition," also contains information that indicates the scenarios in the scenarios document are the minimum set of scenarios for the V&V activities. As such, the staff considers the scenarios document to be an extension of the V&V IP. Therefore, the staff thinks the following information should be identified as Tier 1 information because the information contains the acceptance criteria for the DAC that will be the acceptance criteria for the HFE ITAAC, which is Tier 1 information:

- Section 2, "Scope;" Section 3, "Methodology Overview;" Section 4, "Implementation;" Section 5, "Implementation Team;" Section 6, "Results Summary Report;" and Section 8, "Definitions" of the following HFE implementation plans:

  - APR1400-E-I-NR-14001, "Human Factors Engineering Program Plan"
  - APR1400-E-I-NR-14002, "Operating Experience Review Implementation Plan"
  - APR1400-E-I-NR-14003, "Functional Requirements Analysis and Function Allocation Implementation Plan"
  - APR1400-E-I-NR-14004, "Task Analysis Implementation Plan"
  - APR1400-K-I-NR-14005, "Staffing and Qualifications Implementation Plan"
  - APR1400-E-I-NR-14006, "Treatment of Important Human Actions Implementation Plan"
  - APR1400-E-I-NR-14007, "Human-System Interface Design Implementation Plan"
  - APR1400-E-I-NR-14008, "Human Factors Verification and Validation Implementation Plan"
  - APR1400-K-J-NR-14009, "Design Implementation Plan"

- Section 3, "Sampling of Operational Conditions for the Integrated System Verification;" Section 5, "APR1400 Human Factors Verification and Validation Scenarios;" and

Appendices A, B, C, D, E, F, and G of APR1400-E-I-NR-14010, "Human Factors Verification and Validation Scenarios."

Alternatively, the staff would also evaluate a proposal to identify the above listed sections of the HFE implementation plans and scenarios document as Tier 2* information instead of Tier 1.

Questions

a. Either (1) expand the scope of ITAAC Item 1 in Table 2.9-1 to include the other HFE activities that have associated implementation plans as well as the other V&V activities, or (2) add additional ITAAC to Table 2.9-1 for each HFE activity that has an associated implementation plan. DCD Tier 2, Section 14.3.2.9, "ITAAC for Human Factors Engineering," and Section 14.3.5, "Design ITAAC Closure Process," should be revised if DCD Tier 1, Section 2.9, "Human Factors Engineering," is revised.

b. Explain why the sections of the HFE IPs and the scenarios document listed above are not Tier 1 given they contain DAC that will be acceptance criteria for ITAAC.

c. If the sections listed above of the HFE implementation plans and scenarios document will be Tier 1, then delete the HFE implementation plans from DCD Tier 2, Table 1.6-2, and include the sections listed above of the HFE implementation plans and the scenarios document in the DCD Tier 1.

If KHNP proposes to make the sections listed above of the HFE implementation plans and the scenarios document Tier 2* instead of Tier 1, then add the scenarios document to DCD Tier 2, Table 1.6-2, and uniquely identify proposed Tier 2* information in the application (e.g., with brackets and italics).

18-135

Acceptance Criteria

NUREG-0711, Criterion 11.4.3.3 (1) states, "The applicant's testbed should represent completely the integrated system. It should include HSIs and procedures not specifically required in the test scenarios."

Application

APR1400-E-I-NR-14001, "Human Factors Engineering Program Plan" (HFE PP), Rev. 1, Section 4.7.3.6, "Human-System Interface Design Interfaces," states, "Procedure development (PD) generates conventional paper-based operating procedures for all operating and shutdown modes, including normal, abnormal, and emergency conditions. The HD [HSI Design] converts the operating procedures executed from the MCR [main control room] into CBPs [computer-based procedures]. The scope of the HD for this conversion is limited to the procedures used during the ISV of the V&V. Other paper procedures are converted to CBPs within the PD program element."

APR1400-E-I-NR-14007, "Human-System Interface Design Implementation Plan" (HD IP), Rev. 1, Section 2.2, also states, "The HD PE [HSI design program element] also includes the CBPs that are used for the scenarios conducted during the ISV. Other procedures that are unrelated

to the V&V scenarios are not within the scope of the HD PE because they have their own development and verification program through the procedure development (PD) PE."
The HD IP Rev. 1, Section 3.5.6, "Procedure Development," Section 4.2.6, "Computer-Based Procedures," and Section 6, "Results Summary Report," contain similar statements that indicate the development of CBPs and paper procedures during HSI design is limited to those that will be needed to run the ISV scenarios.

The staff is concerned because these portions of the application indicate that the testbed used to conduct the ISV will only include the procedures that will be used during the ISV scenarios. If the full set of plant procedures that will be in the control room are not included in the V&V testbed, then opportunities to identify human performance errors associated with selecting and using procedures may be reduced.

Question

Revise the HFE PP and HD IP such that the testbed used for V&V activities, including ISV, will also include the HSIs and procedures developed as part of the HFE design process that are not specifically required in the test scenarios.

18-136

Acceptance Criteria

NUREG-0711, Criterion 3.4.1(2), states, "The applicant should address the HFE issues identified in NUREG/CR-6400 ["HFE Insights For Advanced Reactors Based Upon Operating Experience"]. The issues are organized into the following categories: unresolved safety issues/generic safety issues (See 10 CFR 52.47(a)(21) and NUREG-0933); TMI [Three Mile Island] issues; NRC generic letters and information notices; operating experience reports in the NUREG-1275 series, Vol. 1 through 14; low power and shut down operations; and operating plant event reports. Additionally, the applicant should review and discuss all operating experience in the preceding categories that was published since NUREG/CR-6400 was published in 1996."

Application

- APR1400-E-I-NR-14002-P, Rev. 1, "Operating Experience Review Implementation Plan" (OER IP), Section 3, "Methodology," states, "The OER for the APR1400 is based on the OER that was conducted for the Shin-Kori Nuclear Power Plant Units 3 and 4 (SKN 3&4) design." Section 4.5, "The Process of Screening Operating Experience for Applicability," states, "OE [operating experience] is first screened to determine whether it transpired before or after the close date of the SKN 3&4 OER. OEs with dates before the SKN 3&4 close date are assumed to be included in the SKN 3&4 OER and are not be screened again."

  The staff does not understand why operating experience that occurred before the close date of the SKN 3&4 OER is assumed to be included in the SKN 3&4 OER. The staff is concerned that relevant operating experience, including events related to the categories listed in NUREG-0711, Criterion 3.4.1(2), were excluded from the SKN 3&4 OER.

- Additionally, the OER IP, Section 4.6, "Grouping Operating Experience," states, "OEs that are found to be relevant are grouped according to the OE categories in NUREG/CR-6400... Grouping the OEs helps the HFE to understand their similarities and differences, which is important when writing the lessons learned described in Subsection 4.8."

  The events and lessons learned included in NUREG/CR-6400, and events and lessons learned that occurred after 1996 and that fall into the categories listed in NUREG/CR-6400, are a set of events and lessons learned that, at a minimum, should be included and evaluated in an applicant's OER. The purpose of NUREG-0711, Criterion 3.4.1(2) is to help ensure the scope of an applicant's OER is adequate. The staff would like to understand how grouping OE into the categories used in NUREG/CR-6400 helps in the process of analyzing lessons learned from operating experience (i.e., how it helps to understand the similarities and differences between the OE lessons learned).

Questions

a. Revise the OER IP to state that OEs that occurred before the SKN 3&4 close date will first be evaluated to determine whether they were included in the SKN 3&4 OER. If they were included in the SKN 3&4 OER, then they may be screened out only if the lessons learned were identified and determined to be adequately addressed using the guidance in NRUEG-0711, Revision 3.

b. Explain how grouping OE into the categories used in NUREG/CR-6400 helps one to understand the similarities and differences between the OE lessons learned.

18-137

Acceptance Criteria

NUREG-0711, Criterion 4.4(2), states, "The applicant's FRA [function requirements analysis] and FA [function allocation] should be performed iteratively to keep it current during design development and operation up to decommissioning, so that it can be used as a design basis when modifications are considered." Also, NUREG-0711, Criterion 5.4(8), states, "The applicant's task analysis should be iterative, and updated as the design is better defined."

Application

- DCD Tier 2, Rev. 1, Section 18.4.1, "Objectives and Scope," states, "For tasks related to plant systems that are site specific, such as the switchyard and ultimate heat sink, the TA [task analysis] is based on generic assumptions that are made to establish a complete plant design that is ultimately reflected in the complete APR1400 HSI design for V&V. These generic assumptions are modified as necessary for each plant-specific application of the APR 1400 during the design implementation (DI) program element."

- APR1400-E-I-NR-14004-P, "Task Analysis Implementation Plan" (TA IP), Rev 1, Section 2, "Scope," contains similar statements.

- Additionally, APR1400-E-I-NR-14003-P, “Functional Requirements Analysis and Function Allocation Implementation Plan” (FRA/FA IP), Rev 1, Section 4.3.3, “Specification of Functional Hierarchy, Success Paths, and Requirements,” contains a similar statement that generic assumptions will be used during the FRA and FA.

The criteria in NUREG-0711 explain that the task analyses and FRA/FA should be iterative and updated as the design is developed. Because the COL applicant will perform task analysis, functional requirements analysis, and function allocation, it is not clear to the staff why it would be necessary to make generic assumptions during these activities when the COL applicant will be able to use site-specific information to develop the control room design at the site. Using generic assumptions when the site-specific information is available may result in some functions being inappropriately allocated to humans or some tasks not being identified.

Question

Either: (1) explain why it is necessary to use generic assumptions for site-specific information when the COL applicant will perform the activities in the HFE implementation plans, or

(2) revise the DCD Tier 2, Section 18.4.1; the TA IP; and the FRA/FA IP to remove statements that generic assumptions may be used in lieu of site-specific information.