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.: **400-8425**

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

Application Section:

Date of RAI Issue: **02/04/2016**

Question No. 18-114

NUREG-0711, "Human Factors Engineering Program Review Model," Criterion 8.4.1(4) states, “Other Requirements – The applicant should identify any other requirements, such as customer requirements, that are inputs to the HSI design.”

APR1400-E-I-NR-14007-P, “HSI Design Implementation Plan” (HD IP), Section 3.2, “APR1400 HSIS,” discusses a toolset that is an input to the HSI design process and is used to ensure that the design standards and guidelines are applied to the design of each HSI resource. It is not clear to the staff how the toolset is developed, or if it has already been developed, because the HD IP does not provide direction to develop the toolset in the HD IP, and the staff did not find a description anywhere else in the application.

Provide a method for developing the toolset in the HD IP if it will need to be developed to be an input in the HSI design process. If it has been developed, provide a description of it or describe how the COL applicant will obtain it. Revise the submittal as necessary.

Response

APR1400-E-I-NR-14007-NP, “HSI Design Implementation Plan” (HD IP) and APR1400-E-I-NR-14001-NP, “Human Factors Engineering Program Plan” (HFE PP) will be revised to clarify the use of the APR1400 Basic HSI toolset as well as any changes that may be needed to that toolset and transfer of HFE tools to the COL applicant.

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-14007-NP, Rev.0, “HSI Design Implementation Plan,” Sections 3.1, 3.2 and 3.7, and technical report APR1400-E-I-NR-14001-NP, Rev.0, “Human Factors Engineering Program Plan,” Section 4.2 will be revised, as indicated in the Attachment associated with this response.

TS

3.2 APR1400 HSIS

TS

3.5.8 Human Factors Verification and Validation

TS

3.5.9 Design Implementation

TS

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

TS

3.6.2 Plant System Designs

TS

3.7 HD Input from Predecessor and Reference Plants

TS

4. IMPLEMENTATION

4.1 Assumptions and Constraints

TS

4.2 Program Duration

TS

4.3 Human Factors Engineering Design Team and Organization

TS

4.3.1 Human Factors Engineering Design Team Responsibilities

TS

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.: **400-8425**

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

Application Section:

Date of RAI Issue: **02/04/2016**

Question No. 18-116

Regulations in 10CFR 50.34(f)(2)(iv) describe requirements for a safety parameter display system (SPDS). NUREG-0711, Criterion 8.4.4.2(1), describes an acceptable method for complying with the regulation. Additionally, NUREG-0700, Section 5, “Safety Function and Parameter Monitoring System” provides guidance for the design of the SPDS.

APR1400-E-I-NR-14012-P, “Style Guide,” copy the statements in NUREG-0700, "HSI Design Review Guidelines," Section 5, Criteria 5.1-7, 5.1-8, and 5.1-9; however, the Style Guide does not specifically describe a method for how the criteria will be implemented in the design of the SPDS HSIs. The staff recognizes that the HD IP states that the predecessor design SPDS HSIs are the starting point for the APR1400 SPDS design; however, these SPDS design details are not included in the Style Guide. Describe how the CSF displays will allow users to: (1) comprehend changes in status, (2) how the sampling rate for each critical variable will be consistent with user needs, and (3) how critical variables will be displayed with sufficient accuracy for the user. Revise the submittal as necessary.

Response

(1) Safety parameter display and evaluation system plus (SPADES+) has the critical function alarm algorithm data set that is the minimum set of monitored parameters necessary to assess the safety status of the plant (i.e., the status of each critical function). The SPADES+ provides the information in a concise, understandable and integrated format to assist the operator to quickly assess the plant safety status.

(2) All inputs of the SPADES+ are scanned, sampled and processed once every second. The Style Guide will be revised as indicated in the Attachment associated with this response.

(3) The accuracy of the signal processing system for each analog input to the SPADES+ are maintained within ± 0.5% of full scale of the referred input value. The Style Guide will be revised as indicated in the Attachment associated with this response.

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-14012-NP, Rev.0, “Style Guide,” Subsection 3.2.4 will be revised, as indicated in the Attachment associated with this response

movement occurring only upon explicit user action, such as pressing the Tab key.

3.2.2 Orientation Features

a) Organization of the Display Network - The organization of the display network should reflect an obvious logic based on task requirements and be readily understood by users.
b) Cues to Display Network Structure - The display system should provide information to support the user in understanding the display network structure.
c) Overview of Display Network - A display should be provided to show an overview of the structure of an information space, such as a display network or a large display page.
d) Perceptual Landmarks - Easily discernable features should appear in successive views and provide a frame of reference for establishing relationships across views.
e) Location Cues - Cues should be provided to help the user retain a sense of location within the information structure.
f) Directional Cues - Directional cues should be provided.
g) Display Page Titles - Display page title and identifying information should be used to communicate the position of a display in a larger information space.
h) Display Overlap - There should be physical or functional overlaps between displays that prevent the displays from appearing as disjointed views.
i) Understanding Successive Views - A hypertext information system should show how a destination node is related to the point of departure.

3.2.3 Retrieval Features

a) Flexibility in Display System Interaction -The display network should provide more than one way to access displays.
b) Minimal Navigation Path Distance - Short navigation paths should be provided between display pages that will be used one after the other.
c) Short Navigational Distances in Hierarchies - Navigation distances should be kept short.
d) Relatedness of Successive Views - During navigation, displays should support users' comprehension of the relationships between successive views or destinations.
e) Time to Complete Navigation - The time required to complete a display navigation action should be minimized.
f) Detection of Navigation Targets - Navigation targets should be easily detectable.
g) Support for 'Top-Down' Strategies for Navigating Hierarchies - Use of top-down navigation strategies should be supported.
h) Support for 'Bottom-Up' Strategies for Navigating Hierarchies - The display system should support users in identifying reversal points.

3.2.4 Display Update, Freeze and Data Quality

a) Readability of Changing Data - Changing data values that must be read should be displayed in a fixed position and updated no more than once per second. If users need only to monitor general trends in changing data values, and do not need to take exact readings, faster update rates may be acceptable.
b) Visual Integration of Changing Graphics - When a user must visually integrate changing patterns on a graphic display, the data should be updated at a rate appropriate to human perceptual abilities for that kind of data change.
c) Labeling Display Freeze - When a display is "frozen," the display should be appropriately labeled to remind users of its "frozen" status.
d) Signaling Changes to Frozen Data - When a display being updated in real-time has been frozen, the user should be advised if some significant, but not displayed, change should be detected in the computer processing of new data.
e) Initial Erasure to Replace Changed Data - When the computer generates a display to update changed data, the old items should be erased before adding new data items to the display.
f) Data Sampling Rate - The sampling rate for each critical plant variable should result in no meaningful loss of information in the data presented.
g) Time Delay - The time delay from when the sensor signal is sampled to when it is displayed

Safety parameter display and evaluation system plus (SPADES+) should scan, sample, and process once every second.

should be consistent with the user's task performance requirements.

h) Accuracy - Each variable should be displayed with an accuracy sufficient for the users to perform their tasks.

i) Display Heartbeat Symbols

j) Representation of Display Feature - A display feature should be provided to indicate to the user that the system is operating properly (or that a system failure has occurred).

k) Location - The Display Heartbeat symbols should appear consistent, and in a similar location on similar screens.

The accuracy of the SPADES+ are maintained within ± 0.5% of full scale of the referred input value.

3.2.5 Display Suppression

a) Temporary Suppression of Displayed Data - The user should be able to temporarily suppress standard data displays.

b) Labeling Display Suppression - A data display that has been suppressed should be annotated with an appropriate label to remind users that data have been suppressed.

c) Resuming Display of Suppressed Data - Data that has been suppressed from a display should be able to be quickly restored to its complete, originally generated form.

3.2.6 Display Control

a) Display Control - Users should be able to specify the information to be displayed and select the format in which it is presented.

b) Display of Control Options - Screen control locations and control options should be clearly and appropriately indicated.

c) Easy Paging - When requested data exceeds the capacity of a single display frame, users should be given some easy means to move back and forth over displayed material by paging.

d) Show Changing Scale - When a display is expanded from its normal coverage, a scale indicator of the expansion factor should be provided.

e) Return to Normal Display Coverage - If a user is allowed to pan over an extended display, or zoom for display expansion, an easy means for the user to return to normal display coverage should be provided.

3.2.7 Prevention, Detection and Correction of Errors

3.2.7.1 General Prevention, Detection and Correction of Errors Guidelines

a) Automatic Data Validation - Automatic data validation should be provided to check any item whose entry and/or correct format or content is required for subsequent data processing.

b) Data Verification by User Review - When verification of prior data entries is required, users should be allowed to review and confirm the data, rather than re-entering the data.

c) Timely Validation of Sequential Transactions - in a repetitive data entry task, the data for one transaction should be validated, and the user should be allowed to correct errors before beginning another transaction.

d) Non-Disruptive Error Message - If data validation detects a probable error, an error message should be displayed to the user at the completion of data entry.

e) Deferral of Required Data Entry - If a user wishes to defer entry of a required data item, the user should be required to enter a special symbol in the data field to indicate that the item has been temporarily omitted rather than ignored.

f) Reminder of Deferred Entry - If a user has deferred entry of required data but then requests processing of entries, that omission should be signaled to the user, and immediate entry (or perhaps further deferral) of missing items should be allowed.

g) User Validation - The user should be able to obtain a paper copy (screen dump) of the contents of alphanumeric or graphic displays.

3.2.7.2 Correcting Information and Command of Errors

a) Immediate Error Correction - When the system detects an error in a user input, the user should be allowed to make an immediate correction.

b) Replacing Erroneous Commands - If a user makes a command entry error, after the error

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.: **400-8425**

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

Application Section:

Date of RAI Issue: **02/04/2016**

Question No. 18-118

Regulations in 10CFR 50.34(f)(2)(v) require automatic indication of the bypassed and inoperable status of safety systems. NUREG-0711, Criterion 8.4.4.2(2), describes an acceptable method for complying with the regulation for bypassed and inoperable status indication (BISI).

Provide a description for the following items and revise the submittal as necessary:

1. The staff could not find a description of the provisions for allowing the operations staff to confirm that a bypassed safety function was properly returned to service, which is addressed in the third bullet in NUREG-0711, Criterion 8.4.4.2(2).

2. The staff could not determine whether or not alarms will indicate to the operators when a bypassed safety function has been properly returned to service, which is addressed in the fourth bullet of NUREG-0711, Criterion 8.4.4.2(2).

3. The staff could not find a description of how the operators can verify the indication and annunciating functions of the BISI, which is addressed in the fifth bullet of NUREG-0711, Criterion 8.4.4.2(2).

4. The staff could not find how the application addresses the following, which is addressed by the sixth bullet of NUREG-0711, Criterion 8.4.4.2(2): “Bypass and inoperable status indicators should be arranged such that personnel can determine whether it is permissible to continue operating the reactor.”

5. The staff could not find how the application addresses the following, which is addressed by the seventh bullet of NUREG-0711, Criterion 8.4.4.2(2): “the control room of all affected units should receive an indication of the bypass for their shared system safety functions.”

Response

1, 2 Return to service is addressed by the clearing of alarms when systems/functions return to normal, operator confirmation of the return to normal condition using drill down displays, and operator reset of the cleared alarm.

3 Verification of BISI conditions is addressed by operator acknowledgment of BISI alarms and drill down displays. Verification of the alarm system operability is addressed by self-testing within redundant alarm processing components.

4 Continued plant operation is addressed by referencing appropriate Technical Specifications in BISI alarm response procedures.

5 APR1400 has no shared system

To clarify the design of the BISI function, and thereby address the first four items of this RAI, APR1400-E-I-NR-14011-NP, “Basic Human-System Interface”, will be revised as follows:

4.6 Large Display Panel

CFM/BISI section: Continuously shows the effect of process parameter and component level alarms on the plant level critical functions, and the system level operability of preferred emergency success paths. The success path displays show inoperable conditions for normal plant conditions when the emergency success paths are in standby. When the emergency success paths are automatically actuated by the PPS, the BISI section identifies success path actuation failures. Therefore, the BISI section also includes the actuation demand status for the automation functions for RT and ESF actuation. The combination of parameters on the LDP mimic and the plant level CFM alarms fulfill the continuous display requirements of NUREG-0696 (Reference 6) for the SPDS. The continuous BISI for preferred emergency success paths fulfills the requirements of RG 1.47. Related alarms are grouped so that the displayed CSF or BISI success path alarm icons always show the alarm coding for the highest priority alarm in its group. The CFM/BISI section is shown in Figure 4-21.

Drill down from the CFM/BISI alarm icons to more detailed alarm list displays, CSF displays and/or system displays, permit verification and diagnosis of specific CSF threats and bypassed/inoperable conditions [Question 3]. Drill down displays include format chaining (i.e., right mouse click) to alarm response procedures. Alarm response procedures for BISI alarms include identification of the appropriate plant Technical Specifications, which require evaluation by plant operators to determine any limiting conditions of operation. The APR1400 does not include an automated Technical Specification monitoring system [Question 4].

When a CSF or bypassed/inoperable condition returns to normal, the associated LDP alarm also clears [Question 2]. Cleared alarms require resetting by the operator using any of the drill down displays. The drill down displays allow the operator to confirm that the adverse condition has returned to normal prior to resetting the alarm [Question 1].

4.15.4 Alarm Processing

Both of these alarm applicability methods significantly reduce the number of nuisance alarms compared to conventional control rooms.

The alarm and supporting display processing achieves high reliability through the following design attributes:

- Monitoring signals for alarm generation and supporting information for display originates within the control and protection systems, which have continuous self-testing for all functions including status information processing.
- Status information for alarm generation and supporting displays is transmitted from the control and protection systems to the alarm processors in the IPS and QIAS-N via digital data communication interfaces, with continuous self-testing.
- The IPS and QIAS-N employ redundant alarm and display processors, each with continuous self-testing.
- Alarms and supporting display data are transmitted to the LDP, IFPDs, mini-LDP and QIAS-N display processors via redundant data communication networks, each with continuous self-testing.
- Self-testing alarms generated by either the IPS or QIAS-N are also transmitted to the alternate system for redundant display; thereby assuring display for any failure, including a failure that would inhibit correct display by the originating system.

[Question 3] In light of the high alarm function reliability achieved through the redundant and continuous self-testing attributes above, there are no specific provisions for manual alarm tests by plant operators, as there are in traditional analog alarm systems. Manual testing is simply not needed for the Basic HSI to achieve high availability. However, since many BISI conditions are manually initiated by operators to accommodate plant maintenance, these actions allow operators to inherently confirm the alarm function operability.

The seventh bullet of NUREG-0711, Criterion 8.4.4.2(2): “the control room of all affected units should receive an indication of the bypass for their shared system safety functions,” is not applicable, because as stated in the following sections of the DCD, “APR1400 is a single unit plant”; therefore, there are no shared systems [Question 5]:

Table 1.9-1

1.81	shared Emergency and Shutdown Electric Systems for Multi-Unit Nuclear Power Plants	Rev. 1 01/1975	Not applicable. The APR1400 is a single unit plant; therefore, this NRC RG is not applicable to the APR1400	N/A

Table 1.9-2

9.2.6 Condensate Storage Facilities	Rev. 3 03/2007	Not applicable. Condensate storage facilities have no safety-relaated functions and handle nonradioactive fluid. The APR1400 is not multi-unit.	9.2.6

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-14011-NP, Rev.0, “Basic Human-System Interface,” Section 4.6 and 4.15.4 will be revised, as indicated in the Attachment associated with this response.

TS

4.6 Large Display Panel

TS

Page intentionally blank

4.15.3 Alarm Auditory Coding

TS

4.15.4 Alarm Processing

TS

4.15.5 Alarm Presentation and Control

TS

4.15.5.1 Alarm presentation on LDP and mini-LDP

TS

Page intentionally blank

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.: **400-8425**

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

Application Section:

Date of RAI Issue: **02/04/2016**

Question No. 18-124

Regulations in 10CFR 50.34 (f)(2)(xxvii) require the applicant to provide for monitoring of inplant radiation and airborne radioactivity. NUREG-0711, Criterion 8.4.4.2(11) states that an applicant should describe how the HSI provides appropriate monitoring of inplant radiation. Also, NUREG-0711, Section 1.2.2, “Review Elements, “ also states that an acceptable implementation plan (IP) describes the methodology in a step-by-step format to ensure that design personnel can reliably use the IP consistent results will be obtained from executing the methodology.

The HD IP, Section 4.1.4.11, “Radiation Monitoring,” states that some types of radiation indications will be able to be viewed on a generic kind of HSI. This statement uses a general term to describe the HSI that lacks sufficient detail for the HSI designers.

1. Specify the type of display that will provide these indications (e.g. which type of APR1400 HSIS listed in the HD IP, Section 3.2, "APR1400 HSIS).

2. Provide direction in the HD IP to the SMEs to include radiation monitors as inputs to the design of the applicable displays.

3. Revise the submittal as necessary.

Response

To clarify the type of display and provide clear direction to the SMEs, APR1400-E-I-NR-14007-P, “HSI Design Implementation Plan” (HD IP), will be revised as follows:

4.1.4.11 Radiation Monitoring

Other radiation indications and alarms are provided via selectable HSI on IFPDs. As a minimum, the display of radiation monitoring instrumentation on IFPDs is via selectable system displays and alarms. Computer-based procedures are provided for radiation

monitoring alarm response. Additional Task displays are also created, as needed, based on the criteria defined in Section 3.2.3.

4.2.1 Critical Safety Function Displays

The HD implementation requirements for CSF displays are applicable to the SDCV portion of the LDP, the QIAS-N SDCV display, and the SPDS display hierarchy within the IFPDs.

1. Starting point from APR1400 Basic HSI

    a. Design basis

        i. Key parameters indicating the status of CSFs (including Accident Monitoring Type B variables)

        ii. Key parameters and components indicating the status of the preferred normal and emergency success paths for each CSF.

        iii. Status for CSFs includes associated threat alarms (including pre-trip/actuation alarms, and radiation monitoring alarms that indicate a direct CSF threat)

4.2.2 System Displays [With changes identified in the response to RAI 18-12]

The HD implementation requirements for system displays are applicable to IFPDs, ESCMs, and QIAS-N selectable displays…

3. Inputs from the APR1400 plant design

    a. P&IDs, electrical system one-line diagrams, system descriptions; include instrumentation for monitoring intersystem leakage, as described in APR1400 DCD Tier 2, Section 5.2.5.4 and radiation monitoring instrumentation.

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-14007-NP, Rev.0, “HSI Design Implementation Plan,” Sections 4.1.4.11, 4.2.1 and 4.2.2 will be revised, as indicated in the Attachment associated with this response.

4.1.4.8 Auxiliary Heat Removal

TS

[ ]

4.1.4.9 Reactor Level Monitoring

TS

[ ]

4.1.4.10 Leakage Control

TS

[ ]

4.1.4.11 Radiation Monitoring

TS

[ ]

4.1.4.12 Manual Initiation of Protective Actions

TS

[ ]

4.1.4.13 Diversity and Defense-in-Depth

TS

[ ]

4.1.4.14 Important Human Actions

TS

[ ]

4.1.4.15 Computer-Based Procedure Systems

TS

[ ]

TS

4.2.1 Critical Safety Function Displays

TS

TS