Operating Experience Review Implementation Plan

Revision 2

Non-Proprietary

January 2018

REVISION HISTORY

Revision	Date	Page	Description
0	December 2014	All	First Issue
1	March 2017	5-7 (4.1) 5-7 (4.1) 7 (4.2) vii, 2, 7, 8 (Overall)	Description for OE Reviews for PWR Korea plants are categorized and revised R_53-7982(3R) Description for PWR plants are revised R_53-7982(2R) Description for OEs from U.S. sources are added R_53-7982(2R) Editorial corrections (typos, acronyms)
2	January 2018	6 (4.1) 9-10 (4.5)	Editorial corrections (typos) CR_17-J-220 Revised description for process of screening OEs R_553-9084(136)

ABSTRACT

This document provides the implementation plan (IP) for the human factors engineering (HFE) Operating Experience Review (OER) program element, which is one of eleven program elements within the Advanced Power Reactor 1400 HFE Program. This IP governs the technical activities conducted within the OER program element by defining the scope and methodology of the OER, including the output products and the personnel qualifications of those who will generate those products.

The main purpose of the OER is to evaluate operating, design, and construction experience (referred to collectively as “operating experience" (OE)) to ensure that germane OE are provided to those designing and constructing the plant to identify historical HFE-related safety issues and to input this information into the design process as an human engineering discrepancy.

The human factors engineering design process includes the requirement to include a review of relevant OE so that mistakes of the past are not repeated and that good practices of the past are not excluded. These mistakes are considered to be HFE-related safety issues.

This IP provides a methodology which uses the Shin-Kori 3&4 plant OE review as a basis. From there, U.S. and international OEs are continually screened for relevance. Once screened the OE is grouped with other like OEs and classified for importance. A statement called a lesson learned is developed from the OE to capture the learning in a positively worded statement that can be generically applied throughout the design process. Lessons learned are fed into the other human factors program elements (see Figure 3-1) as human engineering discrepancies (HEDs) which are tracked to completion (Section 4.11).

Section 1 of this document defines the OER Purpose, Section 2 establishes the Scope. Section 3 provides a Methodology Overview, the details of the methodology are provided in Section 4. Section 5 establishes the qualification requirements for the OER implementation team. Section 6 defines the required content of the OER Results Summary Report, which demonstrates that the OER was conducted in accordance with this IP.

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ACRONYMS AND ABBREVIATIONS

APR	Advanced Power Reactor
CFR	Code of Federal Regulation
DCD	Design Control Document
EPRI	Electric Power Research Institute
HED	human engineering discrepancy
HFE	human factors engineering; human factors engineer
HSI	human-system interface
I&C	instrumentation and control
IAEA	International Atomic Energy Agency
IHA	important human action
IP	implementation plan
ITS	issue tracking system
KEPCO	Korea Electric Power Corporation
KHNP	Korea Hydro & Nuclear Power Co., Ltd.
MCR	main control room
NRC	U.S. Nuclear Regulatory Commission
OE	operating experience
OECD	Organization for Economic Co-operation and Development
OER	operating experience review
PWR	pressurized water reactor
ReSR	results summary report
RSR	remote shutdown room
SKN 3&4	Shin-Kori Nuclear Power Plant Units 3 and 4
TIHA	treatment of important human actions
TMI	Three Mile Island
TS	trade secret
V&V	verification and validation

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1 PURPOSE

This operating experience review (OER) implementation plan (IP) describes the methodology for identifying, evaluating, tracking and incorporating human performance based operating experience (OE) into the APR1400 plant and human system interface (HSI) design. The identified OE includes issues from the design, construction and actual OE of a predecessor plant, international industry OE, as well as non-nuclear OE. These OE allow the human factors analyst to identify and understand human factors related safety issues.

Interviews conducted with operations, maintenance and training personnel allow the human factors analysts to not only identify negative features associated with previous designs but to identify and retain positive features. The OEs are used as input into the human factors engineering (HFE) design process for the APR1400 plant design.

2 SCOPE

The scope of the OER for the APR1400 plant design includes information from the following sources:

- Predecessor plants and systems
- Recognized industry HFE issues
- Related HSI technology
- Issues identified by plant personnel
- Important human actions (IHAs)
- U.S. and international nuclear industry OE
- Interviews with predecessor plant operations personnel
- Non-nuclear OEs of similar HSIs or system design

3 METHODOLOGY OVERVIEW

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. SKN 3&4 are currently under construction in Republic of Korea. The SKN 3&4 design is based on the U.S. Nuclear Regulatory Commission (NRC) certified, but never constructed, System 80+.

A Predecessor plant is an operating plant with characteristics that are similar to the characteristics of the APR1400. The predecessor plants for both SKN 3&4 and System 80+ are the Palo Verde plants, Units 1, 2, and 3, and eight large two-loop units operating in Republic of Korea.

OE from U.S. and South Korean nuclear sources and non-nuclear sources are reviewed. Each OE is screened, for applicability based on the criteria described in Subsection 4.5. Once screened, the OE is grouped with other similar OEs in Subsection 4.6 and then classified by importance described in Subsection 4.7. All screened OEs are entered into an OE database and tracked to resolution.

A statement referred to as a lesson learned is developed from a single OE or group of OEs to capture the lesson in a positively worded statement that can be generically applied throughout the design process in Subsection 4.8. Lessons learned that are to be reviewed in HFE program elements are captured in an issue tracking system (ITS) as human engineering discrepancies (HEDs).

For example:

- IHAs that are input into the treatment of important human actions (TIHA) element
- Items that are identified as problematic are input into the human factors verification and validation (V&V) element
- Items that are directly related to the Style Guide (Reference 10)

A result summary report (ReSR) is prepared to document the results as follows:

- How the OER was conducted,
- Results of the OER
- Findings including findings from interviews
- Number and status of any open HEDs that are being tracked in ITS.

The ReSR is described in more detail in Section 6.

A data flow diagram showing the flow and translation of OE information within the APR1400 HFE design process is described in Figure 3-1.

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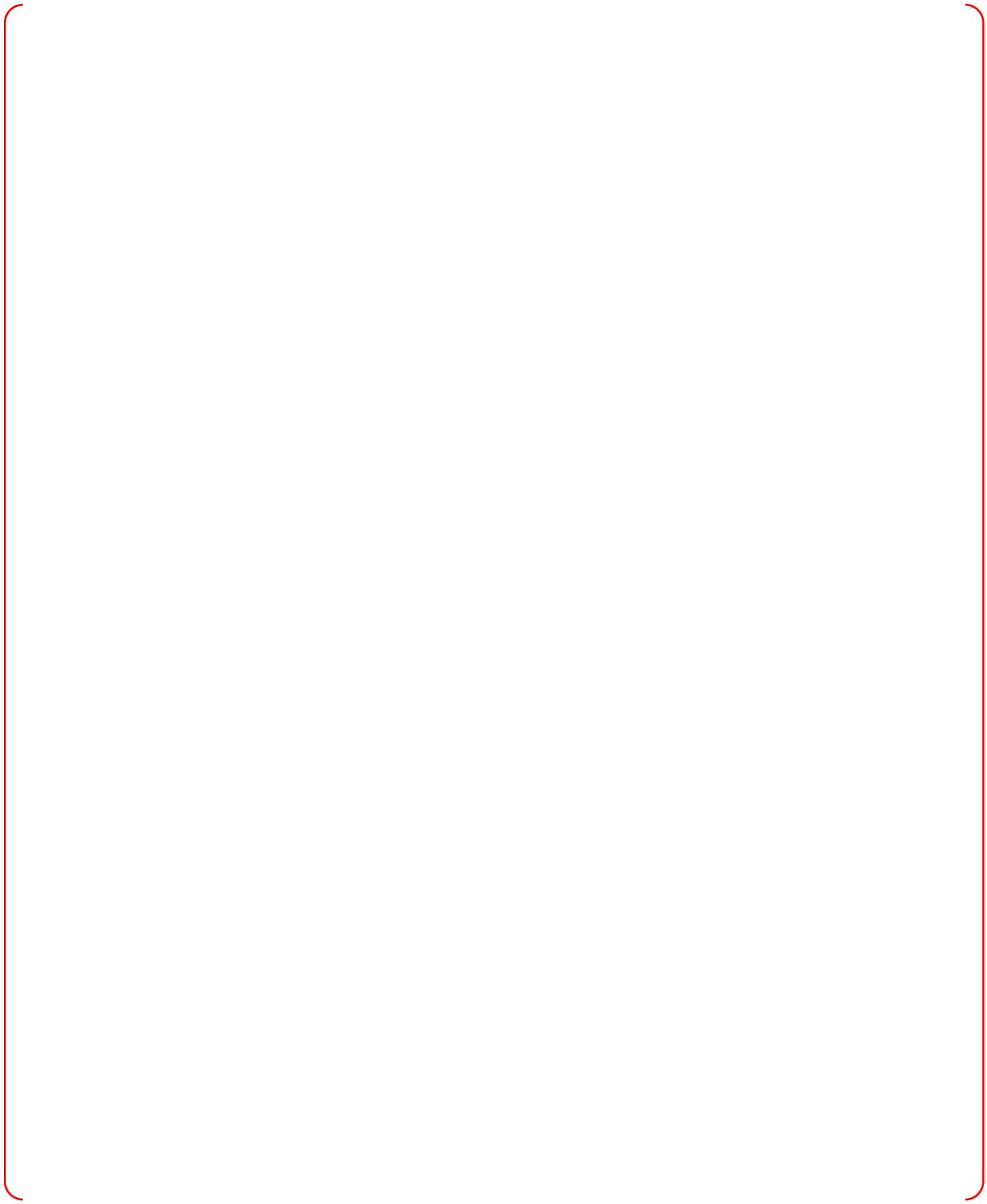

Figure 3-1 Flow Diagram for Operating Experience Review

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:

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

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. 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
- 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

- U.S. vendor groups: The vendors of PWR type plants are Westinghouse and Combustion Engineering
- Significant OEs and significant event reports from the World Association of Nuclear Operators
- U.S. commercial nuclear power plant industry support groups, such as:
    - Institute for Nuclear Power Operations: 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
    - 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)

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
- Real-time communications with plant personnel and other organizations
- Procedures, training, staffing and qualifications, and job design

The interviews of operations personnel allow the human factors analysts to not only identify negative features associated with previous designs but to identify and retain positive features. The interviews cover all plant operation modes and the personal experience of individuals. The scripted interview questions are written by human factors specialists who are experts in conducting personnel interviews. Interviews also include a free-form discussion to allow the individuals to offer comments and insights that might not have been included otherwise.

Examples of the interview questions and the written questionnaires that KHNP uses in its operational personnel interviews are available for audit. Each question is developed to match the bulleted items in Section 3.4.1(4) in NUREG-0711 Rev 3 (Reference 6). The interviews focus on design concerns that should be improved upon and design aspects that should be retained, all of which are entered into the OE database.

4.4 Non-nuclear Sources of Operating Experience

Human performances OEs found in non-nuclear industrial applications that use digital screen-based HSI technology are reviewed. The review is limited to HFE-related problems with the HSI. At a minimum, sources from the following industries are included:

- Chemical industry – U.S. Chemical Safety Board
- Nuclear industry – Defense Nuclear Facilities Safety Board
- Transportation industry (marine, piping, railroad, aviation)
    - National Transportation Safety Board
    - Aviation Safety Network
    - Interstate Aviation Committee
- Electrical transmission

These data sources are selected because they represent a broad sampling of industries that employ digital HSI technology. Data from each of the sources of OE is entered into the OE database.

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 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 NUREG-0711, Revision 3. 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:

- 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
- Operating plant event reports

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. OEs are grouped by the HFE design team based on technical knowledge. The groupings are reviewed and approved by the HFE design team leader.

4.7 Classifying Operating Experience

The OEs that have been determined to be applicable to the APR1400 are classified as follows:

- Class 1 OE (high priority) contains information related to activities that may affect HFE-related safety goals. Class 1 OEs are addressed in the design to maintain the safety and health of the public and plant staff and are tracked through resolution. The resolution is reviewed during human factors verification.

- Class 2 OE (medium priority)-does not affect safety goals directly but is addressed to improve consistency and to avoid the cumulative effects of significant issues. Class 2 OEs are not deemed to be essential. Class 2 OE resolutions are tracked by the HFE design team.

- Class 3 OE (low priority) is not Class 1 or 2. Class 3 OEs are considered when the HSI is redesigned. Class 3 OEs are reviewed only for quality improvement and are used for HSI designer reference only. OE implementation team performs this classification activity for OEs, and the technical team leaders review and approve the results.

The OE database is updated with the classification of each OE. Figure 4-1 describes the OE classification process.

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Figure 4-1 Operating Experience Classification Process

4.8 Operating Experience Lessons Learned Analysis

Most of the negative OEs include an assessment of the root cause of the experience determined by the organization responsible for the plant or technology involved in the OE. For OEs without an identified root cause implementation team determine an apparent cause based on their technical expertise including technical disciplines other than human factors.

The OE reviewer then develops a lessons learned statement for each OE. For example, if the root cause or apparent cause is operator error that is related to the color coding in the user interface AUTO/MANUAL of a particular motor-controlled valve, the lesson learned statement is worded to provide reasonable assurance that it is applied to the design of the APR1400 wherever color coding in the user interface AUTO/MANUAL is used, including the particular motor-controlled valve, the class of valves (motor operated), and similar types of operation. This method ensures that the lesson learned is applied generically throughout the APR1400 design and implementation process.

Each lesson learned is entered into the OE database so that it can be applied to the HSI design. If a lesson learned is assigned to other HFE program elements, it is also entered into the ITS as an HED. One lesson learned may be coded to apply to one, some, or all of the HFE program elements,

The implementation team documents the lesson learned in the database by providing information in the following fields:

- HSI design artifact involved in the OE (e.g., control room layout, alarm presentation, operating procedure presentation, operator training module)
- Key human factors issues (root causes or apparent cause)
- Method of incorporating in the HFE design process. This field is divided into several subfields to direct where in the HFE design process the lesson learned is to be used.

  Examples of the subfields are:

  - HSI functional requirements
  - Style Guide
  - Procedure modification
  - Training module modification

4.9 Operating Experience Lessons Learned Applied in Design

Many of the lessons learned are applicable to the development of new or modified HSI functional requirements or to the Style Guide. Appendix B provides examples of this type of OE and the options for including lessons learned in the HSI design and development of the HSI design process.

The HFE design team leader reviews and approves the method chosen for applying the OE lessons learned in the HSI and assures, through meetings and independent reviews with the technical disciplines who are developing the HSI design, that an effective design or design changes is implemented. These meetings ensure that all technical disciplines working on the design are aware of the implications of the OE to the respective design activities.

4.10 Important Human Actions

Using the OE database, the OE reviewer identifies OEs that involve actions that are similar to IHAs by identifying scenarios in which human actions are credited for accident mitigation including whether the successful completion of the action is required. These human actions are any actions that the reviewer regards as being needed for accident mitigation and include backup manual actions such as actions taken because of the failure of an automatic system.

The OE reviewer determines from the OE whether there are aspects of the design that ensure or deter success of the human action. OEs that include errors in the execution of the human action are also captured as lessons learned and therefore HEDs. The implementation team provides the OEs to the HFE program TIHA element as HEDs so the OEs may be adequately considered in the HFE design. The HEDs are tracked to resolution in the ITS.

The OE reviewer reviews the list of IHAs developed in the TIHA element and determines where IHAs for the new plant design differ from those of the predecessor plant. The implementation team then identifies whether there is an OE with the different human actions and writes an HED for inclusion in the ITS and tracking purposes.

4.11 Tracking and Verification with Respect to Operating Experience Lessons Learned

The status of each lesson learned is assessed periodically and documented in the OE database. Tracking assures that each lesson learned is included in the HSI design. Tracking is sometimes referred to as verification but should not be confused with the human factors V&V process.

All lessons learned that affect other HFE program elements are entered into the ITS, which allows them to be reviewed and analyzed by the other program element reviewers. These lessons learned are also tracked to completion.

4.12 Documenting the Operating Experience Review - The Operating Experience Database

The HFE design team maintains a database of OEs that includes the following data fields:

- Description of the OE from the source of the OE
- Root cause the organization that determined the root cause, and justification of the root cause
- Design artifact (high level affected area such as the control room layout, alarm presentation, operating procedure presentation, or operator training module)
- Category of the lesson learned (highest category if the OE is grouped)
- Root cause or apparent cause
- Recommended method of incorporating the correction into the HSI design (e.g., change to functional requirements, change to Style Guide, change to operator or maintenance procedures, change to operator or maintenance training), as determined by the HFE design team.
- Lessons learned
- Identification of lessons learned that are appropriate for consideration in the other HFE program elements, other than HSI.

- Date indicating the inclusion of the lesson learned in the HFE design process (e.g., date the functional requirements were modified to include the lesson learned or other method of OE resolution)

The implementation team monitors the design process by conducting an appropriate verification of each step of this IP, by reviewing the APR1400 engineering design documentation for appropriateness and completeness. The documentation resulting from the OER is part of the design bases for the APR1400 design and as such, is entered into the APR1400 engineering design documents.

4.13 Interfaces with Other Human Factors Program Elements

The product of the OER is lessons learned. Lessons learned developed from the OER are input into the ITS as HEDs so that can be used as input into the relevant elements of the HFE design program.

- The OER identifies IHAs that are to be included TIHA program element
- Items that are identified as problematic are input into the HF V&V program element
- The OER identifies items that are directly related to the Style Guide

5 IMPLEMENTATION TEAM

The HFE design team is responsible for reviewing, commenting, and approve the HFE design work. The OER implementation team is composed of systems engineers, I&C engineers, architect engineers, plant operations, and human factors engineers. The qualifications of the implementation team are described in the HFE Program Plan.

As part of these responsibilities, the technical group leaders the HFE design team periodically conduct a technical review of the progress of the HSI design. The review enables the technical disciplines represented on the HFE design team to acquire an understanding of the design decisions that are being made in the other technical disciplines and to assess the impact of the decisions on their own design work. This cross discipline exchange helps to prevent latent design errors that can cause problems in the construction or operation of the APR1400 plant. In the course of such exchanges, the OER is approved by the entire HFE team.

6 RESULTS SUMMARY REPORT

The results of the OER are provided in the OER results summary report (ReSR). The ReSR reiterates the following information, contained in this OER IP:

- Predecessor/related plants and systems
- Review Methodology
- OE sources/documents reviewed

If the processes used to generate the ReSR differ from the information described in the IP, the differences are identified and the rationales for the differences are described in the ReSR.

The ReSR additionally discusses:

- Names and qualifications of all members of the team that performed the OER
- Conduct of the OER and results of reviewing relevant HSI technology
- Findings from interviews with plant personnel and other users
- List of the OEs that are incorporated into the design
- Number and status of the open HEDs that are still being tracked in the ITS. (As shown in Figure 3-1, these items may be appropriate for review in the functional analysis and function allocation (FRA/FA), task analysis (TA), other program elements.)

Appendix B provides a sample of typical results from the OER, and illustrates the format for documenting each OE and its lessons learned.

7 REFERENCES

1. OECD, Halden Reactor Project, “Experimental Evaluation of the Computerized Procedure System,” HWP-277, December 1990.

2. NUREG/CR-6400, “HFE Insights For Advanced Reactors Based Upon Operating Experience,” U.S. Nuclear Regulatory Commission, 1996.

3. EPRI TR-1008122, “Human Factors Guidance for Control Room and Digital Human-System Interface Design and Modification,” Electric Power Research Institute, November 2004.

4. “Hybrid Human-System Interface: Human Factors Considerations,” Brookhaven National Laboratory, December 1996.

5. IAEA-Techdoc-812, “Control Room Systems Design for Nuclear Power Plant,” July 1995.

6. NUREG-0711, “Human Factors Engineering Program Review Model,” Rev.3, U.S. Nuclear Regulatory Commission, November 2012.

7. 10 CFR 52.47(a)(21), “Contents of Applications; Technical Information.” U.S. Nuclear Regulatory Commission.

8. NUREG-0933, “Resolution of Generic Safety Issues,” Rev. 34, U.S. Nuclear Regulatory Commission, September 2011.

9. NUREG-1275, "Operating Experience Feedback Report," U.S. Nuclear Regulatory Commission, November 2000.

8 DEFINITIONS

Apparent cause The most probable cause of a problem based on readily available information.

At power Those plant operating states characterized by the reactor being critical and producing power, with automatic actuation of critical safety systems not blocked and with essential support systems aligned in their normal power operation configuration.

Operating experience review A systematic review, analysis and evaluation of OE with the purpose of learning from others experiences and apply the learning to the HSI design and the other human factors program elements.

APPENDIX A NUREG-0711 REV. 3 CONFORMANCE TABLE

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
3.4 Review Criteria 3.4.1 Scope (1) *Predecessor/Related Plants and Systems* – The applicant's OER should include information about human factors issues in the predecessor plant(s) or highly similar plants, systems, and HSIs, including the following:	3.0 Methodology Overview including the three bulleted items.
• The OER should identify previous or predecessor design(s)/plant(s) used as part of the design basis of the plant being reviewed.	3.0 Methodology Overview 4.1 Internationally Sourced Operating Experience Data Collection 4.2 United States Sourced Operating Experience Data Collection 4.3 Operator Interviews as a Source of Operating Experience
• The OER should define the relevance of each predecessor plant/design to the new design, when there is more than one predecessor.	3.0 Methodology Overview
• 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.	4.0 Implementation
• The OER should address how the applicant identified, evaluated, and incorporated or retained any positive features of previous plants/designs.	4.3 Operator Interviews as a Source of Operating Experience 4.8 Operating Experience Lessons Learned Analysis
• The OER should describe the predecessor plant(s) and systems, explaining the relationship of each to the new design.	3.0 Methodology Overview
• For applicants proposing to use new technology or systems that were not used in the predecessor plants, the OER should review and describe the operating experience of any other facilities that already use that technology.	4.1 Internationally Sourced Operating Experience Data Collection 4.2 United States Sourced Operating Experience Data Collection 4.3 Operator Interviews as a Source of Operating Experience 4.4 Non-nuclear Sources of Operating Experience 4.5 The Process of Screening Operating Experience for Applicability
(2) *Recognized Industry HFE Issues* – The applicant should address the HFE issues	4.2 United States Sourced Operating Experience Data Collection

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
identified in NUREG/CR-6400. The issues are organized into the following categories:	
• unresolved safety issues/generic safety issues (See 10 CFR 52.47(a)(21) and NUREG-0933)	4.2 United States Sourced Operating Experience Data Collection 4.6 Grouping Operating Experience
• TMI issues	4.2 United States Sourced Operating Experience Data Collection 4.6 Grouping Operating Experience
• NRC generic letters and information notices	4.2 United States Sourced Operating Experience Data Collection 4.6 Grouping Operating Experience
• operating experience reports in the NUREG-1275 series, Vol. 1 through 14	4.2 United States Sourced Operating Experience Data Collection 4.6 Grouping Operating Experience
• low power and shut down operations	4.2 United States Sourced Operating Experience Data Collection 4.6 Grouping Operating Experience
• operating plant event reports	4.2 United States Sourced Operating Experience Data Collection 4.6 Grouping Operating Experience
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.	4.5 The Process of Screening Operating Experience for Applicability
(3) Related HSI Technology – The applicant's OER should cover operating experience with the proposed HSI technology in the applicant's design. Additional Information: For example, if a computer operated support system, a computerized procedures system, or advanced automation are planned to be used, the OER should describe the HFE issues associated with using them.	4.2 United States Sourced Operating Experience Data Collection 4.3 Operator Interviews as a Source of Operating Experience 4.4 Non-nuclear Sources of Operating Experience 4.5 The Process of Screening Operating Experience for Applicability
(4) Issues Identified by Plant Personnel – The applicant's OER should discuss issues identified through interviews with plant personnel based on their operating experience with plants or systems applicable to the new design. As a minimum, the interviews should include the following topics:	4.3 Operator Interviews as a Source of Operating Experience
Plant Operations - normal plant evolutions (e.g., startup, full power, and shutdown)	4.3 Operator Interviews as a Source of Operating Experience 4.6 Grouping Operating Experience

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
- failure modes and degraded conditions of the I&C systems, including, but not limited to, the sensor, monitoring, automation and control, and communications subsystems. These include, for example, the safety-related system logic and control unit, fault tolerant controller (nuclear steam supply system), the local "field unit" for the multiplexer (MUX) system, the MUX controller (balance-of-plant), and a break in the MUX line failure modes	4.3 Operator Interviews as a Source of Operating Experience
- degraded conditions of the HSI resources (e.g., losses of video display units, of data processing, and of large overview display)	4.3 Operator Interviews as a Source Of Operating Experience
- transients (e.g., turbine trip, loss of offsite power, station blackout, loss of all feedwater, loss of service water, loss of power to selected buses or MCR power supplies, and safety/relief valve transients)	4.3 Operator Interviews as a Source Of Operating Experience
- accidents (e.g., main steam line break, positive reactivity addition, control rod insertion at power, control rod ejection, anticipated transients without scram, and various-sized loss-of-coolant accidents)	4.3 Operator Interviews as a Source of Operating Experience
- reactor shutdown and cooldown using the remote shutdown system	4.3 Operator Interviews as a Source of Operating Experience
HFE Design Topics - alarms and annunciation - displays - controls and automation - information processing and job aids - real-time communications with plant personnel and other organizations - procedures, training, staffing/qualifications, and job design	4.3 Operator Interviews as a Source Of Operating Experience

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
(5) Important Human Actions – The applicant's OER should identify important HAs in the predecessor plants or systems (Section 7 defines important HAs), and determine whether they remain important in the applicant's design. Additional considerations cover the following: • For the important HAs, the OER should identify the scenarios wherein actions are needed, and state whether they were needed and successfully completed. Those aspects of the design that helped ensure success should be identified. • If errors occurred in the execution of the HAs, the applicant should identify insights to the needed improvements in human performance. • When important HAs for the new plant are determined to differ from those of the predecessor plant, the OER should specify whether there is any operational experience with these different HAs.	4.10 Important Human Actions
3.4.2 Issue Analysis, Tracking, and Review	
(1) OER Process – The applicant should discuss the administrative procedures for evaluating the operating, design, and construction experience, and for ensuring that applicable important industry experiences will be provided in a timely manner to those designing and constructing the plant.	4.0. Implementation 5.0 Implementation Team Admin procedures are available for audit by KHNP.
Additional Information: 10 CFR 50.34(f)(3)(i) requires these administrative procedures.	Admin procedures are available for audit by KHNP.
(2) Analysis Content – The applicant should analyze issues to identify: • human performance issues and sources of human error	4.5 The Process of Screening Operating Experience for Applicability
• design elements supporting and enhancing human performance	4.3 Operator interviews as a source of Operating Experience 4.5 The Process of Screening Operating Experience for Applicability 4.6 Grouping Operating Experience 4.7 Classifying Operating Experience 4.8 Operating Experience Lessons Learned Analysis 4.9 Operating Experience Lessons Learned Applied in Design

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
(3) Documentation – The applicant should document the analysis of operating experience.	4.5 The Process of Screening Operating Experience for Applicability 4.7 Classifying Operating Experience 4.11 Tracking and Verification with respect to Operating Experience Lessons Learned 4.12 Documenting the OER - The Operating Experience Database 4.13 Interfaces with Other Human Factors Program Elements
(4) Incorporation Into the Tracking System – The applicant should document each issue determined to be relevant to the design, but yet to be addressed, in the issue-tracking system (see Section 2.4.4).	4.8 Operating Experience Lessons Learned Analysis 4.11 Tracking and Verification with respect to Operating Experience Lessons Learned
3.4.3 Plant Modifications	
(1) Additional Considerations for Reviewing the HFE Aspects of Plant Modifications – In addition to any of the criteria above that relate to the modification being reviewed, the applicant should address the following considerations:	N/A
The focus of the scope of the applicant's OER should provide information on the plant's systems, HSIs, procedures, or training that are being modified.	N/A
The applicant's OER should account for the operating experience of the plant that will be modified, including experiences with the systems that will be changed, and with technologies similar to those being considered.	N/A
Additional Information: Useful information may be found in the plant's corrective action program.	N/A

APPENDIX B A SAMPLE OF THE OER ISSUES ASSOCIATED WITH THE APR1400 HSI DESIGN

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