US-APWR

Operating Experience Review Implementation Plan

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Abstract

This document provides the operating experience review (OER) implementation plan (IP) for the US Advanced Pressurized-Water Reactor (US-APWR). The OER program element identifies and evaluates human factors engineering (HFE) issues from previous nuclear power plants that are applicable to the US-APWR, and HFE issues from other process industries related to the advanced digital human-system interface (HSI) technology that is employed in the US-APWR.

These HFE issues in OER are evaluated to ensure they are addressed in the US-Basic HSI system (HSIS) or the US-APWR plant design, including the US-APWR HSI inventory, and US-APWR HFE process. The evaluation is based on the US-Basic HSIS and the US-APWR plant design, including US-APWR HSI inventory and US-APWR HFE process, known at the time of the OER, based on the design and process descriptions identified in the US-Basic HSIS and US-APWR documentation. OER generates human engineering discrepancies (HEDs) for any HFE issues that are not adequately addressed.

To identify HFE issues, the OER implementation team reviews industry databases, U.S. Nuclear Regulatory Commission publications, the use of digital HSI technologies in databases from other non-nuclear industries, and issues identified by predecessor nuclear plant personnel. HFE issues applicable to the US-APWR are extracted into the US-APWR OER database for further evaluation.

The human reliability analysis (HRA) program element identifies the risk-important human actions (RIHAs) extracted from the US-APWR probabilistic risk assessment (PRA) and the deterministically important human actions (DIHAs) extracted from the US-APWR transient and accident analysis (TAA) and the diversity and defense-in-depth coping analysis (D3CA); these are collectively referred to as important human actions (IHAs). The OER program element identifies actions similar to the IHAs from the OER database, and then ensures the PRA, TAA and D3CA have adequately considered the HFE issues and the US-APWR resolution of those issues.

This IP also describes the requirements for documenting the results of the OER in a results summary report (ReSR). The OER results documented in the ReSR are used in the plant design and in other HFE program elements. The ReSR also demonstrates that the OER was conducted in accordance with this IP, which is a closure requirement for the associated inspections, tests, analyses, and acceptance criteria (ITAAC).

This OER IP also provides brief descriptions of how the HFE issues from OER are addressed in functional requirements analysis and function allocation (FRA/FA), task analysis (TA), staffing and qualifications analysis (S&Q), human-systems interface design (HD) and human factors verification and validation (V&V). These descriptions are provided for completeness only. These activities are part of other HFE program elements, therefore they are not included in the OER ReSR and they are not required for OER ITAAC closure.

Table of Contents

List of Tables ii
Acronyms iii

1.0 PURPOSE 1
2.0 SCOPE 2
3.0 METHODOLOGY OVERVIEW 4
4.0 METHODOLOGY 6
4.1 Sources of Data 6
4.1.1 Predecessor/Related Plants and Systems 6
4.1.2 Recognized Industry Human Factors Engineering Issues from NUREGs 7
4.1.3 Related Human Factors Engineering Technology 8
4.1.4 Issues Identified by Plant Personnel 9
4.2 Issue Extraction, Analysis, Documentation, and Review 11
4.2.1 Extraction and Analysis Process 11
4.2.2 Extraction and Analysis Documentation 12
4.2.3 Important Human Actions 14
4.2.4 OER Results Review Process 15
5.0 IMPLEMENTATION TEAM 17
6.0 RESULTS SUMMARY REPORT CONTENT 18
7.0 NUREG-0711 COMPLIANCE EVALUATION 19
8.0 REFERENCES 21

List of Tables

Table 4-1 Format of OER Issues and Resolutions List Table 12
Table 4-2 Format of HEDs Generated through the OER 13
Table 4-3 Numbering Scheme of OER Information Sources (Nuclear Industries) 14
Table 4-4 Numbering Scheme of OER Information Sources (Non-Nuclear Industries) 14
Table 5-1 OER Implementation Summary 17
Table 7-1 Compliance with NUREG-0711 19

Acronyms

ADAMS	Agencywide Documents Access and Management System
APWR	advanced pressurized-water reactor
ATWS	anticipated transient without scram
BWR	boiling-water reactor
CR	control room
D3CA	diversity and defense-in-depth coping analysis
DCD	Design Control Document
DIHA	deterministically important human action
DTM	design team manager
FA	function allocation
FRA	functional requirements analysis
GSI	Generic Safety Issue
HA	human action
HD	human-system interface design
HED	human engineering discrepancy
HFE	human factors engineering
HFEPMP	human factors engineering program management plan
HRA	human reliability analysis
HSI	human-system interface
HSIS	human-system interface system
I&C	instrumentation and control
ID	identifier
IHA	important human action
IN	Information Notice
INPO	Institute of Nuclear Power Operations
IP	implementation plan
ITAAC	inspections, tests, analyses, and acceptance criteria
LER	licensee event report
LOCA	loss-of-coolant accident
MHI	Mitsubishi Heavy Industries
MUX	multiplexer
NRC	U.S. Nuclear Regulatory Commission
NUCIA	Nuclear Information Archives
OE	operating experience
OER	operating experience review
PRA	probabilistic risk assessment
PWR	pressurized-water reactor
RIHAs	risk-important human actions
ReSR	results summary report
S&Q	staffing and qualifications analysis
SER	significant event report

SME	subject matter expert
SOER	significant operating experience report
TA	task analysis
TAA	transient accident analysis
TMI	Three Mile Island
US, U.S.	United States
US-APWR	US Advanced Pressurized-Water Reactor
V&V	verification and validation
VDU	visual display unit

1.0 PURPOSE

This document provides the operating experience review (OER) implementation plan (IP) for the US Advanced Pressurized-Water Reactor (US-APWR). This IP conforms to the OER guidance in NUREG-0711, Revision 2, "Human Factors Engineering Program Review Model," issued February 2004 (Reference 8-1).

The objective of the OER is to identify and evaluate human factors engineering (HFE)-related problems and issues encountered in previous nuclear plant designs, so that the negative features are not repeated and positive features are retained. Because the nuclear industry lacks significant experience with the modern human-system interface (HSI) technology used in the US-APWR, the OER also encompasses the use of similar digital HSI technologies from other process industries.

This program element uses the following inputs to evaluate the applicability of operating experience (OE) to the US-APWR, and to assess if the identified HFE issues are adequately resolved by the current US-APWR designs and processes:

- US-Basic HSI system (HSIS) design documentation
- US-APWR plant design documentation
- US-APWR HFE program documentation

The human reliability analysis (HRA) program element identifies important human actions (IHAs). The OER program element identifies actions similar to the IHAs from the historical HFE issues, and then ensures the probabilistic risk assessment (PRA), transient accident analysis (TAA) and diversity and defense-in-depth coping analysis (D3CA) have adequately considered the HFE issues and the US-APWR resolution of those issues.

The OER program element results are used by the following HFE program elements to ensure the OE is adequately captured in the US-Basic HSIS, US-APWR HSIS, and US-APWR plant design or US-APWR HFE program, as may be applicable:

- Functional Requirements Analysis and Function Allocation (FRA/FA)
- HRA
- Task Analysis (TA)
- Staffing and Qualifications Analysis (S&Q)
- HSI Design (HD)
- Human Factors Verification and Validation (V&V)

2.0 SCOPE

The scope of HFE OER encompasses the following HFE issue topics:

- Predecessor plants, including plants that employ Mitsubishi digital instrumentation and control (I&C) or HSI technology
- Highly related plants and plant systems
- Recognized industry HFE issues
- Related HFE technology
- Issues identified by plant personnel
- IHAs
- Issues related to plant operations and maintenance

The US-APWR plant design is based on conventional pressurized-water reactor (PWR) designs. The OER includes the evaluation of known HFE-related problems in conventional nuclear plants in the United States and Japan. HFE issues related to the HSIS, maintenance or testing activities are not dependent on the reactor type and can be treated as common HFE issues in nuclear power plants. Therefore, the OER issue collection scope encompasses both PWRs and boiling-water reactors (BWRs).

The OE from the commercial nuclear power industry is evaluated through the following data sources:

- Japanese nuclear power plants – Nuclear Information Archives (NUCIA) database (Reference 8-2)

- US nuclear plants

  - Institute of Nuclear Power Operations (INPO) database as specified in Section 4.1.1.2 (Reference 8-3)

  - NUREG/CR-6400, “Human Factors Engineering (HFE) Insights for Advanced Reactors Based upon Operating Experience,” issued December 1996 (Reference 8-4)

These data sources are selected because they represent a comprehensive collection of nuclear industry problems that have high potential for applicability to the US-APWR. The review of these sources supports the identification of HFE issues related to human performance, as well as issues related to advanced HSI technology. These data sources identify human performance problems related to numerous personnel actions. Some of which are expected to be related to the IHAs that are identified for the US-APWR in the HRA program element. IHAs encompass the risk-important human actions (RIHAs) from the US-APWR PRA and the deterministically important human actions (DIHAs) from the TAA and the D3CA. The interface between the OER and HRA program elements is described in Section 3.0.

The evaluation of nuclear plant OE also includes HFE issues identified by nuclear plant personnel. These issues were identified through interviews conducted with plant operators during the US-APWR Phase 1 “US-Basic Human-System Interface System Verification and Validation (Phase 1),” MUAP-08014 (Reference 8-5).

The OER also evaluates HFE-related problems in non-nuclear industrial applications that use digital screen-based HSI technology (similar to the US-Basic HSIS); this evaluation is limited to HFE-related problems with the HSI. As a minimum, the following sources are included in the scope of the OER evaluation:

- 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 (Reference 8-6)

These data sources are selected because they represent a broad sampling of industries that employ digital HSI technology.

3.0 METHODOLOGY OVERVIEW

The OER is implemented as follows:

(1) Identify nuclear and non-nuclear sources of OE information to be evaluated.

(2) Review the collected OE information to identify HFE issues.

(3) Evaluate each HFE issue to determine whether the issue is applicable to the US-APWR, and resolved by the US-Basic HSIS or by the US-APWR (plant design, HSI inventory, or HFE process).

(4) If the HFE issue is within the scope of the US-Basic HSIS but is not adequately resolved by the US-Basic HSIS, a human engineering discrepancy (HED) is created. New HEDs are not created in OER if the issue is already addressed by an HED from the Phase 1 testing of the US-Basic HSIS, MUAP-08014 (Reference 8-5).

(5) If the HFE issue is outside the scope of the US-Basic HSIS but within the scope of the US-APWR and is not already in the process of being resolved by the US-APWR design or HFE process, an HED is created. New HEDs are not created in OER if the issue is already addressed by an HED applicable to the US-APWR from the Phase 1 testing of the US-Basic HSIS, MUAP-08014 (Reference 8-5).

(6) Examine OER issues related to the IHAs identified in the HRA. Confirm that the PRA, TAA and D3CA have adequately considered the potential for human performance errors, including problematic operations and tasks, for human actions (HAs) from predecessor plants that are similar to the US-APWR IHAs. This confirmation considers the resolutions and HEDs described in items 3, 4 and 5, above.

After completion of the OER program element, HEDs are resolved according to the HED resolution process as described in technical report MUAP-09019, “US-APWR Human Factors Engineering Program Management Plan” (Reference 8-7) (hereafter referred to as the “HFEPMP”). The HEDs are categorized by their applicability to subsequent HFE program elements or HSI display elements (see Section 4.2.2.2). The HEDs are then evaluated and resolved within the applicable subsequent HFE program element; they are not resolved within the OER program element

The evaluations in items (3), (4) and (5) above are based on the US-Basic HSIS, US-APWR plant design, US-APWR HSI inventory, and US-APWR HFE process known at the time of the OER implementation. This “known” design is based on the design descriptions and HSI inventory identified in the US-Basic HSIS and the US-APWR plant design documentation. The “known” process refers to the US-APWR HFE program documentation for subsequent HFE program elements after OER. Subsequent HFE program elements reexamine the OER results to confirm that the conclusions about the adequacy of the US-Basic HSIS or US-APWR plant design remain consistent with any evolution that may occur in these designs.

The OER results are evaluated in subsequent HFE program elements as follows:

- FRA/FA: Examine OER issues related to the critical functions or success paths

identified in FRA/FA, including the bases for initial requirements and allocations. Confirm that the OER-identified issue is adequately addressed by the US-APWR FA results from FRA/FA. Resolve any OER HEDs specific to FRA/FA.

- TA: Examine OER issues related to the task complexities, constraints, or performance-shaping factors considered in TA. Confirm that the TA has adequately considered these task characterizations. Resolve any OER HEDs specific to TA.

- S&Q: Examine OER issues related to licensed operator or non-licensed operator staffing positions. Confirm that the OER issue is adequately addressed despite any changes in staffing for the US-APWR from current operating plants. Resolve any OER HEDs specific to S&Q.

- HD: Examine OER issues related to HSI technology. Confirm that the OER issue is adequately addressed despite any changes in the US-Basic HSIS. Resolve any OER HEDs specific to HD.

- V&V: Examine OER issues related to plant operators or interfaces with plant operators. Confirm that the OER issue is adequately addressed in the V&V program element, to the extent practicable. This includes selection of tasks, scenarios, and performance measures. Resolve any OER HEDs specific to V&V.

The HFEPMP (Reference 8-7) describes the overall management of the US-APWR HFE program.

The OER methodology complies with NUREG-0711, Revision 2, as demonstrated in Section 7.0.

4.0 METHODOLOGY

The detailed methodology for performing and documenting the HFE OER is described in this section. Section 4.1 describes the OER process applied to obtain HFE issues from documented industry data sources, plant personnel interviews, and IHAs. Section 4.2 describes issue extraction, evaluation, documentation, and review.

4.1 Sources of Data

The OER implementation team, as described in Section 4.2.1, collects HFE issues according to the scope of industry data sources defined in Section 2.0.

Sections 4.1.1 to 4.1.3 describe the methods used to search industry databases to identify events that may be caused by HFE issues. After each search, the OER implementation team reads the abstract or main text of each event report and extracts only the event reports that identify HFE issues (this review eliminates non-HFE issues). Section 4.1.4 describes the method used to collect issues identified by plant personnel, and Section 4.1.5 describes the method used to identify IHAs.

4.1.1 Predecessor/Related Plants and Systems

The OER implementation team collects information pertaining to the HFE issues related to predecessor plants or highly similar plants and plant systems.

4.1.1.1 NUCIA Database

The HFE-related OE issues for Japanese nuclear power plants are obtained from the NUCIA database. In the NUCIA database, HFE-related OE issues are classified in three categories (event, qualification/maintenance, other). Issues are further classified in relation to their cause (e.g., age deterioration, defects from maintenance, personnel error). A search engine is available that allows search conditions, such as reactor type, information classification, and keyword. The search engine allows search refinement within the search results. The OER implementation team uses this search engine to easily and completely extract HFE-related issues from predecessor Japanese plants.

The OER implementation team enters the following search conditions into the NUCIA search engine to collect relevant OE event reports:

- Reactor type
  - PWR and BWR
- Information classification
  - Event, Qualification/Maintenance
- Keyword
  - Human Error
- Search refinement
  - No setting

4.1.1.2 INPO Database

The HFE-related OE issues for U.S. nuclear power plants are obtained from the INPO OE database. The scope of the OER implementation covers the following INPO OE data sources:

- Licensee event reports (LERs)
- Significant event reports (SERs)
- Significant operating experience reports (SOERs)

In the INPO database, HFE-related OE issues are classified in three categories (event, qualification /maintenance, other). Issues are further classified in relation to their cause (e.g., age deterioration, defects from maintenance, human error). A search engine is available that allows search conditions, such as reactor type, information classification, and keyword. The search engine allows search refinement within search results. The OER implementation team uses this search engine to extract HFE-related issues from predecessor U.S. plants.

The OER implementation team enters the following search conditions into the INPO members' Web site (Reference 8-3) and collects relevant event reports:

- Reactor type
  - PWR and BWR
- Information classification
  - Event, Qualification/Maintenance
- Keyword
  - Human Error
- Search refinement
  - No setting

4.1.2 Recognized Industry Human Factors Engineering Issues from NUREGs

Recognized industry HFE issues are identified from NUREG/CR-6400 (Reference 8-4). These issues are categorized in NUREG/CR-6400 as follows:

- Unresolved safety issues/Generic Safety Issues (GSIs)
- Three Mile Island (TMI) issues
- U.S. Nuclear Regulatory Commission (NRC) generic letters and information notices
- Report of the former NRC office for analysis and evaluation of operational data
- Low-power and shutdown operations
- Operating plant event reports
- HFE-related problems and issues in non-nuclear industries

As NUREG/CR-6400 only provides a brief summary description for each of the issues, the OER implementation team collects detailed information on each of the events in the above categories from the following documents and databases.

- Unresolved safety issue information – NUREG-0933, "Resolution of Generic Safety Issues," issued December 2011, Section 2 (Reference 8-8)

- GSI information – NUREG-0933, Section 3 (Reference 8-8)

- TMI issues information – NUREG-0933, Section 1 (Reference 8-8)

- NRC generic letters – searches in the NRC's Agencywide Documents Access and Management System (ADAMS)

- NRC information notices – ADAMS searches

- Low-power and shutdown operations – NUREG-1449, "Shutdown and Low-Power Operation at Commercial Nuclear Power Plants in the United States," issued September 1993 (Reference 8-9)

Information notices, such as 95-48 and 97-78, which are specified in NUREG-0711 section 6, are also evaluated in this category.

4.1.3 Related Human Factors Engineering Technology

The following HFE technologies are applied to the US-APWR HSIS or the US-APWR local control stations:

- touch screen interface
- large-screen displays
- computerized procedures
- conventional controls
  - indicators
  - control switches
  - status/alarm tiles

Because these technologies are applied to not only the nuclear industry but also other industries, HFE issues from non-nuclear industries are also collected. HFE-related issues are obtained from following sources:

- 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 (Reference 8-6)

These databases provide event reports by chronological-order list and have no categorization or related search functions. The OER implementation team identifies events with potential HFE issues by conducting a full-text search of the abstract or main text with the following keywords:

- Indication

- Display
- Monitoring
- Screen
- Control
- Switch
- Operate (operation, operator, operating)
- Procedure
- Alarm
- Awareness
- Overload
- Timely action

4.1.4 Issues Identified by Plant Personnel

During the US-Basic HSIS Phase 1 V&V program, U.S. plant operators (13 crews, 32 operators in all) evaluated the Japanese-Basic HSIS (the starting point for the US-Basic HSIS) through scenarios reflecting the following plant conditions:

- Normal plant evolutions (e.g., startup, full power, shutdown)

- Instrument failures (e.g., safety-related system logic and control unit, fault-tolerant controller (nuclear steam supply system), local “field unit” for multiplexer (MUX) system, MUX controller (balance of plant), break in MUX line)

- HSI equipment and processing failure (e.g., loss of video display units, loss of data processing, loss of large display panel)

- 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 control room (CR) power supplies, safety/relief valve transients)

- Accidents (e.g., main steamline break, positive reactivity addition, control rod insertion at power, control rod ejection, anticipated transients without scram (ATWSs), various-sized loss-of-coolant accidents (LOCAs))

After these scenarios, the operators were interviewed by the US-APWR HFE team to assess the Japanese-Basic HSIS from a perspective that reflects their OE with similar scenarios at their own plants. The following topics were addressed in these interviews;

- Plant operations
  - Normal plant operations (startup, full power, shutdown)
  - Instrument failures
  - HSI equipment and processing failures
  - Transients
  - Accidents
  - Reactor shutdown and cooldown using remote shutdown system

- HD topics
  - Alarm annunciation

- Display (operational visual display unit (VDU), alarm VDU, large display panel)
- Control and automation
- Information processing and job aids
- Real-time communications with plant personnel and other organizations
- Procedure, training, staffing/qualifications, and job design

Interview results are documented in HFE technical report MUAP-08014, Revision 2 (Reference 8-5), as follows:

> MUAP-08014 Part 1 Section 3.9.6 describes the operator interview process conducted during Phase 1a, which included pre-engineered questionnaires which encompassed areas critical to human performance such as situation awareness, crew coordination, workload and error potential and recovery. In addition, the interview process included unstructured debriefs where operators could discuss any performance problems that arose and any issues that operators felt contributed to performance difficulties. A final interview was conducted with each operating crew which systematically went through each of the major topic areas covered in the final questionnaire to elicit more background information on the sources of operator concerns. Part 1 Sections 3.10.3 and 3.10.4 explain how the data obtained from these operator interviews was analyzed, including the use of video tape for all interviews. Part 1 Sections 3.13.2 and 3.13.3 summarize the interview results.
>
> MUAP-08014 Part 2 Section 4.2 describes the operator interview process conducted during Phase 1b. Phase 1b was conducted to test the resolutions for many of the HEDs that were generated during Phase 1a and to test HSI elements of the US-Basic HSIS that were not available for testing in Phase 1a. As in Phase 1a, Phase 1b included subjective operator feedback collected via questionnaires and verbal debrief sessions. Following each test scenario operators filled out a short questionnaire followed by a 15 to 30 minute verbal debrief where the operators were given the opportunity to mention any problems of particular concern. At the completion of all test scenarios, participants were given a final written feedback questionnaire. Operators took approximately an hour to an hour and a half to fill out this questionnaire. Following the written final feedback questionnaire, a final verbal debrief session was conducted where operators were provided the opportunity to explain and discuss the HEDs they identified. This final verbal debrief took approximately one hour. All sessions were videotaped and the video tapes reviewed as in the Phase 1a tests. The operator feedback results are provided in Part 2 Section 5.1.

The personnel interviews described above were conducted as part of the evaluation of the Japanese-Basic HSIS for the development of the US-Basic HSIS. Operator feedback from these interviews reflected their OE as it applied to their evaluation of the HSI during dynamic simulations of a broad sampling of plant scenarios for both normal and abnormal conditions. Where the Japanese-Basic HSIS design did not address the concerns expressed by U.S. operators, HEDs were identified by the HFE team and incorporated into the HFE issues tracking system. Operators were also encouraged to write their own HEDs. All HEDs are evaluated by the HFE team for their applicability to the US-Basic HSIS, the US-APWR HSI inventory, or the plant design. The resolution process for all HEDs is described in the HFEPMP.

The US plant personnel (i.e., reactor operators and senior reactor operators) who contributed to the development of the US-Basis HSIS, as described above, based their evaluations and the issues they identified on their personal OE. Since the interview process and results are fully documented in MUAP-08014, Revision 2 (Reference 8-5), this portion of the OER IP has been completed. Therefore, there is no additional documentation for issues identified by plant personnel" in the OER results summary report (ReSR).

4.2 Issue Extraction, Analysis, Documentation, and Review

4.2.1 Extraction and Analysis Process

The events that are extracted from the information sources identified in Sections 4.1.1, 4.1.2, and 4.1.3 and are captured in the OER database include events with human performance issues, as well as events that identify problems with HSI elements that support human performance. In the analysis described in this section, the HSI/I&C and HFE subject matter experts (SMEs) extract these events and evaluate them for applicability to the US-APWR design. These SMEs are all members of the HSI design team and are collectively referred to as the OER implementation team.

The information sources are divided among the OER implementation team such that each event is evaluated by one member of the OER implementation team. OER implementation team members read the event report and make their own evaluation based on their own judgment. Any event considered outside the expertise of a specific SME (by their own judgment) is given to a more appropriate SME for evaluation. Because the OER is conducted by members of the HSI design team, the Design Team Manager (DTM) oversees this event exchange. The DTM assigns other SMEs if a unique event is identified that is outside the expertise of the original SMEs.

For each event, the evaluator does the following:

(1) Determines whether the human performance issues, problems, and sources of human error are related to HFE (plant design, HSI inventory, or HFE process). If yes, the issue is captured in the OER database (unrelated issues are not captured in the OER database).

(2) Identifies US-Basic HSIS design features, US-APWR design features (HSI inventory or plant design) that support and enhance human performance, or US-APWR HFE processes that address the HFE issue. Also assesses procedures and training. Captures this evaluation in the OER database.

(3) If the issue is not addressed in the current design, generates an HED. Associates the HED with the US-Basic HSIS if the issue is applicable to the generic methods of alarm, indication, control, or computerized procedures. Otherwise, associates the issue with the US-APWR HSI inventory, plant design, or HFE process, as appropriate. Captures this HED in the OER database to allow tracking to closure in subsequent HFE program elements.

4.2.2 Extraction and Analysis Documentation

The extraction and analysis process described above is documented in two key products:

- OER Issues and Resolutions List
- HED list generated from OER

The HFE design aspects incorporated into the US-APWR design from previous or predecessor plant designs are clearly identified in these lists. Each of the lists is initiated and maintained electronically.

Collectively, these lists make up the OER database. The OER database is maintained in a specific location accessible to all HFE team members. The OER database is also included in the OER ReSR.

4.2.2.1 OER Issues and Resolutions List

The “OER Issues and Resolutions List,” presented in table form, contains the following columns (for the table template, refer to Table 4-1):

- No. – Sequential number
- Item – ID number of each HFE-related OE issue (defined in Section 4.2.3, based on the data source)
- Issue/Scope – Event report issue category determined by the SME from the detailed description of the issue.
- HFE Aspect of Issue – Human performance issues, problems, and sources of human error determined by the SME from the detailed description of the issue.
- HFE Issue Addressed by US-Basic HSI System or US-APWR – Results of the applicability evaluation of the HFE aspect of the issue to the US-APWR design are shown, with an explanation of the design feature(s) that resolves the issue. If the current design does not resolve the issue, HEDs are identified in this column, along with their description and recommended resolution, and applicability to the US-Basic HSIS or US-APWR (HSI inventory, plant design, or HFE process).

Table 4-1 Format of OER Issues and Resolutions List Table

No.	Item	Issue/Scope	HFE Aspect of Issue	HFE Issue addressed by US-Basic HSI System or US-APWR

4.2.2.2 HEDs Generated through Operating Experience Review

This table provides a summary of the HEDs from the OER Issues and Resolutions List described in Section 4.2.2.1. The table includes the following columns (for the table template, refer to Table 4-2):

- Category – HFE/HSI design components related to the HED (e.g., displays, alarms).
- HED Summary Description – First, the HED applicability to the US-Basic HSIS or US-APWR is identified. Then each of the HEDs within each Category (from above) is consecutively numbered, and the description is extracted from the OER Issues and Resolutions List.

Table 4-2 Format of HEDs Generated through the OER

Category	HED Summary Description
HFE/HSI Component	Applicability Consecutive Number Description

4.2.2.3 Issue Numbering

This section defines the numbering rules for the HFE-related OE issues that are collected into the OER Issues and Resolutions List described in Section 4.2.2.1. All collected issues are numbered with unique identifiers (IDs). Table 4-3 and Table 4-4 show the numbering method for nuclear industry and non-nuclear industry data sources, respectively.

Table 4-3 shows the source document/database citation and the format of the unique ID number used in the OER database for each event. In most cases, the ID number used in the OER database is the same as that used in the source database. However, since events from NUREG-1275, “Operating Experience Feedback Report – Human Performance in Operating Events,” Vol. 8, issued December 1992 (Reference 8-10), NUREG-1449 (Reference 8-9), and Section 7 of NUREG/CR-6400 (Reference 8-4) do not have an original ID number in their data source, unique IDs are given to each issue in the OER database according to the numbering rule.

Because events from the online databases identified in Section 4.1.3 also don’t have an original ID number in their data source, the ID number of each issue is defined as shown in Table 4-4 (e.g., if the issue database category ID of the chemical plant is “CP” and the event report ID of CSB Report 2003-13-I-LA is “A,” then the ID number of this issues should be “CP-A-N,” with *N* being a consecutive letter for the HFE events extracted from each evaluated report.).

Table 4-3 Numbering Scheme of OER Information Sources (Nuclear Industries)

Source Document/ Database Citation	OER Database ID (X)
Unresolved safety issues	A-N, B-N
GSIs	GI-N
TMI issues	1v, 1vi, 2x, 2xi, etc.
Generic letter and information notices	Generic Letter N, Information Notice N
Report of the former NRC Office for Analysis and Evaluation of Operational Data	NUREG-1275, Vol. N
Low-power and shutdown operations	NUREG-1449
Operating plant event reports	Operating plant event reports
INPO information	INPO N, MR N, ORE N, LER N
NUCIA database	N-(utility name)-N

Note: *N* is a consecutive letter for the HFE events extracted from each evaluated report.

Table 4-4 Numbering Scheme of OER Information Sources (Non-Nuclear Industries)

Source Document/ Database Citation	ID Number
Chemical Plants	CP-X-N
Nuclear Processing	NP-X-N
Marine Events	M-X-N
Railroad Events	RR-X-N
Aircraft Events	AC-X-N
Electrical Transmission	ET-X-N
Pipeline Events	PL-X-N
Japanese industries	J-N

Note: *X* is a specific alpha-numeric ID of the event report. *N* is a consecutive letter for the HFE events extracted from each evaluated report.

4.2.3 Important Human Actions

The HRA program element identifies the RIHAs extracted from the US-APWR PRA and the DIHAs extracted from the US-APWR TAA and D3CA; these are collectively referred to as IHAs. The OER program element identifies actions similar to the IHAs from the OER database, and then ensures the PRA, TAA and D3CA have adequately considered the HFE issues, the US-APWR resolution of those issues, and any HEDs.

The OER confirms that the PRA has adequately considered the potential for human performance errors, based on the experience documented in the OER. For any events documented in the OER that are related to US-APWR RIHAs, the OER evaluates the human performance characteristics of that event, such as operator staffing, action complexity, and HD, to ensure the problems identified in the OER are accurately reflected in the probability of US-APWR human performance errors. Similarly, the OER confirms that the time required to execute the DIHAs identified in the TAA or D3CA reflects the human performance issues for any events documented in the OER that are related to US-APWR DIHAs.

For each US-APWR this analysis documents the following:

(1) US-APWR IHA description: This includes a unique identifier that correlates directly to the IHA list from HRA, and identification of this IHA as a RIHA or DIHA

(2) Related OER action description: This includes a unique identifier that correlates directly to a specific item in the OER database. If there are none, record “none”

(3) For RIHAs with related OER issues: The SME assessment of the PRA to confirm the historical HFE issues from the OE are accurately reflected in the assessment of human error probability, or that the PRA accurately reflects US-APWR plant design or HSI features that are expected to mitigate the historical HFE issue.

(4) For DIHAs with related OER issues: The SME assessment of the TAA or D3CA to confirm the historical HFE issues from the OE are accurately reflected in the time required to execute the credited manual action, or that this time accurately reflects adjustments facilitated by the US-APWR plant design or HSI features that are different than in the historical HFE issue.

(5) HED: For any IHAs where the plant analysis does not accurately reflect the OE as evaluated in items 3 and 4, above.

4.2.4 OER Results Review Process

The OER results reviewers check the OER results for conformance to this OER IP; they are not checking adequacy of the IP, since that adequacy is determined through the licensing review process. The OER results review is conducted by a different member of the OER implementation team than the person who prepared the OER result (i.e., the data search and the issue entry and analysis in the OER Issues and Resolutions List). The distinction between the personnel who conduct the OER data search and evaluation and those who conduct the review is managed by the DTM. Any result considered outside the expertise of a specific SME is given to a more appropriate SME for review. The OER results reviewers check results as follows:

- Check accuracy of all internet links to data sources.
- Conduct a sample search of three data sources to confirm the search criteria; generate results with events that have HFE issues.
- Sample check (minimum 10 percent) the item numbering to ensure conformance to the IP numbering method.
- Sample check (minimum 10 percent) the Issue/Scope entries to ensure they accurately represent the event.

- Read all HF aspect descriptions and applicability descriptions to ensure concurrence.
- Sample check (minimum 10 percent) the completeness of the HED summary list.
- Sample check (minimum 10 percent) the entry of HEDs into the HFE issues tracking system.
- Sample check (minimum 10%) the IHA evaluations

The OER implementation team revises the draft results to resolve the reviewer's comments.

5.0 IMPLEMENTATION TEAM

The SMEs who conduct the OER program element are described in Section 4.0 above and summarized in Table 5-1.

Table 5-1 OER Implementation Summary

Implementation Activity	Section	Subject Matter Expert
Search industry sources to extract HFE issues	4.1	HSI/I&C Engineering, HFE
Evaluate HFE issues; identify HEDs	4.2.1	HSI/I&C Engineering, HFE
Evaluate IHAs; identify HEDs	4.2.2	Plant Operations
Review OER results	4.2.3	HSI/I&C Engineering, HFE, Plant Operations (different person from 4.1 for each data source, and different person from 4.2.1 and 4.2.2 for each HFE issue)

The SME qualifications are defined in the HFEPMP (Reference 8-7).

6.0 RESULTS SUMMARY REPORT CONTENT

All results of the OER program element are compiled in a ReSR. This report is used to identify and analyze HFE-related issues encountered in previous nuclear plant designs in accordance with this IP. The objective of the OER is to identify and analyze HFE-related problems and issues encountered in previous nuclear plant designs, so that the negative features are not repeated and positive features are retained. Since the nuclear industry lacks significant experience with the modern HSI technology used in the US-APWR, the OER also encompasses the use of similar digital HSI technologies from other process industries. This ReSR is a requirement of the inspections, tests, analyses, and acceptance criteria (ITAAC) closure defined in the US-APWR Design Control Document (DCD) Tier 1 (Reference 8-11).

The ReSR includes:

- Each OER implementation team member's name and SME position that they fulfill
- Each OER results reviewer's name and SME position that they fulfill
- The OER results overview, which includes the principal findings of the HFE program element
- The OER execution results, which include all details that demonstrate compliance to the Methodology section of this IP, using the Table output format defined in Section 4, including:
  - A table detailing the OE references reviewed, as defined by Section 4.1
  - The OER database as defined in Section 4.2.2, which details all HFE issues extracted from the data source review and the OER evaluation
  - The HED list as defined by Table 4-2 that extracts all HEDs from the OER database
  - The IHA list and evaluation as defined by Section 4.2.3
  - Evidence of OER review as defined by Section 4.2.4
- A conclusion that the OER program element has been conducted in accordance with the OER IP, and that the OER has identified and analyzed HFE-related problems and issues encountered in previous nuclear plant designs that are to be resolved by the US-APWR

7.0 NUREG-0711 COMPLIANCE EVALUATION

Table 7-1 lists the criteria of NUREG-0711 (Reference 8-1) and cross-references to the section in this report where compliance is demonstrated.

Table 7-1 Compliance with NUREG-0711

Review Criteria Stated in NUREG-0711, Rev. 2	OER IP Section No.
3.4.1 Scope (1) *Predecessor/Related Plants and Systems* – The review should include information pertaining to the human factors issues related to the predecessor plant(s) or highly similar plants and plant systems.	Section 4.1.1; Section 2.0, first and second bullets after paragraph 1
For a review of plant modifications, the scope of the OER should be focused to provide information relevant to the plants' systems,	Modification is not applied in the new plant application per Section 6.4 in the HFEPMP
(2) *Recognized Industry HFE Issues* - NUREG/CR-6400 (Higgins and Nasta, 1996) issues should be addressed. The issues are organized into the following categories: • unresolved safety issues/generic safety issues • TMI issues • NRC generic letters and information notices • reports of the former NRC Office for Analysis and Evaluation of Operational Data • low power and shutdown operations • operating plant event reports	Section 2.0, second sub-bullet of the second bullet after paragraph 3; Section 4.1.2
(3) *Related HFE Technology* - The OER should address related HFE technology. For example, if touch screen interfaces or computerized procedures are planned, HFE issues associated with their use should be reviewed.	Section 4.1.3; Section 2.0, paragraph 4, second sentence, and paragraph 6
(4) *Issues Identified by Plant Personnel* - Personnel interviews should be conducted to determine operating experience related to predecessor plants or systems. The following topics should be included in the interviews as a minimum: • Plant Operations – normal plant evolutions (e.g., startup, full power, and shutdown) – instrument failures [e.g., safety-related system logic and control unit, fault tolerant controller (nuclear steam supply system), local "field unit" for multiplexer (MUX) system, MUX controller (balance of plant), break in MUX line] – HSI equipment and processing failure (e.g., loss of video display units, loss of data processing, loss of large overview display) – 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 control room (CR) power supplies, and safety/relief valve transients) – accidents (e.g., main steam line break, positive reactivity addition, control rod insertion at power, control rod ejection, anticipated transients without scram (ATWS), and various-sized loss-of-coolant accidents (LOCA)) – reactor shutdown and cooldown using remote shutdown system	Section 4.1.4; Section 2.0, third paragraph from end of section

Review Criteria Stated in NUREG-0711, Rev. 2	OER IP Section No.
• HFE Design Topics – alarm and annunciation – display – control and automation – information processing and job aids – real-time communications with plant personnel and other organizations procedures, training, staffing/qualifications, and job design	Section 4.1.4, paragraph 2, bullet 2and its sub-bullets; Section 2.0, third paragraph from end of section
(5) *Risk-Important Human Actions* - The OER should identify risk-important HAs that have been identified as different or where errors have occurred. The human actions should be identified as requiring special attention during the design process to lessen their probability.	Section 4.1.5 Note: "as different or where errors have occurred" refers to "processor's plant." The last sentence of Section 4.1.5 addresses "requiring special attention during the HFE design process."
3.4.2 Issue Analysis, Tracking, and Review (1) *Analysis Content* - The issues should be analyzed with regard to the identification of • human performance issues, problems, and sources of human error • design elements that support and enhance human performance	Section 4.2.1: last paragraph, bullet (1) last paragraph, bullet (2)
(2) *Documentation* - The analysis of operating experience should be documented in an evaluation report.	Section 6.0
(3) *Incorporation Into the Tracking System* - Each operating experience issue determined to be appropriate for incorporation in the design (but not already addressed in the design) should be documented in the issue tracking system.	Section 4.2.1, last paragraph, bullet (3); Section 4.2.2 and all its subsections Note: The HED list generated from OER is the issue tracking system.

8.0 REFERENCES

8-1 Human Factors Engineering Program Review Model, NUREG-0711, Revision 2, U.S. Nuclear Regulatory Commission, February 2004.

8-2 NUCIA database, http://www.nucia.jp/index.html.

8-3 INPO members' Web site, http://www.inpo.org/inpo/HomePage.asp.

8-4 Human Factors Engineering (HFE) Insights for Advanced Reactors Based Upon Operating Experience, NUREG/CR-6400, J. Higgins and K. Nasta, U.S. Nuclear Regulatory Commission, December 1996.

8-5 US-Basic Human-System Interface System Verification and Validation (Phase 1), MUAP-08014, Revision 2, MHI, 2013.

8-6 Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations, U.S.–Canada Power System Outage Task Force, April 2004.

8-7 Human Factors Engineering Program Management Plan, MUAP-09019, Revision 3, MHI, June 2013.

8-8 Resolution of Generic Safety Issues, NUREG-0933, U.S. Nuclear Regulatory Commission, December 2011.

8-9 Shutdown and Low-Power Operation at Commercial Nuclear Power Plants in the United States, NUREG-1449, U.S. Nuclear Regulatory Commission, September 1993.

8-10 Operating Experience Feedback Report – Human Performance in Operating Events, NUREG-1275, Vol. 8, J.V. Kauffman, G.F. Lanik, R.A. Spence, and E.A. Trager, U.S. Nuclear Regulatory Commission, December 1992.

8-11 Design Control Document for the US-APWR, Chapter 18, Human Factors Engineering, MUAP-DC-018, Revision 3, March 2011.