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.: **383-8458**

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

Application Section:

Date of RAI Issue: **02/01/2016**

Question No. 18-108

NUREG-0711, Criterion 8.4.5(4) states, “the applicant should determine the necessary compensatory actions and supporting procedures to ensure that personnel effectively manage degraded I&C and HSI conditions, and the transition to back-up systems.”

The HD IP, Appendix A, states that this criteria is satisfied by identifying these actions and procedures during the task analysis (TA). The TA IP (APR1400-E-I-NR-14004-P), Section 2, “Scope,” says that procedures from predecessor designs and predecessor plants are used to identify certain tasks for tasks analysis, including those tasks required to mitigate three kinds of degraded HSI conditions.

The predecessor design and predecessor plants, as defined in the HFE program plan (APR1400-E-I-NR- 14001-P), don’t include digital I&C systems in their design. Thus, the staff does not have reasonable assurance that the compensatory actions needed to manage the degraded I&C and HSI conditions that may occur in the APR1400, which are described in the DCD Tier 2, Chapter 7 and in additional detail in the Control System CCF Technical Report and the CCF Coping Analysis, are included in these procedures and will therefore be included in the task analysis and HSI design processes.

Describe how (1) the necessary compensatory actions and supporting procedures to ensure that personnel effectively manage degraded I&C and HSI conditions, and (2) the transition to back-up systems, will be determined. For example, if procedures from the reference plant will used, then describe whether or not those procedures address the same degraded HSI conditions that can occur in the APR1400, and how those procedures would be translated or made available to a COL applicant in the US.

Revise the submittal as necessary.

Response

The third paragraph of the Abstract to the Task Analysis Implementation Plan (TA IP), APR1400-E-I-NR14004 will be revised to include the reference plants in identification of plant operations tasks, as follows:

“The TA is conducted for plant operations tasks conducted by licensed and non-licensed operators, which are identified in (1) APR1400 operating procedures that are available at the time the TA is conducted or (2) procedures from APR1400 predecessor plants, predecessor designs, or reference plants; the predecessors and references are identified in the APR1400 HFE Program Plan (HFEPP). This encompasses plant operations tasks for all modes, including shutdown and refueling.”

Section 2, “Scope,” Item 2 of the TA IP will be revised to include the reference plants in the scope to the TA, as follows:

2. Tasks directed by normal, abnormal, emergency, and alarm response procedures from APR1400 or procedures from predecessor plants, predecessor designs or reference plants, during all modes of operation, shutdown, and refueling. Abnormal procedures include the following degraded I&C and HSI conditions:

    a. Continued stable operation with loss of all non-safety HSI

    b. Accident mitigation and safe shutdown with only safety HSI

    c. Accident mitigation and plant stabilization with concurrent common cause failure (CCF) in digital I&C systems (as defined by the D3CA)

    d. Safe shutdown from the RSR

While the procedures from predecessor plants, predecessor designs, and reference plants are expected to have a high level of applicability to the APR1400, SMEs utilize these procedures in conjunction with APR1400 system design and analysis documentation (e.g., APR1400 Chapter 15 safety analysis and D3CA) to ensure the tasks applicable to APR1400 are correctly and completely identified, and that non-applicable tasks are excluded. Procedures from predecessor plants, predecessor designs, and reference plants which are used by SMEs are to be translated to English before use. The tasks identified for degraded I&C and HSI conditions include compensatory actions and the transition to back-up systems.

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-14004-NP, Rev.0, “Task Analysis Implementation Plan,” Abstract and Section 2 will be revised, as indicated in the attachment associated with this response.

ABSTRACT

This document provides the implementation Plan (IP) for the human factors engineering (HFE) task analysis (TA) program element (PE), which is one of 12 PEs in the Advanced Power Reactor 1400 (APR1400) HFE Program. This IP governs the technical activities conducted within the TA PE by defining the scope and methodology of the TA PE, including the output products generated and the qualifications of the personnel who generate the products.

The main purposes of the TA are to:

1. Define the APR1400 human systems interface (HSI) inventory of process indications, alarms and controls, that support the accomplishment of plant operations tasks for normal, abnormal and emergency conditions. The HSI inventory is implemented in other APR1400 HFE PEs through soft displays and controls, control panels, operating procedures, and training programs.

2. Establish the number and qualifications of operations personnel for individual plant operations task. Where deemed necessary, staffing for a specific task is based on a quantitative analysis of workload and time margin. While the TA examines staffing on a task-by-task basis, the HFE staffing and qualifications (S&Q) PE examines staffing in aggregate for all plant modes to assure a meaningful job and adequate workload.

3. Confirm the human performance (HP) assumptions for important human actions (IHAs) as defined in the HFE treatment of important human actions (TIHA) PE. The TIHA extracts these HP assumptions from the APR1400 probabilistic risk assessment (PRA), transient and accident analysis (TAA) and the defense-in-depth and diversity coping analysis (D3CA).

The TA is conducted for plant operations tasks conducted by licensed and non-licensed operators, ~~who~~ which are identified in (1) APR1400 operating procedures that are available at the time the TA is conducted or (2) procedures from APR1400 predecessor plants ~~or~~ , predecessor designs; the predecessors are identified in the APR1400 HFE Program Plan (HFEPP). This encompasses plant operations tasks for all modes, including shutdown and refueling. The TA is conducted by plant operations subject matter experts (SMEs) whose qualifications are defined in the HFEPP. SMEs use their experience to select additional tasks for TA implementation that are known to challenge plant operating crews, and references

The TA may be conducted before or after instrumentation and control (I&C) design requirements have been established by the mechanical and I&C system designers for a specific plant system. If the TA is conducted before the I&C design, then the TA establishes HSI inventory requirements for the plant system design. If the TA is conducted after the I&C design has been developed for a specific plant system, then the TA confirms that the I&C design is acceptable to support the HSI inventory; if it is not, human engineering discrepancies (HEDs) are generated as the conclusion of the TA PE. For all plant systems, the piping and instrumentation diagrams are the starting point for creating HSI indication and control designs during the APR1400 human-system interface design (HD) HFE PE. Any discrepancies between these HSI designs and the HSI inventory defined by the TA are identified during the HFE verification and validation (V&V) PE. The HFE PP describes the HED resolution process.

The TA is a one-time non-recurring HFE PE whose closure is marked by issuance of the TA results summary report (ReSR). However, the analyses conducted within the TA are iterative in that HEDs generated by other HFE PEs are evaluated for any potential changes needed in those analyses. Similarly, APR1400 plant design changes are evaluated for their impact to the output of all HFE PEs, including the output of the TA PE, and HEDs are generated as needed. Therefore, any analysis changes that may be needed after completing the TA ReSR are managed through the HED resolution process. HEDs that affect TA outputs are resolved prior to completing the HD, which establishes the APR1400 HSI design for V&V.

2. SCOPE

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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

RAI No.: **383-8458**

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

Application Section:

Date of RAI Issue: **02/01/2016**

Question No. 18-111

NUREG-0711, Criterion 8.4.6.2(2) states that the applicant should base the general approach to testing on the test's objective(s). The following aspects of the tests should be described: tasks or scenarios used, performance measures, test procedures, and data analyses. Also, NUREG-0711, Section 1.2.2, states that an IP is acceptable if it is verifiable, i.e., the final results can be evaluated using NUREG-0711 criteria, and the IP describes the products (expected results from executing the methodology).

The HD IP, Section 4.1.7, "Basic HSI Tests and Evaluations," describes a performance-based test of the APR1400 Basic HSI concept with US operators. This section lacks specific detail about the scenarios, the performance measures, the test procedures, and the data analyses.

To ensure that the IP will produce verifiable results, describe the following:

1. Guidelines for developing the specified scenarios and identifying objectives for the scenarios.

2. The specific, objective performance measures and specific, objective acceptance criteria that will be applied to determine if the results of the testing are acceptable or not.

3. Data analyses that will be performed.

Revise the submittal as necessary.

Response

General Response:

There is a need to understand that there is a significant difference between design evaluations and testing which is to be performed under the Human-System Interface Design (HD) element of the HFE program and the Integrated System Validation (ISV) performed during the Verification and Validation (V&V) element. The former occurs as the design process moves forward and is not predetermined. The scenarios (if required), performance measures, acceptance criteria and data analysis methods are dependent on the objectives of the evaluation or the test and this cannot be determined until the design process identifies the question. What can be identified at this time are high level assumptions regarding the plant and HSI design and the types of evaluations and tests that will, as a minimum, be performed. The HD Implementation Plan (IP) describes these high level needs as discussed in the specific responses to questions 1, 2 and 3 below. NUREG-0711 (Rev 0) identifies these inherent limitations during the design process and allows flexibility to the applicant (Section 8.4.6.2 (2));

"The applicant should base the general approach to testing on the test's objective(s).

The following aspects of the tests should be described (note that not all items are applicable to every type of test):

- participants
- testbed
- design features or characteristics of the HSI being tested
- tasks or scenarios used
- performance measures
- test procedures
- data analyses"

Unlike tests, performed during the ISV program, as described in the Human factors Verification and Validation Implementation Plan (V&V IP), APR1400-E-I-NR-14008-P (Rev 0), most of the activities that occur during the design process, under the HD IP, are trade off evaluations that are intended to evaluate alternative designs and fall under NUREG-0711 (Rev 3) Section 8.4.6.1 (1).

When a need for design performance based tests are identified they may require a focused test using a mock up or part task simulation, or an integrated test that uses the Basic HSI Test Facility as described in Section 3.1, page 7 of APR1400-E-I-NR-14007-P (Rev 0).

In order to obtain consistent test results across the HFE program, when there is a need to conduct specific design performance tests using the Basic HSI Test Facility, Section 5 of the Human Factors Verification and Validation Implementation Plan, APR1400-E-I-NR-14008-P (Rev 0) will be used as guidance. Tests will follow a test procedure and results will be documented.

This question states, "To ensure that the IP will produce verifiable results, describe the following." The Basic HSI design, APR1400-E-I-NR-14011-P (Rev 0), represents the product of

the evaluation and test design process as described in the HD IP. The Basic HSI design was developed using the same process of multiple trade-off evaluations and performance tests and as such was submitted to the NRC for review. Verification that the evaluations and tests performed under the HD IP will produce verifiable results can be ensured by:

1. Review of the Basic HSI Design
2. If needed, the results for the evaluation and test program that resulted in the SKN 3 & 4 plants and the Basic HSI Design can be made available for audit by the NRC staff
3. Review of the HD IP
4. NRC audits of design evaluations or tests as they are performed
5. The V&V program

Response to Question 1:

Objectives for the design performance tests will be set when the specific design question has been identified.

Initial, high level scenarios and there selection criteria are identified in Section 4.1.7 of APR1400-E-I-NR-14007(Rev 0):

"The following scenarios are conducted for these tests:

1. Steam generator tube rupture
    a. With normal HSI
    b. With loss of all non-safety HSI
    c. With CCF of all safety systems
2. Plant startup with normal HSI

These scenarios are selected because they represent plant conditions that have challenged US plant operating crews. Additional scenarios may be conducted at the discretion of the test administration SMEs."

When the SMEs decide that, based on the specific design question being investigated, additional scenarios are required; the guidance in Section 4.5 of APR1400-E-I-NR-14008-P (Rev 0) will be applied.

Response to Question 2:

The minimum set of performance measures are described in Section 4.1 of the HD IP, APR1400-E-I-NR-14007-P (Rev 0), as the following:

"1. Considers IHAs

2. Bases the layout of HSIs within consoles, panels, and workstations on analyses of personnel roles (job analysis) and systematic strategies for organization, such as arrangement by importance and frequency and sequence of use.

3. Designs the HSIs to support inspection, maintenance, test, and repair of (1) plant equipment and (2) the HSIs. The applicant is responsible for designing the HSIs so that inspection, maintenance, test, and repair of the HSIs do not interfere with other plant-control activities.

4. Supports personnel task performance within the HFE program plan (HFEPP) (Reference 1) staffing constraints.

5. Accounts for using the HSIs over the duration of a shift where decrements in human performance due to fatigue may be a concern. Fatigue is minimized by using touch screens only for safety-related controls; all IFPD interactions use mouse pointing. Also, the use of SDCV indications on the LDP reduces the need for screen navigation to accommodate routine plant monitoring.

6. Supports human performance under the full range of environmental conditions, from normal to credible extreme conditions, such as loss of lighting and ventilation. Loss of lighting and ventilation are not a concern for the MCR, RSR, or TSC because of redundant and diverse power sources.

7. Promotes plant-level situation awareness through SDCV alarms and indications.

8. Facilitates human-system interaction through status indication feedback to operators for control and information selection actions.”

Additional test specific measures will be identified, once the specific design question has been formulated, using Section 4.5.5 of APR1400-E-I-NR-14008-P (Rev 0)

Initial general acceptance criteria for each component or facility of the HSIS are discussed in Section 4.2.1 through 4.2.9, item 10 of APR1400-E-I-NR-14007-P (Rev 0).

Response to Question 3:

Data analysis will be dependent on the test objectives and test scope which will be determined later in the design process when it is determined that a specific test is needed.

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

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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Docket No. 52-046

RAI No.: **383-8458**

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

Application Section:

Date of RAI Issue: **02/01/2016**

Question No. 18-112

NUREG-0711, Criterion 8.4.6.2(2) states that the applicant should base the general approach to testing on the test's objective(s). The following aspects of the tests should be described: tasks or scenarios used, performance measures, test procedures, and data analyses. Also, NUREG-0711, Section 1.2.2, states that an IP is acceptable if it is verifiable, i.e., the final results can be evaluated using NUREG-0711 criteria, and the IP describes the products (expected results from executing the methodology).

The staff reviewed the performance-based tests identified for selected HSI resources in the HD IP, Section 4.2. Please clarify the following items:

1. Section 4.2.1, "Critical Safety Function Displays," Item 6b: The second sentence seems to not be in alignment with the first sentence.

2. Section 4.2.1, "Critical Safety Function Displays" Item 7: The meaning of this sentence is not clear. Please describe how the performance-based test be conducted and what specifically will be tested.

3. Section 4.2.3, "Task Displays" and Section 4.2.4, "Application Displays:" Section 3.2.7, "Performance-Based Tests," suggests that these types of HSI resources will be sampled for testing. Describe any criteria that will be used to determine the sample of displays that are selected.

4. Sections 4.2.1, 4.2.3, 4.2.4, 4.2.5, 4.2.6, 4.2.7: Describe test procedures that will be used to verify that the acceptance criteria have been satisfied, or describe a method of development.

5. Sections 4.2.1, 4.2.3, 4.2.4, 4.2.5, 4.2.6, 4.2.7: These sections refer to a predecessor plant and predecessor design, and Section 4.2.4 4.b. identifies the predecessor design as SKN 3&4. However, the HFE PP, section 8, defines SKN 3&4 as the reference plant.

Clarify whether or not the inputs to the design processes described in these sections are the reference plant (SKN 3&4) or the predecessor designs/plants.

6. Section 4.2.5, “Alarms:” For Item 7, describe any criteria that will be used to select alarms for sampling.

7. Section 4.2.6, “Computer-Based Procedures:” For Item 7, describe any criteria that will be used to select CBPs for sampling.

8. Section 4.2.7, “Safety Console:” For Item 7, describe any criteria that will be used to select CBPs for sampling and clarify if all IHAs are included in the sample or if they will be sampled (if so, describe how sampling is performed).

Response

Question 1:

The HSI Design Implementation Plan (HD IP), APR1400-E-I-NR-14007, Rev.0, Section 4.2.1, “Critical Safety Function Displays,” Item 6b will be revised, as follows:

> Alarm grouping facilitates high-level operator recognition without drill down. Therefore, these alarms are distinctly grouped for each CSF and for each success path (i.e., the alarms for multiple different CSFs or multiple different success paths are not grouped together).

Question 2:

The HSI Design Implementation Plan (HD IP), APR1400-E-I-NR-14007, Rev.0, Section 4.2.1, “Critical Safety Function Displays,” Item 7 will be modified, as follows:

7. Performance-based tests

   Performance-based testing, using US licensed operators and a part-task simulator, confirms correct HSI design implementation of FRA, TA and plant design requirements for a sampling of plant modes/scenarios. A key focus of this effort is to confirm the effectiveness of the HSI design in promoting CSF situation awareness. Therefore, scenarios are designed to specifically challenge CSFs, and these performance-based tests are conducted in conjunction with performance-based tests for alarms (Subsection 4.2.5).

Question 3:

The HSI Design Implementation Plan (HD IP), APR1400-E-I-NR-14007, Rev.0, Section 3.2.7, “Performance-Based Tests” will be modified, as follows:

> Performance-based tests are conducted for a sampling of task and application displays using part-task simulation. The sampled displays are selected by plant operations SMEs based on tasks and applications that are known to have challenged operators in predecessor plants or the reference plants, or may be expected to challenge operators for

APR1400. As a minimum, the sampling includes task and application displays for all complex control system functions, including:

1. Control element drive mechanism control system
2. Turbine control system
3. Steam bypass control system
4. Makeup control system
5. Feedwater control system
6. Heatup/cooldown

Performance-based tests are also conducted for task displays, alarms, and CBPs for a sampling of plant scenarios, including those that encompass the HSI design features for all IHAs. All scenarios selected for performance-based tests are determined and conducted by plant operations SMEs. Performance-based tests for task and application displays include CBPs in which the display is used primarily in conjunction with an operating procedure.

Question 4:

The HSI Design Implementation Plan (HD IP), APR1400-E-I-NR-14007, Rev.0, Section 3.2.7, “Performance-Based Tests” will be modified, as follows:

….Performance-based tests for task and application displays include CBPs in which the display is used primarily in conjunction with an operating procedure.

HFE SMEs generate generic performance-based test procedures, which are applicable to all scenarios, prior to beginning the HD testing program. Before any specific HD test, generic procedures are supplemented for each scenario by HSI/I&C and plant operations SMEs to encompass the specific challenges and acceptance criteria for each specific HSI design feature under test. The procedure for each test defines the scenario sequence, any prerequisites for test personnel and test participant training, and the data to be collected.

HEDs are generated …

Question 5:

The HSI Design Implementation Plan (HD IP), APR1400-E-I-NR-14007, Rev.0 will be modified, as follows:

Abstract Item 1:

...the conceptual design of the APR1400 Basic HSI is based on the Basic HSI of the reference plants (Shin Kori Nuclear Power Plant Units 3 and 4 [SKN 3&4]).

Section 3.1 APR1400 Basic HSI, third paragraph:

The HSI inventory for an APR1400 reference plant is implemented within the Basic HSI prototype, and the prototype is interfaced to a simulated plant model to create a dynamic APR1400 Basic HSI test facility.

Section 3.7 HD Input from Predecessor Design and Reference Plants

Since APR1400 is an evolutionary plant, much of its HSI inventory is expected to be common to its predecessor design, System 80+. Taking this even further, SKN 3&4 are reference plants that use a Basic HSI that is similar to the APR1400 Basic HSI. Therefore, HSI designs have already been created that are effective starting points for the APR1400 HSI design. The HD PE evaluates the input from the predecessor design and reference plants for applicability to APR1400. Changes are made to reflect changes in the Basic HSI, plant design, input from previous HFE PEs, and changes in regulatory conformance.

Section 4.1.1.2 Soft Control, fourth paragraph:

… The HSI tests conducted for the reference plants, SKN 3&4, confirmed the HFE suitability of each pointing method and their concurrent use.

Section 4.1.5 Basic HSI Design Inputs:

The APR1400 Basic HSI and the Basic HSI for the reference plants, SKN 3&4, are the same or similar except for the changes described in Subsections 4.1.5.1 and 4.1.5.2.

Section 4.2 APR1400 HSIS and Facilities, paragraph 2, Item 4:

4. Inputs from predecessor design and reference plants

Section 4.2.1 Critical Safety Function Displays, Item 4:

4. Inputs from predecessor design and reference plants

    a. The LDP, QIAS-N, and SPDS displays from the reference plants are the starting point for APR1400 since they have the same HSI inventory design basis.

Section 4.2.2 System Displays, Items 4 and 6:

4. Inputs from predecessor design and reference plants

    a. System displays from the reference plants are modified for APR1400 plant system changes.

6. Key design aspects to be fulfilled by the HSIS

    a. Reference plant designs are correctly modified for APR1400 plant system changes.

Section 4.2.3 Task Displays, Items 4 and 6:

4. Inputs from predecessor design and reference plants

a. Task displays from the reference plants are modified for APR1400 plant system and task changes.

6. Key design aspects to be fulfilled by the HSIS

a. Reference plant designs are correctly modified for APR1400 plant system and task changes.

Section 4.2.4 Application Displays, Items 4 and 6:

4. Inputs from predecessor design and reference plants

a. PPS and CPC operator module, QIAS-P, and IFPD application displays from the reference plants are the starting point for APR1400 since the I&C and application designs are similar.

b. DIS displays from the reference plants, SKN 3&4, are also the starting point for APR1400. However, DIS displays are expanded for APR1400 to consider large break loss-of-coolant accidents and main steam line break accidents with concurrent CCF; these accidents were not considered for the predecessor design or reference plants.

6. Key design aspects to be fulfilled by the HSIS

a. Reference plant designs are correctly modified for APR1400 I&C system and application changes….

Section 4.2.5 Alarms, Item 4:

4. Inputs from predecessor design and reference plants

a. The alarm database from the reference plants is the starting point for APR1400 since the alarm design basis is the same.

Section 4.2.6 Computer-Based Procedures, Item 4:

4. Inputs from predecessor design and reference plants

The PD uses operating procedures from the reference plants as the starting point for the procedures needed for ISV scenarios. PD modifies these procedures as needed to conform with US procedure practices (e.g., two column format, section breaks, fold-out pages for continuous actions).

Section 4.2.7 Safety Console, Item 4:

4. Inputs from predecessor design and reference plants

a. The console layout from the reference plants is the starting point for the APR1400 safety console because the design basis of the console is the same.

Section 4.2.8 Central Facilities, Item 4:

4. Inputs from predecessor design and reference plants

Section 4.2.9 Local Control Stations and Facilities, Item 4:

4. Inputs from predecessor design and reference plants

    a. LCS designs from the reference plants are the starting point for APR1400; these LCS are modified to reflect APR1400 plant design changes.

Question 6:

The HSI Design Implementation Plan (HD IP), APR1400-E-I-NR-14007, Rev.0, Section 4.2.5, “Alarms” Item 7 will be modified, as follows:

7. Performance-based tests

    a. Performance-based testing using part-task simulation confirms correct prioritization and applicability logic for a sampling of plant modes/scenarios. The selected plant modes/scenarios encompass the alarms credited in the TA to prompt all IHAs. In addition, plant operations SME’s select a sampling of plant modes/scenarios that are known to generate large numbers of alarms in predecessor plants, presenting the potential for information overload.

Question 7:

The HSI Design Implementation Plan (HD IP), APR1400-E-I-NR-14007, Rev.0, Section 4.2.6, “Computer-Based Procedures” Item 7 will be modified, as follows:

7. Performance-based tests

    a. Performance-based testing using part-task simulation confirms correct CBP support for a sampling of plant modes/scenarios. The selected plant modes/scenarios encompass all IHAs, where CBPs are employed; CBPs are not employed for some degraded HSI conditions. In addition, plant operations SME’s select a sampling of plant modes/scenarios that encompass all tasks with less than or equal to 25% Time Margin from the TA.

Question 8:

The HSI Design Implementation Plan (HD IP), APR1400-E-I-NR-14007, Rev.0, Section 4.2.7, “Safety Console” Item 7 will be modified, as follows:

7. Performance-based tests

    a. Performance-based testing using part-task simulation confirms HSI suitability for selected degraded HSI scenarios, including scenarios with IHAs from the D3CA, and IHAs from the TAA with concurrent loss of IFPDs. Since the CBP system is assumed to be unavailable with concurrent loss of IFPDs, some of these scenarios will employ paper-based procedures.

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, “Human-System Interface Design Implementation Plan,” Abstract, Sections 3.1, 3.2.7, 3.7, 4.1.1.2, 4.1.5 and 4.2 will be revised, as indicated in the Attachment associated with this response.

ABSTRACT

This document provides the implementation plan (IP) for the human factors engineering (HFE) human-system interface design (HD) program element (PE), one of 12 PEs in the Advanced Power Reactor 1400 (APR1400) HFE Program. This IP governs the technical activities conducted in the HD PE by defining the scope, methodology, output products, and the qualifications of the personnel who conduct the PE.

The main purpose of the HD PE is to create functional designs for the following:

reference plants

1. The detailed design for the APR1400 Basic Human-System Interface (HSI), which establishes the generic indication, alarm, control, and procedural methods applied to all systems and functions controlled from the main control room (MCR) and the remote shutdown room (RSR). The same HSI methods apply to the safety parameter display system (SPDS) indications in the MCR and the technical support center (TSC). The APR1400 Basic HSI also defines indication, alarm, and control methods for local control stations (LCSs) used for important human actions (IHAs). The detailed design for the APR1400 Basic HSI is an extension of the conceptual design described in APR1400 Basic Human-System Interface Technical Report (TeR) (Reference 2); the conceptual design of the APR1400 Basic HSI is based on the Basic HSI of the ~~predecessor design~~ (Shin Kori Nuclear Power Plant Units 3 and 4 [SKN 3&4]).
2. The APR1400 HSI System (HSIS), which establishes soft and conventional indications, alarms, controls and operating procedures that encompass the HSI inventory in the task analysis (TA) HFE PE and APR1400 plant system designs, within the generic HSI methods defined in the APR1400 Basic HSI.
3. APR1400 HSI Facilities, which include the ARP1400 MCR, RSR, and TSC. The facility designs accommodate the APR1400 HSIS as well as storage, communication, meeting, and other habitability features important to support required operations crew performance during all facets of plant operation.

The integration of the APR1400 HSIS and APR1400 HSI Facilities is referred to as the APR1400 HSI Design.

This HD IP controls the HSI design process and scope, including the translation of HSI inventory requirements from the TA PE into the detailed designs of alarms, displays, controls, and other aspects of the HSI. Key HD outputs include soft graphical displays, soft and conventional controls, alarm prioritization and applicability logic, computer-based operating procedures, control consoles and the configuration of control rooms. This IP provides reasonable assurance that these functional designs reflect the systematic application of HFE principles and criteria through the generation of design documents, prototypes, part-task simulators and focused design tests.

HD uses input from the following APR1400 HFE PEs to create its outputs: functional requirements analysis and function allocation (FRA/FA), treatment of important human actions (TIHA), TA, staffing and qualifications (S&Q), and procedure development (PD). The end product of the HD is the functional design of the APR1400 HSI (i.e., the APR1400 HSI Design), which is incorporated into the detailed designs of HSI hardware, software, and physical facilities. The APR1400 HSI design is then formally verified and validated in the human factors verification and validation (V&V) HFE PE through high fidelity simulation.

The HD for the APR1400 Basic HSI may be conducted at any time because it does not depend on the output of other APR1400 HFE PEs, which are incorporated primarily to generate the APR1400 HSI inventory. The HD for the APR1400 HSIS is conducted after the Basic HSI is documented (as defined herein) after the APR1400 HSI inventory is identified through the HFE PEs identified above and after the instrumentation and control (I&C) design requirements are established by the mechanical and I&C system designers for each APR1400 plant system. The piping and instrumentation diagrams (P&ID) are the starting point for creating HSI indication and control designs during the HD PE. The APR1400

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3.2 APR1400 HSIS

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3.2.5 Alarms

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3.2.6 Computer-Based Procedures

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3.2.7 Performance-Based Tests

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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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3.7 HD Input from Predecessor and Reference Plants

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4.1.1.2 Soft Control

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4.1.1.3 Information Display Hierarchy

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4.1.4.19 Emergency Offsite Facility

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4.1.5 Basic HSI Design Inputs

reference plants

The APR1400 Basic HSI and the Basic HSI for the ~~predecessor design~~, SKN 3&4, are the same or similar except for the changes described in Subsections 4.1.5.1 and 4.1.5.2. The evolution of SKN 3&4 is also described.

4.1.5.1 Design Evolution

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4.2 APR1400 HSIS and Facilities

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4.2.1 Critical Safety Function Displays

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4.2.2 System Displays

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4.2.3 Task Displays

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4.2.4 Application Displays

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4.2.5 Alarms

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4.2.6 Computer-Based Procedures

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4.2.7 Safety Console

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4.2.8 Central Facilities

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4.2.9 Local Control Stations and Facilities

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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

RAI No.: **383-8458**

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

Application Section:

Date of RAI Issue: **02/01/2016**

Question No. 18-113

NUREG-0711 Section 1.2.2, “Review Elements, “states that an acceptable implementation plan (IP) is complete, i.e., the IP describes the scope, inputs, analyses to be performed, outputs, and documentation. Also, NUREG-0711, Section 4, "Functional Requirements Analysis and Function Allocation (FRA/FA)," Criterion 4.4(3) states that the applicant should define, for each safety function and other plant function (e.g., electrical power generation), the set of system configurations or success paths that are responsible for, or able to carry out the safety functions.

The HD IP, Section 4.1.4.4, “Manual Feedwater Control” identifies specific equipment as part of an emergency success path. Also, the critical safety function (CSF) success paths and the equipment used to achieve those success paths are identified in other sections of the DCD Tier 2 application (e.g., Section 5.4.14.2, which describes pilot-operated safety relief valves). However, the FRA/FA IP (APR1400-E-INR-14003-P, Rev. 0) describes a process to determine the APR1400 success path equipment instead of identifying this equipment or identifying where it is located in the application. It’s not clear to the staff why the FRA/FA describes a process instead of either identifying the equipment that form the normal and emergency success paths or identifying where the information is in the application.

In the FRA/FA IP, identify the normal and emergency success paths or state where the information is located. Revise the submittal as necessary.

Response

The normal and emergency success paths descriptions are located in the APR1400 Emergency Operating Guidelines as resource trees in the Functional Recovery Guideline (Ref. KHNP submittal MKD/NW-15-0126L dated September 7, 2015). Section 4.3.3, “Specification of Functional Hierarchy, Success Paths, and Requirements” of the Functional Requirements Analysis and Function Allocation Implementation Plan 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-14003-NP, Rev.0, “Functional Requirements Analysis and Function Allocation Implementation Plan,” Subsection 4.3.3 will be revised, as indicated in the Attachment associated with this response.

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Figure 4-3 Success Path Resource Tree

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