
REVISED 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.: 53-7982
SRP Section: 18 – Human Factors Engineering
Application Section: 18.2 Operating Experience Review
Date of RAI Issue: 06/26/2015

Question No. 18-2

Title 10 of the Code of Federal Regulations (10CFR) Section 52.47(a)(8) requires an applicant for a design certification to provide an FSAR which includes the information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), with certain exceptions. Section 10 CFR 50.34(f)(2)(ii) requires an applicant to "Establish a program, to begin during construction and follow into operation, for integrating and expanding current efforts to improve plant procedures. The scope of the program shall include.....human factors engineering.." The current NRC guidance for developing a human factors engineering (HFE) program is NUREG-0711, Rev 3, "Human Factors Engineering Program Review Model." The applicant stated in the FSAR, Tier 2, Chapter 18 "Human Factors Engineering," that it was working in accordance with the criteria of NUREG-0711 in establishing its HFE program.

NUREG-0711, Section 3.4, "Review Criteria," Criterion 2 states that the applicant should address the HFE issues in NUREG/CR-6400.

The staff notes that each of the items provided in the bulleted list are restated in the "Operating Experience Review Implementation Plan" (OER IP), APR1400-E-I-NR-14002, Rev. 0, Section 4.6, "Grouping Operating Experience" and NUREG/CR-6400 is specifically called out as a source for US operating experience in Section 4.2, "U.S. Source Operating Experience Data Collection." However, in Section 4.2, other descriptions for the sources of OE are very general.

Some examples:

- "NRC NUREGs" listed, but which NUREGs (other than 6400) will be part of the OER?
- "Vendor groups" is listed as well, but which vendor groups?
- The Institute for Nuclear Power Operations (INPO) is also listed. What type(s) of information will be gathered from INPO in the OER?

Please provide greater specificity and detail that describes which parts of the source items are used or searched during the OER process.

Response – (Rev. 1)

In addition to NUREG/CR-6400, NUREGs referred to in NUREG-0711, Rev. 3 will be parts of the OER:

- U.S. NRC, NUREG-0933, Resolution of Generic Safety Issues: Task HF1: Staffing and Qualifications, 2010
- U.S. NRC, NUREG-1275, Operating Experience Feedback Reports series, Vols. 1 through 14

Additionally, NUREGs related to both HSI issues and the other HFE program elements will be parts of the OER:

- U.S. NRC, NUREG-0696, Functional Criteria for Emergency Response Facilities, 1981
- U.S. NRC, NUREG-0700, Human-System Interface Design Review Guidelines, 2002
- U.S. NRC, NUREG-0737, Clarification of TMI Action Plan Requirements: Requirements for Emergency Response Capability, 1983
- U.S. NRC, NUREG-1220, Training Review Criteria and Procedures, 1993
- U.S. NRC, NUREG-1358, Lessons Learned from the Special Inspection Program for EOPs, 1989
- U.S. NRC, NUREG/CR-6634, Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance, 2000
- U.S. NRC, NUREG/CR-6749, Integrating Digital and Conventional Human-System Interfaces: Lessons Learned from a Control Room Modernization Program, 2002
- U.S. NRC, NUREG/CR-6751, The Human Performance Evaluation Process: A Resource for Reviewing the Identification and Resolution of Human Performance Problems, 2002
- U.S. NRC, NUREG/CR-6753, Review of Findings for Human Performance Contribution to Risk in Operating Events, 2002
- U.S. NRC, NUREG/CR-6947, Human Factors Considerations with Respect to Emerging Technology in Nuclear Power Plants, 2008

In regard to U.S. vendor groups, the vendors of pressurized water reactor (PWR) type plants are Westinghouse and Combustion Engineering. OEs from these vendors will be identified and analyzed.

Regarding the information gathered from INPO, accident and failure records of PWR type plants will be identified and then reflected into the design. In addition, information related to HSI designs similar to that of APR1400 will be collected and provided for OER analysis.

The NUREGs (other than NUREG-6400) which are parts of the OER will be added to Section 4.2 of OER IP.

The detail information for Vendor groups and the information gathered from INPO in the OER will be added to Section 4.2 of OER IP, 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-14002-P/NP, Rev.0, "Operating Experience Review Implementation Plan," Section 4.2 will be revised, as indicated in the attachment associated with this response.

4 IMPLEMENTATION

Subsections 4.1 through 4.4 describe the sources of OEs, and Subsections 4.4 through 4.13 describe the steps of the OER.

4.1 Internationally Sourced Operating Experience Data Collection

The HFE design team maintains a database of world-wide OEs and lessons learned to keep the database current with information from the latest model plant that KHNP has built in Republic of Korea (SKN 3&4). The HFE design team also reviews the database along with current OEs from all of the nuclear power plants that are operating or have operated in the country of Republic of Korea.

The OE review includes OEs from the following sources of information from international pressurized water reactor (PWR) plants:

- Korean 1000MW two-loop plants
- Issues identified by plant personnel (e.g., maintenance and test personnel)
- main control room (MCR) and auxiliary operator interviews
- Operator training instructor interviews
- Emergency operator (e.g., shift technical advisors, technical support center staff) interviews
- Operating plant event reports
- Halden Reactor Project reports
- Reviews of related HFE technology
- Organization for Economic Co-operation and Development (OECD) Specialists Meeting, "Human Factors and Operation Aspects in Computerization of the Control Room: A French Safety View Based on N4 Experience" (Reference 1)
- Significant OEs and significant event reports from the World Association of Nuclear Operators

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The HFE OE reviewer continues to refresh the international OE database and keeps the OE database current. The database of U.S. sourced OE is also maintained current and is described below (Section 4.2).

4.2 U.S. Sourced Operating Experience Data Collection

The APR1400 HFE design program includes a review of OEs from countries other than Republic of Korea that have commercial nuclear power plants. OEs are collected from the following U.S. sources:

- NRC unresolved and generic safety issues
- NRC NUREGs, including NUREG/CR-6400 (Reference 2), which addresses lessons learned from U.S OEs, such as Three Mile Island (TMI), and non-U.S. OEs
- U.S. vendor groups
- U.S. commercial nuclear power plant industry support groups, such as:

The vendors of PWR type plants are Westinghouse and Combustion Engineering.

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Category 1 – Predecessor Plant and Systems including General MMI Issues

- OER for System 80+ MMI design (NPX80-IC-RR790-01, Rev. 1), June, 1993
- Kori 1 NPP Control Room Design Reviews (CRDR), KOPEC/90-P-002, KEPCO, June, 1990
- Kori 2 NPP CRDR, KOPEC/90-P-003, KEPCO, June, 1990
- Kori 3, 4 and YG 1, 2 NPP CRDR, KOPEC/90-P-001, KEPCO, June, 1990
- The Operating Experience Report of YG 3 & 4, KEPCO YG Site, December, 1997
- The Summary Report of Operating Experience in YG 1, KEPCO YG Site, May, 1996

Category 2 – Recognized Industry HFE Issues including Issues Identified in Nuclear Regulatory Authorities

- U.S. NRC, NUREG-1358, lessons learned from the special inspection program for EOPs, 1989
- U.S. NRC, NUREG/CR-6400, Human Factors Engineering Insights for Advanced Reactors based upon Operating Experience, 1997

- HFE tracking of open issues databases of ABB-CE, December, 1993

- Korean NPP LERs, August, 1978-May, 1996
- U.S. NRC Information Notice 84-58, July, 1984
- Ergonomics in Design, Vol. 5, No. 3, July, 1997

- Development of the ABWR type control room panel, Proceeding of IERE workshop, TEPCO
- The Proceedings of the First HPES Workshop, 1. Trend Analysis on Human Error, KEPCO NTC, October 28, 1996

- EdF N4 and S3C Simulator Trip Report, 1990

- Establishment of Human Factors Experiment Plan for the Resolution of Human Factors Issues Related to Advanced Human-System Interface, KAERI, January 20, 1999

Category 3 – Related HSI Technology

- OECD Specialists Meeting, human factors and operation aspects in computerization of the control room, 1999

- BNL, hybrid human-system interface: human factors considerations, December, 1996

- Evaluation issues for computer-based control rooms, HFS-1991, Dr. E. M. Roth

- Exploring the Impact of Advanced Alarms, Displays and Computerized Procedures on Teams, Emilie M. Roth, John M. O'Hara

- IEEE Sixth Human Factors Meeting, "Global Perspectives of HFs in Power Generation," June, 1997

- IAEA, Techdoc-812, Control Room Systems Design for NPP, July, 1995

- HWP-385, "COPMA-III discussions on requirement and design issues," October, 1994

- HWP-277, "Experimental Evaluation of the CPS," December, 1990

- HWP-451, "Integrated Information Overview Displays," April, 1996

- HWR-398, "Alarm System CASH: main design characteristic," October, 1994

- HWR-592, "The Operator Interface of the BWR Simulator in HAMMLAB," HRP, May, 1999

- HWR-597, "Human Factors Evaluation on the 1988 NORS MMI in HAMMLAB," HRP, May, 1999

- Designing a first-of-a kind group view display for team decision making, Dr. E. M. Roth, 2001

- HWR-184, "Further Evaluation Exercises with the Integrated Process Status Overview (IPSO)," HRP, April, 1987

Category 4 – Operator Interviews

- Operators and instructors interviews in YGN unit 1 through 4

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- o U.S. NRC, NUREG-0933, Resolution of Generic Safety Issues: Task HF1: Staffing and Qualifications, 2010
- o U.S. NRC, NUREG-1275, Operating Experience Feedback Reports series, Vols. 1 through 14
- o U.S. NRC, NUREG-0696, Functional Criteria for Emergency Response Facilities, 1981
- o U.S. NRC, NUREG-0700, Human-System Interface Design Review Guidelines, 2002
- o U.S. NRC, NUREG-0737, Clarification of TMI Action Plan Requirements: Requirements for Emergency Response Capability, 1983
- o U.S. NRC, NUREG-1220, Training Review Criteria and Procedures, 1993
- o U.S. NRC, NUREG-1358, Lessons Learned from the Special Inspection Program for EOPs, 1989
- o U.S. NRC, NUREG/CR-6634, Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance, 2000
- o U.S. NRC, NUREG/CR-6749, Integrating Digital and Conventional Human-System Interfaces: Lessons Learned from a Control Room Modernization Program, 2002
- o U.S. NRC, NUREG/CR-6751, The Human Performance Evaluation Process: A Resource for Reviewing the Identification and Resolution of Human Performance Problems, 2002
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- o U.S. NRC, NUREG/CR-6947, Human Factors Considerations with Respect to Emerging Technology in Nuclear Power Plants, 2008

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- Significant OEs and significant event reports from the World Association of Nuclear Operators

- Institute for Nuclear Power Operations
- Electric Power Research Institute (EPRI) (Reference 3), which hosts the Nuclear Safety Analysis Center
- Human factors information system which is maintained by the NRC and includes summaries of human performance issues identified in licensee event reports, inspection reports, and licensed operator examination reports
- “Hybrid Human-System Interface: Human Factors Considerations,” Brookhaven National Laboratory (Reference 4)
- IAEA-Techdoc-812, “Control Room Systems Design for Nuclear Power Plants” (Reference 5)

All OEs are screened for relevance as described in Subsection 4.5.

4.3 Operator Interviews as a Source of Operating Experience

The following plant operations personnel from the predecessor plant S&K 3&4 are interviewed as a potential source of OEs.

- Maintenance and test personnel
- MCR and auxiliary operators
- Operator training instructors
- Emergency operator (e.g., shift technical advisors, technical support center staff)

: Accident and failure records of PWR type plants will be identified and then reflected into the design. In addition, information related to HSI designs similar to that of APR1400 will be collected and provided for OER analysis.

The interviews include scripted questions regarding:

- Normal plant evolutions
- Failure modes and degraded conditions of the instrumentation and control (i&c) systems
- Degraded conditions of the HSI
- Transients
- Accidents
- Reactor shutdown and cooldown using the remote shutdown system

The interviews also contain scripted questions on the following HFE design topics:

- Alarms and annunciation
- Displays and information requirements
- Controls and automation
- Information processing and job aids

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Application Section: 18.2 Operating Experience Review
Date of RAI Issue: 06/26/2015

Question No. 18-3

NUREG-0711, Section 3.4, "Review Criteria," Criterion 1, states that the applicant's operating experience review (OER) should include information about human factors issues in the predecessor plant(s) or highly similar plants, and that the OER should detail how the applicant identified and analyzed any HFE-related problems in the previous plants/designs, and how these issues are avoided in the new design.

Section 4.5, "The Process of Screening Operating Experience for Applicability," of APR1400-EI-NR-14002, Rev.0 (OER IP), provides the APR1400 screening process for operating experience applicability. In the first paragraph the OER IP states that "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 acknowledges KHNP's approach to make use of the existing SKN 3&4 OER. However, staff had the following questions related to this statement:

Question 1:

The word "assumed" does not provide clarity on what was actually included in the SKN 3&4 OER. What OEs were included in the SKN 3&4 OER?

Question 2:

As stated in the OER IP abstract, the SKN 3&4 OER is the basis of the APR1400. However, given that SKN 3&4 is not an NRC approved design, the staff has the following questions:

- Was the OER NUREG-0711 process used for the SKN 3&4 OER?
- Will the results of the SKN 3&4 OER be included in the APR1400 ReSR or if SKN 3&4 used the NUREG-0711 process, is there a ReSR that NRC could review now during Phase 2 review that describes the SKN 3&4 OE review results?

Response – (Rev. 1)**Response to Question 1:**

OEs with dates before the SKN 3&4 OER close date will be used as input data for the APR1400 OER since SKN 3&4 are reference plants for APR1400.

Representative OEs included in the SKN 3&4 OER for each category are as follows:

Category 1 – Predecessor Plant and Systems including General MMI Issues

- OER for System 80+ MMI design (NPX80-IC-RR790-01, Rev. 1), 1993.6
- Kori 1 NPP Control Room Design Reviews (CRDR), KOPEC/90-P-002, KEPCO, 1990.6
- Kori 2 NPP CRDR, KOPEC/90-P-003, KEPCO, 1990.6
- Kori 3, 4 and YG 1, 2 NPP CRDR, KOPEC/90-P-001, KEPCO, 1990.6
- The Operating Experience Report of YG 3 & 4, KEPCO YG Site, 1997.12
- The Summary Report of Operating Experience in YG 1, KEPCO YG Site, 1996.5

Category 2 – Recognized Industry HFE Issues including Issues Identified in Nuclear Regulatory Authorities

- U.S. NRC, NUREG-1358, lessons learned from the special inspection program for EOPs, 1989
- U.S. NRC, NUREG/CR-6400, Human Factors Engineering Insights for Advanced Reactors based upon Operating Experience, 1997
- HFE tracking of open issues databases of ABB-CE, 1993.12
- Korean NPP LERs, 1978.8-1996.5
- U.S. NRC Information Notice 84-58, 1984.7
- Ergonomics in Design, Vol. 5, No. 3, 1997.7
- Development of the ABWR type control room panel, Proceeding of IERE workshop, TEPCO
- The Proceedings of the First HPES Workshop, 1. Trend Analysis on Human Error, KEPCO NTC, 1996.10.28
- EdF N4 and S3C Simulator Trip Report, 1990
- Establishment of Human Factors Experiment Plan for the Resolution of Human Factors Issues Related to Advanced Human-System Interface, KAERI, 1999.1.20

Category 3 – Related HSI Technology

- OECD Specialists Meeting, human factors and operation aspects in computerization of the control room, 1999
- BNL, hybrid human-system interface: human factors considerations, 1996.12
- Evaluation issues for computer-based control rooms, HFS-1991, Dr. E. M. Roth
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- IEEE Sixth Human Factors Meeting, "Global Perspectives of HFs in Power Generation," 1997.6
- IAEA, Techdoc-812, Control Room Systems Design for NPP, 1995.7
- HWP-385, "COPMA-III discussions on requirement and design issues," 1994.10
- HWP-277, "Experimental Evaluation of the CPS," 1990.12
- HWP-451, "Integrated Information Overview Displays," 1996.4
- HWR-398, "Alarm System CASH: main design characteristic," 1994.10
- HWR-592, "The Operator Interface of the BWR Simulator in HAMMLAB," HRP, 1999.5
- HWR-597, "Human Factors Evaluation on the 1988 NORS MMI in HAMMLAB," HRP, 1999.5
- Designing a first-of-a kind group view display for team decision making, Dr. E. M. Roth, 2001
- HWR-184, "Further Evaluation Exercises with the Integrated Process Status Overview (IPSO)," HRP, 1987. 4

Category 4 – Operator Interviews

- Operators and instructors interviews in YGN unit 1 through 4

Response to Question 2:

The SKN 3&4 OER was carried out in accordance with the process of NUREG-0711, Rev. 0.

HFE-related safety issues allocated into each category (Predecessor Plant and Systems, Recognized Industry HFE Issues, Related HSI Technology, and Operator Interviews) were reviewed, analyzed, and provided input to the SKN 3&4 design.

[The results of the SKN 3&4 OER will be incorporated into the APR1400 OER ReSR.](#)

The OEs included in the SKN 3&4 OER for each category will be added to Section 4.1 of the OER IP, 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

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4 IMPLEMENTATION

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4.2 U.S. Sourced Operating Experience Data Collection

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- HWR-597, "Human Factors Evaluation on the 1988 NORS MMI in HAMMLAB," HRP, May, 1999

- Designing a first-of-a kind group view display for team decision making, Dr. E. M. Roth, 2001

- HWR-184, "Further Evaluation Exercises with the Integrated Process Status Overview (IPSO)," HRP, April, 1987

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- o U.S. NRC, NUREG/CR-6634, Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance, 2000
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- Significant OEs and significant event reports from the World Association of Nuclear Operators