# RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**APR1400 Design Certification**

**Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD**

**Docket No. 52-046**

**RAI No.:** **553-9084**

**SRP Section:** **18 – Human Factors Engineering**

**Application Section:**

**Date of RAI Issue:** **09/06/2017**

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## Question No. 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.

## Response

a. The site-specific PRA will be used to complete Table 4-1 of the TIHA IP. The Section 4.1 of the TIHA IP, Rev. 1 will be revised as indicated in the attachment associated with this response.

b. The Section 18.6.2 of the DCD Tier 2, Rev.1, and the Section 4.1 of the TIHA IP, Rev.1 will be revised to explain that the PRA/HRA expertise to be working with the I&C engineering SMEs to extract the RIHAs from the PRA documentation. The Section 18.6.2 of the DCD Tier 2, Rev.1, and the Section 4.1 of the TIHA IP, Rev. 1 will be revised as indicated in the attachment associated with this response.

c. The preliminary outputs for the DIHAs and RIHAs support the basis for the Basic HSI design. Refer to Basic HSI technical report APR1400-E-I-NR-14001-NP, Rev.1 Section

3.5.2 and Section 4.3.2.1. The IHAs from each document will be updated iteratively as the design progresses including the site-specific PRA.

Also, the list of DIHAs and RIHAs have been included in the TIHA IP, Rev. 1 in accordance with the RAI 315-8091, Question 18-56, Rev.1, and the RAI 510-8650, Question 18-127.

Therefore, the Appendices B and C of the TIHA IP, Rev.1 will not be deleted.

d. Plant design changes are conducted in accordance with engineering change procedures, which include the changes in evaluation of IHAs from the result of the site-specific seismic PRA documentation. The TIHA output (i.e., list of IHAs and corresponding HFE characteristics) is revised as needed in accordance with the engineering change process; TIHA output revisions are available for regulatory inspection.

The acceptability of the RIHAs identified in the PRA documentation is confirmed in subsequent HFE program elements (PEs), as described in Section 3.5 of the TIHA IP, Rev. 1. If any HEDs pertinent to the IHAs are generated during these HFE PEs, the HED resolution is fed back to the APR1400 plant design and to the TIHA output as needed.

As stated in Section 3.5.8 of the TIHA IP, Rev.1, the design implementation (DI) PE demonstrates that the as-built HSI design, including the HSI for IHAs, for each site specific APR1400 reflects the HSI design output from the human factors verification and validation (HF V&V) PE. Therefore, if additional IHAs are identified for a specific plant, and those IHAs are not encompassed by the HF V&V PE, HEDs are generated. Those HEDs are resolved as part of the DI PE, using HED resolution process of the HFEPP. The design changes after DI PE will be resolved using COLA's corrective action program.

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**Impact on DCD**

There is no impact on the DCD.

**Impact on PRA**

There is no impact on the PRA.

**Impact on Technical Specifications**

There is no impact on the Technical Specifications.

**Impact on Technical/Topical/Environmental Reports**

Technical Report APR1400-E-I-NR-14006-NP, Rev.1, "Treatment of Important Human Actions Implementation Plan," will be revised, as indicated in Attachment associated with this response.

## 18.6 Treatment of Important Human Actions

### 18.6.1 Objectives and Scope

The identification of important human actions (IHAs) is based on a combination of probabilistic insights from the probabilistic risk assessment (PRA) and human reliability analysis (HRA) and deterministic insights from Chapters 7 and 15. IHAs are integrated into the HFE program and the HSI design process so that personnel errors are minimized and their detection and recovery capabilities are enhanced.

The objective of the human factors engineering (HFE) treatment of important human actions (TIHA) program element is to create a consolidated list of IHAs, including the HFE characteristics assumed for those actions, as extracted from APR1400 plant-level analyses. The process for creating this list of IHAs and assumptions is described in the TIHA Implementation Plan (Reference 1). The IP also provides an overview of how IHAs are addressed in subsequent APR1400 HFE program elements per NUREG-0711 (Reference 2) the details of how IHAs are treated is provided in the IPs for each of the HFE program's elements.

The scope of IHAs includes risk-important human actions (RIHAs) identified by the PRA (DCD Chapter 19), and deterministically important human actions (DIHAs), which are the credited manual actions from the transient and accident analysis (DCD Chapter 15), and the credited manual actions from the diversity and defense-in-depth (D3) analysis of the instrumentation and control design process (DCD Chapter 7).

(I&C)

All IHAs are addressed in functional requirements analysis and function allocation (FRA/FA), task analysis (TA), staffing and qualifications (S&Q) analysis, human-system interface (HSI) design, procedure development, human factors (HF) verification and validation (V&V), design implementation (DI) and training program development to ensure that the design supports IHAs to minimize human error and to enhance detection and recovery capability. These HFE program elements confirm the HFE characteristics assumed for the IHAs in the plant analyses, design the HSI to support the IHAs, and then confirm that the HSI design facilitates achieving acceptable human performance.

### 18.6.2 TIHA Methodology

The TIHA identifies risk-important human actions (RIHAs) and deterministic important human actions (DIHAs) as follows:

a. RIHAs

The list of RIHAs is developed from the analysis results of Chapter 19. RIHAs are those that have a significant impact on plant risk. These actions are identified from the Level 1 and Level 2 PRAs for internal and external events of all operating modes. The RIHAs are identified using more than one importance measure and an HRA sensitivity analysis to provide reasonable assurance that an important action is not overlooked because of the selection of the measure or the use of a particular assumption in the analysis. For each RIHA, the PRA identifies assumptions regarding factors that lead to human performance error probability, including the action location, time available to take the action, and action complexity.

and

~~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~~.

I&C engineering subject matter experts (SMEs) will coordinate with personnel who have PRA/HRA knowledge to extract the RIHAs from the PRA.

b. DIHAs

DIHAs are identified from the D3 (Chapter 7) and transient accident analysis (TAA) (Chapter 15). Operator actions directly credited to mitigate an accident and achieve plant stabilization, as identified for any accident examined in the TAA or D3, are considered DIHAs. These manual actions are credited because automatic actions, such as reactor trip (RT) and engineered safety features (ESF) actuation, are not triggered. Operator actions needed to maintain a stable plant condition for the long term are not DIHAs, even though they may be identified in the TAA or D3.

A plant operations or systems safety engineering ~~subject matter experts (~~SME~~)~~ reviews the TAA and D3 to extract the DIHAs. DIHAs are listed in the TIHA ReSR along with the assumed HFE characteristics, including the time available and time required to execute these actions, as documented in the TAA and D3.

The RIHAs and the resulting list of DIHAs are combined into one list of IHAs that are then applied to the HFE program.

# 4. IMPLEMENTATION

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## 4.1 Risk-Important Human Actions

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## Question No. 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.

## Response

The representative and important operational conditions are selected for ISV scenarios from the emergency operating procedures, normal operating procedure, and abnormal operating procedures. The selected operating procedures are converted to the CBP in advance for ISV. The inventory of CBP for the ISV scenarios includes additional procedures that are related to the ISV scenarios, but not actually needed to execute the ISV scenarios, to ensure the operator decisions are not influenced by the CBP inventory. The complete CBP inventory is not necessary to ensure this, because the operator decisions would not be influenced by procedures that are completely unrelated to the ISV scenarios. Other paper procedures are converted to CBPs within the procedure development program element, in accordance with the COLA's procedure development program.

The HFEPP, Rev. 1 and HD IP, Rev. 1 will be revised as indicated in the attachment associated with this response.

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**Impact on DCD**

There is no impact on the DCD.

**Impact on PRA**

There is no impact on the PRA.

**Impact on Technical Specifications**

There is no impact on the Technical Specifications.

**Impact on Technical/Topical/Environmental Reports**

Technical Report APR1400-E-I-NR-14001-NP, Rev.1, "Human Factors Engineering Program Plan," and Technical Report APR1400-E-I-NR-14007-NP, Rev.1, "Human-System Interface Design Implementation Plan," will be revised, as indicated in Attachment associated with this response.

activities.

The FRA identifies the critical safety functions and critical power production functions to support high-level power production and safety goals. The FRA also identifies the preferred normal and emergency success paths used to control the critical functions during all plant operating modes under both normal and abnormal conditions. The FRA identifies the key parameters and components that are monitored for critical functions and success paths. The HD uses these FRA outputs to define the HSI inventory for developing the graphical designs of the LDP and related function displays for CFM and SPM.

The TA generates requirements for a complete HSI inventory and the characteristics of the inventory for operator tasks under normal and abnormal plant conditions, including inspection test and repair of plant equipment. The inventory includes the indications, alarms, and controls needed for manual allocations, the indications and alarms to maintain situation awareness for automated allocations, and the indications and controls to manually backup automation. The HD uses these TA outputs to establish alarm designs (including priority and applicability logic), display and control designs, and procedure checking criteria. The HD uses the TA narratives to establish the grouping of HSI inventory necessary to perform related tasks. This grouping is used to create navigational links between related system displays, in the design of task displays, and in the design of the safety console. HEDs that identified discrepancies between the HSI inventory required by the TA and the APR1400 plant design are resolved during the HD.

TIHA identifies IHAs from the PRA, the TAA, and the D3CA and the HFE characteristics of the HSI assumed in these analyses to be available to support those IHAs (e.g., HSI accessibility from the MCR). These characteristics support the analysis conclusions regarding the ability for operators to reliably perform these IHAs within the time available. HD implements the HSI assumptions identified in the TIHA or identifies HEDs when those assumptions cannot be achieved within the HSI.

In addition, the Basic HSI defines HSI characteristics that promote HSI accessibility for IHAs. This includes SDCV high priority prompting alarms, and task displays to ensure the necessary plant information and controls for IHAs are available on the same display (to reduce screen navigation task burden). These HSI design attributes reduce the potential for human performance errors.

S&Q establishes the operating crew for all operating and shutdown modes, including normal, abnormal and emergency conditions. The HD program element designs the MCR, RSR and TSC to support that staffing. S&Q includes resolution of any staffing-related HEDs that affect the Basic HSI or the APR1400 facilities. S&Q also confirms the staffing defined by the TA for local control actions. The HD program element designs the LCSs to accommodate this staffing.

Procedure development (PD) generates conventional paper-based operating procedures for all operating and shutdown modes, including normal, abnormal, and emergency conditions. The HD converts the operating procedures executed from the MCR into CBPs. ~~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. PD is a COL applicant responsibility.

Operators are trained on the HSI, a key output of HD. Training is conducted in part using the simulator, whose functional specification is an HD output. PD is a COL applicant responsibility.

The functional designs of the HSI and APR1400 facilities are key outputs of the HD. These outputs are used to create the specification for the simulator, which is used during design verification and integrated system validation, both of part of the V&V program element.

The DI confirms that the site-specific as-built HSI design is the same as the HSI design that was confirmed during V&V. Therefore, the DI confirms the design traceability to the outputs of the HD.

in advance for the ISV. The inventory of CBP for the ISV scenarios includes additional procedures that are related to the ISV scenarios, but not actually needed to execute the ISV scenarios, to ensure the operator decisions are not influenced by the CBP inventory.

10. Methods for control transfer between HSI facilities.
11. Nomenclature and labeling standards for all elements of both soft and conventional HSI, including abbreviations and syntax for labels and alarm messages.

The APR1400 Basic HSI also establishes standard functional specifications for the indications and controls associated with plant instrumentation and components, referred to as the basic component control and instrumentation design guide. The guide provides reasonable assurance of HSI consistency across all APR1400 plant systems.

### 2.2 APR1400 HSIS

The HD implements the HSI inventory defined by the TA and plant system designs in the Basic HSI methods described above, which encompass both video and conventional devices. For plant systems that are site specific, such as the switchyard and ultimate heat sink, the HD is based on generic assumptions that are made to establish a complete plant design that is reflected in the complete APR1400 HSIS. These generic assumptions are modified as necessary for each plant-specific application of the APR1400 during the design implementation (DI) HFE PE.

The scope of the APR1400 HSIS encompasses soft displays and controls, and conventional displays and controls for all aspects of the APR1400 Basic HSI, as follows:

1. Large display panel (LDP); SDCV sections
2. Information flat panel displays (IFPDs); selectable displays with soft controls, including SPDS (displays are also applicable to the selectable sections of the LDP)
3. Engineered safety features control modules (ESCMs); selectable soft controls
4. Qualified indication and alarm system –- non-safety (QIAS-N); SDCV and selectable displays
5. Qualified indication and alarm system – post accident monitoring (QIAS-P); SDCV and selectable displays
6. Plant protection system (PPS) and core protection calculator (CPC) operator modules; selectable displays with soft controls
7. Reactor trip (RT) and engineered safety features (ESF) system-level initiation (SLI) controls; conventional SDCV controls
8. Minimum inventory controls (MICs); conventional SDCV controls
9. Diverse manual actuation (DMA) controls; conventional SDCV controls
10. Diverse indication system (DIS); selectable displays
11. Safety console configuration (encompassing all items above, except LDP and IFPD)
12. Alarms that are displayed on the LDP, IFPDs, and QIAS-N displays
13. LCS; conventional indications and controls

For all items in the above list, the HD generates pictorial design drawings with a database that correlates each pictorial element to a unique instrumentation or control item in the plant system designs. The pictorial designs integrate the HSI inventory defined by the TA and plant system designs in the information hierarchy of the APR1400 Basic HSI, using the conventions established by the APR1400 Style Guide.

As for all computer driven displays, the HD graphical design output for the SPDS is implemented in software for the MCR, RSR, RCC, and TSC. However, for the EOF the HD output for the SPDS is provided only to define the HSI inventory requirements and to provide guidance for graphical implementation of the SPDS within the EOF. The EOF HSI system is provided by the combined license (COL) applicant. Therefore, the COL applicant provides the actual graphical design and software for the SPDS in the EOF, in accordance with the EOF HSI system style guide to provide reasonable assurance of conformance with the HFE criteria for the EOF.

The HD PE 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 inventory of CBP for the ISV scenarios includes additional procedures that are related to the ISV scenarios, but not actually needed to execute the ISV scenarios, to ensure the operator decisions are not influenced by the CBP inventory.

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### 3.5.7 Training Program Development

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### 3.5.8 Human Factors Verification and Validation

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### 3.5.9 Design Implementation

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## 3.6 HD Interfaces with the APR1400 Plant Design

The HD interfaces with the APR1400 plant design in the following key areas:

- I&C system designs
- Plant system designs

The interfaces are described in Subsections 3.6.1 and 3.6.2.

### 3.6.1 Instrumentation and Control System Designs

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### 3.6.2 Plant System Designs

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# RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**APR1400 Design Certification**

**Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD**

**Docket No. 52-046**

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|---|---|
| **RAI No.:** | **553-9084** |
| **SRP Section:** | **18 – Human Factors Engineering** |
| **Application Section:** | **18.2 Operating Experience Review** |
| **Date of RAI Issue:** | **09/06/2017** |

## Question No. 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.

## Response

a. The Operating Experience Review Implementation Plan (OER IP), APR1400-E-I-NR-14002-P/NP, Rev.1, Section 4.5 will be revised 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. The current grouping (i.e., Predecessor/Related Plants and Systems, Recognized Industry HFE Issues, Related HSI Technology, Issues Identified by Plant Personnel, Important Human Actions) meets NUREG-0711 criteria.
NUREG/CR-6400 Provides expanded HFE design issue categories and proposed resolutions. OE grouping following this issue category helps designer to clarify his/her OE-related design issues and to decide the resolutions.

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**Impact on DCD**

There is no impact on the DCD.

**Impact on PRA**

There is no impact on the PRA.

**Impact on Technical Specifications**

There is no impact on the Technical Specifications.

**Impact on Technical/Topical/Environmental Reports**

Technical report APR1400-E-I-NR-14002-P/NP, Rev.1, “Operating Experience Review Implementation Plan,” Section 4.5 will be revised, as indicated in the attachment associated with this response.

### 4.5 The Process of Screening Operating Experience for Applicability

An OE 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.~~ OEs with dates that are after the SKN 3&4 close date are screened for applicability to the APR1400 plant design using the following questions:

Insert "A" on the next page

- Is the OE applicable or related to a PWR?
- Is the human performance OE related to functions performed by the APR1400, regardless of reactor type? OEs in other types of commercial nuclear reactors have relevance to PWRs (e.g., the Tennessee Valley Authority's Brown's Ferry fire and are therefore must be included in the APR1400 OER)
- Is the OE related to human performance?
- Is the OE related to the level of automation in the HSI design?
- Is the OE concerned with an automation or HSI technology that is being planned for use in the APR1400?

Additionally, there are three issues from SKN 3&4 are considered to have the potential for significant human factors concerns in the APR1400 design and are given especially careful attention:

- Plant processes with expected operational differences between SKN 3&4 and the APR1400 design that are due to differences in the process or in the equipment that implements the process. These differences are particularly relevant if they involve IHAs and include risk-important human actions (RIHAs) and deterministically identified important human actions
- Changes and differences in the level of automation between SKN 3&4 and the APR1400 design
- Transition from predominately analog I&C and HSI technology in SKN 3&4 to predominately digital technology for the APR1400 I&C and HSI design

All OEs are entered into the OE database. OEs that pass the screening are then grouped in Subsection 4.6 and classified in Subsection 4.7.

### 4.6 Grouping Operating Experience

The OEs that are found to be relevant are grouped according to the OE categories in NUREG/CR-6400, which are as follows:

- Unresolved safety issues / generic safety issues: 10 CFR 52.47(a)(21) (Reference 7) and NUREG-0933 (Reference 8)
- TMI issues
- NRC Generic Letters and information notices
- OE reports in the NUREG-1275 (Reference 9) series, Volumes 1 through 14
- Low power and shutdown operations

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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.

# RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**APR1400 Design Certification**

**Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD**

**Docket No. 52-046**

**RAI No.:** **553-9084**

**SRP Section:** **18 – Human Factors Engineering**

**Application Section:**

**Date of RAI Issue:** **09/06/2017**

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## Question No. 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 APR1400 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.

## Response

The generic assumptions support the preliminary results of the FRA/FA and TA, and those results provide the basis for the HSI design. As site-specific information is known, the generic assumptions are modified as necessary. When the COL applicant performs the HFE activities, the site specific information is applicable to develop the APR1400 HSI design at the site, and the preliminary results of the FRA/FA and TA are updated accordingly. The updated information leads to the complete HSI design which is verified and validated during the HF V&V program element (PE). DI PE confirms the as-built design with the application of the site-specific information. Where the site-specific information is not reflected, the DI PE conducts a regression analysis to define the necessary HFE rework.

The DCD Tier 2, Rev. 1, Section 18.4.1, the FRA/FA IP, Rev. 1, Section 4.3.3, and the TA IP, Rev. 1, Section 2 will be revised as indicated in the attachment associated with this response.

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**Impact on DCD**

DCD Tier 2, Rev. 1 will be revised, as indicated in Attachment associated with this response.

**Impact on PRA**

There is no impact on the PRA.

**Impact on Technical Specifications**

There is no impact on the Technical Specifications.

**Impact on Technical/Topical/Environmental Reports**

Technical Report APR1400-E-I-NR-14003-NP, Rev. 1, “Functional Requirements Analysis and Function Allocation Implementation Plan,” and APR1400-E-I-NR-14004-NP, Rev. 1, “Task Analysis Implementation Plan,” will be revised, as indicated in Attachment associated with this response.

The tasks identified in the TA scope defined above originate from other HFE program elements or plant procedures. The tasks include tasks executed with both paper and computer-based procedures. SME judgment is therefore not required in the task selection. The following areas are evaluated by SMEs using their plant operations and simulator training experience to identify and select additional tasks that have challenged predecessor plant operating crews:

a. Surveillance, test, inspection, and maintenance, with special focus on tasks that pose potential threats to personnel safety and plant safety.

b. Operational tasks that are precursors to plant transients that are not procedure based and are not IHAs. These tasks include unusual failure modes that may not have alarm response procedures, such as spurious opening of a pressurizer spray valve and a spurious control rod withdrawal, or situations in which the operators had to revert to skill-based manual operation (e.g., low-power steam generator level control).

c. Beyond-design-basis conditions such as station blackout and severe accident

d. Tasks associated with the APR1400 fire safe shutdown analysis

In addition, SMEs use their judgment and experience to identify and select tasks they believe challenge plant operations crews based on new or unique features of the APR1400 plant design, with consideration of both workload and complexity. These tasks include tasks that are performed significantly differently from predecessor plants and tasks that use new automated support aids such as computer-based procedures.

The additional tasks selected by SMEs are those that are not already encompassed by previous HFE program elements and operating procedures.

~~For tasks related to plant systems that are site specific, such as the switchyard and ultimate heat sink, the TA 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.~~

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18.4.2 Methodology

TA includes the following methods:

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### 4.3.2 Identification of Power Production Functions

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### 4.3.3 Specification of Functional Hierarchy, Success Paths, and Requirements

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The TA is based on generic assumptions that are made to establish a plant design that is reflected in the initial APR1400 HSI design. As site specific information is known, the generic assumptions are modified. When the COL applicant performs the HFE activities, the site specific information such as the switchyard and ultimate heat sink, that is applicable to develop the APR1400 HSI design at the site, and the TA is updated accordingly. The updated information is ultimately reflected in the complete APR1400 HSI design for V&V. The design implementation (DI) program element confirms the as-built design with the application of the site specific information.

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