

**Non-Proprietary**

Human Factors Engineering Program Plan

APR1400-E-I-NR-14001-NP, Rev.3

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# **Human Factors Engineering Program Plan**

**Revision 3**

**Non-Proprietary**

**May 2018**

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## **ABSTRACT**

This document provides the human factors engineering program plan (HFEPP) for the Advanced Power Reactor 1400 (APR1400). The HFEPP is one of human factors engineering (HFE) program elements in the APR1400 HFE program. The HFEPP is the guiding document for implementing the HFE program in a consistent and systematic manner.

The HFEPP applies to the HFE design program as set forth in the NUREG-0711, Human Factors Engineering Program Review Model, and to the APR1400 HFE design program implementation plans (IPs) and results summary reports (ReSR).

The APR1400 HFE design program includes the following elements:

- Human factors engineering program plan
- Operating experience review
- Functional requirements analysis and function allocation
- Task analysis
- Staffing and qualifications
- Treatment of important human actions
- Human-system interface design
- Human factors verification and validation
- Design implementation

The HFEPP includes, by reference, the element descriptions that are contained in the individual IP for the each program elements.

The HFE design program supports the development of the procedures and training programs that are described in Chapter 13 of the Design Control Documents.

The human performance monitoring program is the responsibility of the combined license applicant.

The scope of the APR1400 HFE design program includes the main control room, remote shutdown room, technical support center, emergency operations facility as applied to communications and information requirements, and local control stations associated with important human actions.

The HFEPP describes the HFE design assumptions, explains the overall project goals, describes the HFE design management process, and sets roles, responsibilities and authorities of positions in the HFE design program team and establishes the minimum qualifications for specific positions in the organization.

The HFEPP describes the HFE issue control process through the use of human engineering discrepancies (HED) and the information tracking system (ITS).

The HFEPP sets the HFE program's documentation requirements.

## **TABLE OF CONTENTS**

<b>1</b>	<b>PURPOSE .....</b>	<b>1</b>
<b>2</b>	<b>SCOPE .....</b>	<b>2</b>
2.1	Applicable Human-System Interfaces, Procedures, and Training .....	2
2.2	Applicable Codes, Standards, Guides and Regulations .....	2
<b>3</b>	<b>METHODOLOGY OVERVIEW .....</b>	<b>6</b>
<b>4</b>	<b>IMPLEMENTATION .....</b>	<b>8</b>
4.1	Assumptions and Constraints .....	8
4.2	Program Duration .....	8
4.3	Human Factors Engineering Design Team and Organization .....	8
4.3.1	Human Factors Engineering Design Team Responsibilities .....	8
4.3.2	Human Factors Engineering Design Team Organizational Placement and Authority .....	11
4.3.3	Human Factors Engineering Organizational Composition .....	11
4.3.4	Human Factors Engineering Organizational Staffing .....	15
4.4	Human Factors Engineering Design Process and Procedures .....	15
4.4.1	Human Factors Engineering Program Milestones, Schedule and Duration .....	15
4.4.2	Human Factors Engineering Process and Procedures .....	16
4.4.3	Integration of the Human Factors Engineering Program with Other Plant Design .....	19
4.4.4	Human Factors Engineering Documentation .....	19
4.5	Subcontractor Human Factors Engineering Efforts .....	20
4.6	Tracking Human Factors Engineering Issues .....	20
4.6.1	Method .....	21
4.7	Technical Program .....	22
4.7.1	Design Process Elements .....	22
4.7.2	Element Structure .....	23
4.7.3	Element Input and Output .....	23
<b>5</b>	<b>IMPLEMENTATION TEAM .....</b>	<b>30</b>
<b>6</b>	<b>RESULTS SUMMARY REPORT .....</b>	<b>37</b>
<b>7</b>	<b>REFERENCES .....</b>	<b>38</b>
<b>8</b>	<b>DEFINITIONS .....</b>	<b>39</b>
	<b>APPENDIX A NUREG-0711 REV. 3 CONFORMANCE TABLE .....</b>	<b>A1</b>

**LIST OF TABLES**

Table 4-1      Responsibilities for the Human Factors Engineering Design Team..... 10

**LIST OF FIGURES**

Figure 4-1 Human Factors Engineering Design Team Organization ..... 14  
Figure 4-2 APR1400 HFE Program Milestones ..... 15  
Figure 4-3 Human Factors Engineering Design Process ..... 18  
Figure 4-4 Issue Tracking System ..... 21

**ACRONYMS AND ABBREVIATIONS**

ANS	American Nuclear Society
APR1400	Advanced Power Reactor 1400
A/E	architect engineering
BOP	balance of plant
BTA	basic task analysis
CBP	computer-based procedure
CFM	critical function monitoring
COL	combined license
D3CA	diversity and defenses in depth coping analysis
DCD	Design Control Document
DI	design implementation
DIHA	deterministically identified important human actions
EO	electrical operator
EOF	emergency operation facility
FA	functional allocation
FRA	functional requirements analysis
FRA/FA	functional requirements analysis and function allocation
HA	human action
HED	human engineering discrepancy
HDTM	human factor engineering design team meeting
HFE	human factors engineering
HFEPP	human factors engineering program plan
HP	human performance
HPM	human performance monitoring
HSI	human-system interface
I&C	instrumentation and control
IHA	important human action
IP	implementation plan
ISV	integrated system validation
ITS	issue tracking system
KEPCO	Korea Electric Power Corporation
KHNP	Korea Hydro & Nuclear Power Co., Ltd.
LCS	local control station
LDP	large display panel



MCR	main control room
NRC	U.S. Nuclear Regulatory Commission
NSSS	nuclear steam supply system
OER	operating experience review
PD	procedure development
PPM	project procedure manual
PRA	probabilistic risk assessment
QA	quality assurance
QAP	quality assurance program
ReSR	results summary report
RG	Regulatory Guide
RIHA	risk important human action
RSR	remote shutdown room
RO	reactor operator
SDCV	spatially dedicated and continuously visible
SME	subject matter expert
S&Q	staffing and qualifications
SPM	success path monitoring (system)
SS	shift supervisor
STA	shift technical advisor
TA	task analysis
TAA	transient and accident analysis
TIHA	treatment of important human action
TO	turbine operator
TPD	training program development
TS	trade secret
TSC	technical support center
TTA	task timing analysis
V&V	verification and validation
VDU	visual display unit

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## **1. PURPOSE**

The purpose of this document is to describe the human factors engineering program plan (HFEPP) for the Advanced Power Reactor 1400 (APR1400) human factors engineering (HFE) process and human-system interface (HSI) design. The purpose of the HFE design program is to provide an iterative, human-centered approach for the APR1400 design.

The human-centered approach to the design of the APR1400 HSI ensures that:

- Tasks are carried out according to the time and performance criteria.
- Situation awareness is supported by the HSI, operating procedures, training, staffing levels and personnel qualifications.
- Vigilance is maintained over plant operations as supported by the HSI design.
- Acceptable workloads are maintained.
- Personnel error is minimized, and error detection and recovery capabilities are supported.

The human-centered approach ensures that operations personnel are in control of the APR1400 by having the appropriate plant information and controls with procedures to safely operate the APR1400 in all plant modes.

The HFE program goals are to:

- Establish the purpose, scope and duration of the APR1400 HFE program.
- Define the process that integrates HFE into the APR1400 design.
- Identify the HFE program elements and their implementation plans (IPs).
- Ensure that HFE principles, through the application of the IPs, are applied to the development, design, and evaluation of the HSI, procedures and training.
- Define the process to document, track, resolve, and close HFE issues identified during the design using human engineering discrepancies (HEDs) and the issue tracking system (ITS).
- Define the HFE design team organizational structure with its responsibility, organizational placement and authorities within the project.
- Define the composition of the HFE design team and the minimum required qualifications of design team members.
- Ensure that the commitment of the plant design to HFE is met and that HFE is properly developed, executed, overseen, and documented.
- Consider and address the deterministic aspects of design discussed in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.174 (Reference 14).

## 2. SCOPE

The HFE program addresses the following facilities:

- main control room (MCR)
- remote shutdown room (RSR)
- technical support center (TSC)
- emergency operations facilities (EOFs) (communications and information requirements only)
- local control stations (LCSs) associated with important human actions (IHAs)

The HFE design program elements are applied to the facilities using a graded approach. All elements are applied to the MCR and RSR. The applications are discussed in the IPs of the individual elements.

### 2.1 Applicable Human-System Interfaces, Procedures, and Training

The HSIs, procedures, and training which are included in the HFE design program address operations, emergency response, maintenance, test, inspection surveillance interfaces and procedures.

The HFE design program addresses the design of HSIs and identifies inputs to the development of procedures and training for operations, accident management, maintenance, test, inspections, and surveillance tasks that operational personnel will perform or supervise. The HFE design process identifies training program input for the personnel identified in 10 CFR 50.120 (Reference 15) and any other personnel who perform tasks directly related to plant safety, including information technology technicians who troubleshoot and maintain support systems and their HSIs.

### 2.2 Applicable Codes, Standards, Guides and Regulations

The applicable codes, standards, guide, and regulations are as follows:

- Basic requirements
  - NUREG-0800, "Standard Review Plan, Chapter 18 Human Factors Engineering," 2007
  - NUREG-0711, "Human Factors Engineering Program Review Model," Rev. 3, November 2012
- Human factors engineering program plan
  - 10 CFR Part 50.34(f)(3)(vii), "Domestic Licensing of Production and Utilization Facilities Management and Technical Support Organization," U.S. Nuclear Regulatory Commission
  - Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," U.S. Nuclear Regulatory Commission, 2002
  - NUREG-0737 and Supplements, "Clarification of TMI Action Plan Requirements," U.S. Nuclear Regulatory Commission, 1980
- Operating experience review

- 10 CFR Part 50.34(f)(3)(i), "Domestic Licensing of Production and Utilization Facilities; Contents of applications; Technical Information"
- NUREG/CR-6400, "Human Factors Engineering (HFE) Insights for Advanced Reactors based upon Operating Experience," U.S. Nuclear Regulatory Commission, 1997.
- NUREG/CR-6749, "Integrating Digital and Conventional Human-System Interfaces: Lessons Learned from a Control Room Modernization Program," U.S. Nuclear Regulatory Commission, 2002
- Functional requirements analysis and function allocation
  - 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants"
  - Regulatory Guide 1.62, "Manual Initiation of Protective Actions," Rev.1, U.S. Nuclear Regulatory Commission, 2010
  - NUREG/CR-3331, "A Methodology for Allocating Nuclear Power Plant Control Functions to Human or Automatic Control," U.S. Nuclear Regulatory Commission, 1983
  - NUREG-0711, "Human Factors Engineering Program Review Model," Rev. 3, 2012
  - ANSI/ANS 58.8-1994, "Time Response Design Criteria for Safety-Related Operator Actions," American Nuclear Society, 1994
  - IEEE 603-1991, "Standard Criteria for Safety Systems for Nuclear Power Generating Stations," Institute of Electronic and Electrical Engineers, 1991
- Task analysis
  - NUREG/CR-3371, "Task Analysis of Nuclear Power Plant Control Room Crews," 1983
- Staffing and qualifications
  - 10 CFR Part 50.54(i) (m), "Domestic Licensing of Production and Utilization Facilities Conditions of Licenses"
  - Regulatory Guide 1.8, "Qualifications and Training of Personnel for Nuclear Power Plants," 2000
  - NUREG/CR-6400, "HFE Insights for Advanced Reactors based upon Operating Experience," U.S. Nuclear Regulatory Commission, 1997
  - NUREG/CR-6838, "Technical Basis for Regulatory Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)," U.S. Nuclear Regulatory Commission, 2004
  - Information Notice 95-48, "Results of Shift Staffing Study," U.S. Nuclear Regulatory Commission, 1995
  - Information Notice 97-78, "Crediting of Operator Actions in Place of Automatic Actions and Modifications of Operator Actions, Including Response Times," U.S. Nuclear Regulatory Commission, 1997
- Treatment of important human actions

- 10 CFR Part 52.47(a)(27), "A Description Of The Design Specific Probabilistic Risk Assessment (PRA) and Its Results"
- 10 CFR Part 52.47(b)(1), "Combined Licenses – Contents of Applications; Technical Information"
- 10 CFR Part 52.79, "Combined Licenses – Contents of Applications; Technical Information In Final Safety Analysis Report"
- Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," U.S. Nuclear Regulatory Commission, 2009
- NUREG/CR-1278, "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications," U.S. Nuclear Regulatory Commission, 1983
- Human-system interface design
  - 10 CFR Part 50.34(f)(2), "Domestic Licensing of Production and Utilization Facilities - Contents of Applications; Technical Information"
  - 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants Criteria 19 Control Room"
  - Regulatory Guide 1.22, "Periodic Testing of Protection System Actuation Functions," U.S. Nuclear Regulatory Commission, 1972
  - Regulatory Guide 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems," U.S. Nuclear Regulatory Commission, 2010
  - Regulatory Guide, 1.62, "Manual Initiation of Protective Actions," U.S. Nuclear Regulatory Commission, 2010
  - Regulatory Guide, 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, 2006
  - DI&C-ISG-04, "Highly-Integrated Control Rooms – Communications Issues, (HICRc)," U.S. Nuclear Regulatory Commission, 2009
  - DI&C-ISG-05, "Highly-Integrated Control Rooms – Human Factors Issues, (HICR-HF)," U.S. Nuclear Regulatory Commission, 2008
  - NUREG-0700, "Human-System Interface Design Review Guidelines," U.S. Nuclear Regulatory Commission, 2002
  - NUREG-0696, "Functional Criteria for Emergency Response Facilities," U.S. Nuclear Regulatory Commission, 1980
- Procedure development
  - 10 CFR Part 50.34(f)(2)(ii), "Domestic Licensing of Production and Utilization Facilities - Contents Of Applications; Technical Information"
  - NUREG-0899, "Guidelines for the Preparation of Emergency Operating Procedures," U.S. Nuclear Regulatory Commission, 1982

- NUREG-1358, “Lessons Learned from the Special Inspection Program for Emergency Operating Procedures,” U.S. Nuclear Regulatory Commission, 1989
- NUREG/CR-6634, “Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance,” U.S. Nuclear Regulatory Commission, 2000
- Training program development
  - 10 CFR Part 50.120, “Additional Standards for Licenses, Certifications, and Regulatory Approvals – Training and Qualifications of Nuclear Power Plant Personnel”
  - 10 CFR Part 52.79, “Combined Licenses – Contents of Applications; Technical Information in Final Safety Analysis Report”
  - 10 CFR Part 55, “Operators' Licenses”
  - Regulatory Guide 1.149, “Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examinations,” U.S. Nuclear Regulatory Commission, 2011
  - Regulatory Guide 1.8, “Personnel Selection and Training for Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, 2000
  - NUREG-1021, “Operator Licensing Examination Standards for Power Reactors,” 2004
  - NUREG-1122, “Knowledge and Abilities Catalog for Nuclear Power Plant Operators: Pressurized Water Reactors,” U.S. Nuclear Regulatory Commission, 1998
  - Human factors verification and validation
  - DI&C-ISG-04, “Highly-Integrated Control Rooms – Communications Issues (HICRc),” U.S. Nuclear Regulatory Commission, 2009
  - DI&C-ISG-05, “Highly-Integrated Control Rooms – Human Factors Issues, (HICR-HF),” U.S. Nuclear Regulatory Commission, 2008
  - NUREG/CR-6633, “Advanced Information Systems: Technical Basis and Human Factors Review Guidance,” U.S. Nuclear Regulatory Commission, 2000
- Design implementation
  - NUREG-0711, “Human Factors Engineering Program Review Model,” Rev 3, U.S. Nuclear Regulatory Commission, 2012

### 3. METHODOLOGY OVERVIEW

The APR1400 HFE program specifies the elements of the HFE program, identifies the IP, including their interrelationships, for each of the HFE program elements and specifies the management process under which the HFE program is conducted.

The management of the HFE program ensures that the HFE program is properly developed and implemented. The HSI design is conducted in accordance with the HFEPP and the IPs for each of the program elements. The HSI is based on a human centered design process that meets the review criteria of NUREG-0711, Human Factors Engineering Program Review Model (Reference 1).

The HFEPP describes the roles, responsibilities, authority and project organizational placement of the HFE team and its members. It contains the minimum qualification levels for the HFE team members conducting each of the HFE elements.

The HFEPP describes the integration of each of the HFE program elements, as represented by their individual IPs, within the management structure. The HFE element implementation plans are supportive to this plan and, in combination, form the bases for the HFE program and the HSI design.

This document presents the HFE design process and identifies the APR1400 approach to meet the review criteria described in NUREG-0711. This HFEPP provides a complete HFE program management plan for the formal and systematic HSI design. The IPs for the elements of the HFE design program are as follows:

- Operating Experience Review Implementation Plan (Reference 2)
- Functional Requirements Analysis/Function Allocation Implementation Plan (Reference 3)
- Task Analysis Implementation Plan (Reference 4)
- Staffing and Qualifications Implementation Plan (Reference 5)
- Treatment of Important Human Actions Implementation Plan (Reference 6)
- Human-System Interface Design Implementation Plan (Reference 7) and the Basic Human-System Interface (Reference 8)
- Human Factors Verification and Validation Implementation Plan (Reference 9)
- Design Implementation Plan (Reference 10)

Each element is implemented through the application of its IP. By reference, these eight IPs are incorporated into the HFEPP. Each of the eight IPs produces their results summary report (ReSR) containing the results of the element's activities.

The training program and procedure development are supported by the HFE program but are addressed in Chapter 13.

The human performance monitoring program is the responsibility of the COL applicant.

The HFEPP includes:

- General HFE management program goals and scope



- HFE design team and organization
- HFE process and procedures
- HFE issue tracking
- HFE technical program
- Implementation Team description for use by each element's IPs

HFE design program interfaces are described in Section 3 of each HFE IP and the interfaces are summarized in Section 4.7.3 of this document.

**4. IMPLEMENTATION**

**4.1 Assumptions and Constraints**

**TS**



**4.2 Program Duration**

**TS**



**4.3 Human Factors Engineering Design Team and Organization**

**TS**



**4.3.1 Human Factors Engineering Design Team Responsibilities**

**TS**





**Table 4-1**

**Responsibilities for the Human Factors Engineering Design Team**

**TS**



**4.3.2 Human Factors Engineering Design Team Organizational Placement and Authority**

**TS**



**4.3.3 Human Factors Engineering Organizational Composition**

**TS**









**Figure 4-1 Human Factors Engineering Design Team Organization**



### 4.3.4 Human Factors Engineering Organizational Staffing

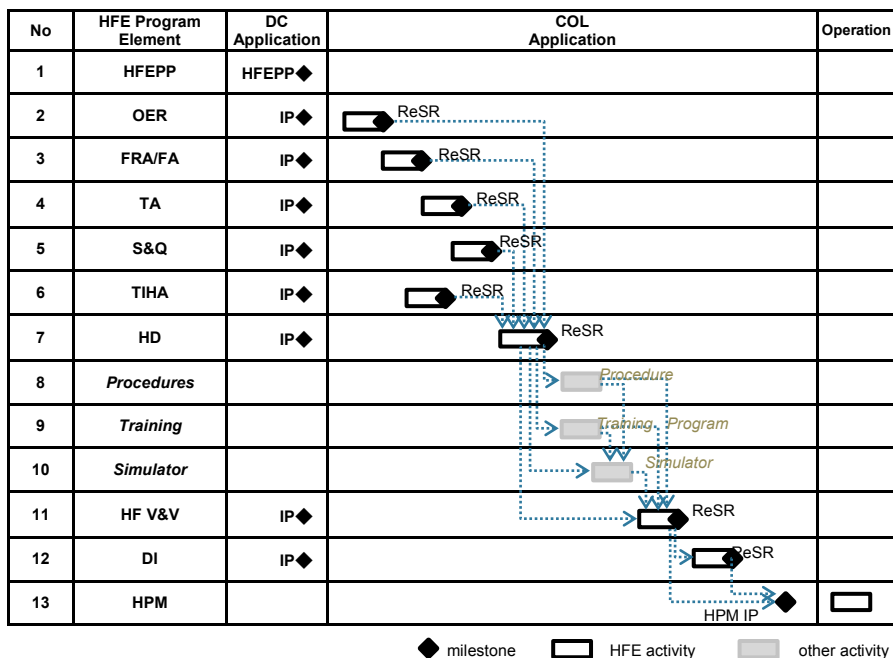
The minimum qualifications of the HFE program design team, including the related organizational staffing for the HFE design team on APR 1400 design, are described in Section 5 of this document. Section 5 of each IP's describes the activities of the element's team.

### 4.4 Human Factors Engineering Design Process and Procedures

This section describes the process and procedures that are implemented for effective management of HFE design activities. The HFE design process and procedures are developed to ensure that HFE principles and guidelines are successfully applied to the HSI design.

#### 4.4.1 Human Factors Engineering Program Milestones, Schedule and Duration

The HFE design team leader uses HFE milestones to identify problem and evaluate the HFE effort using critical checkpoints related to the integrated plant in the sequence of events shown in Figure 4-2. The schedule for HFE program tasks indicates the temporal relationships among HFE elements. The schedule for the HFE program is shown in Figure 4-2.



**Figure 4-2 APR1400 HFE Program Milestones**

#### 4.4.1.1 Summary of Program Elements

Since all IPs are submitted with the of DC application, their content is not repeated or summarized in this HFEPP. The only exception to this is the human performance monitoring (HPM) IP. This element is the responsibility of the COL applicant and will therefore not be supplied as part of the DC application. The HPM IP will be supplied by the COL applicant.

#### 4.4.2 Human Factors Engineering Process and Procedures

##### 4.4.2.1 General Process Procedures

The HFE design team executes the HFE design program based on assigned responsibilities and the following:

- HFE activities are assigned by the HFE design team leader to the responsible engineering group, and each HFE coordinators assigns the activities to individual members based on qualifications.
- HFE design decisions are made through design reviews and design review meetings of the HFE design team. The HFE design team has the authority and organizational placement to ensure that the HSI design is implemented in accordance with the QAP, HFEPP, HFE IPs, Style Guide (Reference 13), Basic HSI, and accepted industry practices.
- Design changes during the APR1400 design process are made by applying the integration of design activities in Section 4.4.3 and the tracking of HFE issues in Section 4.6. When a design change is considered, a determination is made as to how to apply the HFE program elements in a graded manner. As part of the determination process, design change evaluations consider the potential impacts of the proposed change on the performance of plant personnel, schedule disruptions, the training program, and operating procedures. This HFE program is not intended to be applied to existing operating plant upgrades or modifications. This HFE program is applicable to modifications in operating APR1400 plants, as described in the HSI Design IP.
- The HFE design team's review of HFE program results are performed in accordance with the review and comment system in Section 4.4.2.3.

##### 4.4.2.2 Human Factors Engineering Design Process

The HFE design process is shown in Figure 4-3, including the interrelationships of the HFE design activities. The design approach is consistent with the HFE review criteria in NUREG-0711 and is as follows:

- The design process is iterative.
- The results of the HFE analyses (OER, FRA/FA, TA, TIHA, S&Q) are incorporated HSI design by the HFE designers
- The results of the HFE analyses (OER, FRA/FA, TA, TIHA, S&Q) are provided to the training and procedures development groups
- The results of the design tests and evaluations are used extensively to develop the HSI design.
- Interdisciplinary design reviews and review meetings that include all members of the HFE design team are used to coordinate activities among design teams

- The final HSI design is verified and validated
- The as-built design is to ensure that it is the same as the V&V program

Once an element of the HFE program is closed, as marked by the ReSR, further design changes are implemented through the HED process and the design implementation processes.

#### **4.4.2.3 Process Management Tools**

Process management tools are used in the development of the HSI design facilitates communication across design disciplines and organizations to enhance consistency and efficiency. The tools are the review and comment system and the ITS.

The review and comment system allows the designers and independent reviewers to make comments and document opinions on the HSI design and design documents. APR 1400 design drawings and documents are issued through an interdepartmental design review process using the review and comment system.

Documents prepared by responsible engineers are registered in the review and comment system, and the comments and opinions of personnel in the responsible department and interfacing departments are resolved and incorporated. The final version of drawings and documents are distributed to the applicable departments.

This process is tracked and stored by the review and comment system, and also by hard copy.

The review and comment system ensures the quality of products by using the integrated system that ensures the interdisciplinary review, comment resolution, document quality review by quality group, storage of the document, and tracking of the comment and resolution.

#### **Issuing Process of Design Documentation**

- Preparation and Registration

The responsible engineer prepares drawings and documents and registers them in the review and comment system.

- Design Review Request

The responsible engineer requests an interface review using a Document Review Notice. The responsible group leader and supervisor review the appropriateness of documentation before signing and distribution for interface review. This process is tracked by the review and comment system, and hard copies are also distributed if necessary.

- Interface Review

The reviewing department reviews the suitability of the documentation, prepares the review results, and then returns the documentation to the responsible department, possibly with signatures and dates. If there are no comments, the reviewer is to indicate there are no comments by signing and dating the documentation. If there are comments, the reviewer records the comments regarding the subject documentation. The group leader of the reviewing department then reviews the reviewer's comments to ensure they are indicated clearly, are of sufficient detail, and are based on up-to-date information and data. The group supervisor of the reviewing department then checks the adequacy of the comments and review results. The group supervisor of the reviewing department then signs the subject documentation and returns the review results to the responsible group supervisor. A meeting may be held to mutually

resolve comments. In this case, meeting minutes are prepared and appropriate actions are taken in a timely manner.

- Resolution of Comments

The responsible group supervisor is responsible for resolving the comments and determining whether the comments are incorporated into the drawings and documents. After resolution and incorporation of comments, the responsible engineer obtains the consent signature of the reviewer. The responsible group supervisor confirms that all comments have been resolved and incorporated into the design documents, and then signs the Design Review Notice. Revisions to major drawings and documents requiring approval by the department manager are verified by the quality engineering group after completion of all reviews. After completion of all reviews and confirmations, authorized personnel approve the drawings and documents in accordance with appropriate procedures.

- Storage of Review Results

The original Design Review Notice is retained and maintained. The responsible group supervisor dispatches all review results to the drawing and document control center. The review results are stored on electronic media.

HEDs are used throughout all of the elements of the HFE program to document, track, and close issues identified during the development of the HFE design. HEDs are tracked using the ITS.

**TS**



**Figure 4-3 Human Factors Engineering Design Process**

#### 4.4.3 Integration of the Human Factors Engineering Program with Other Plant Design

The integration of design activities is iterative and based on the inputs from other plant design activities to the HFE program and the outputs from the HFE program to other plant design activities. Integrating of the HFE designs with other plant design activities is performed in accordance with the QAP.

HFE program elements are coupled, and the results of each element are exchanged between the elements to assure that re-analysis or retesting is performed as required through the HED process.

The ReSRs from each HFE program elements are formally transmitted to all of the design teams. The HFE design team works with the other design teams to identify the impacts of the HFE program elements results on the design. A report that documented with design changes made as the ReSRs is generated by the other design teams, and the report is reviewed and approved by the HFE design team,.

The iterative design process between the design activities and within the HFE program continues throughout the design process to ensure that all designs are integrated. The HFE design team leader is responsible to ensure that the HFE program is integrated with the other design efforts and that the HFE program elements are integrated with each other. Integration activities are documented and tracked through the HED process, HDTM meeting notes, and reports from design reviews. The HFE coordinator supports the HFE design team leader in integration activities.

#### 4.4.4 Human Factors Engineering Documentation

The scope of documentation includes HFE program IPs, ReSRs, HSI/MCR functional requirements, and HSI/MCR design descriptions (or reports), HFE Style Guide, detail design specifications and drawings, and the Basic HSI. Plans and result reports of HSI design tests and evaluations are performed to ensure that the acceptability of HSI design are documented. The following elements of the HFE program are documented as described:

- Human Factors Engineering Program Plan
- OER IP and ReSR
- FRA&FA IP and ReSR
- TA IP and ReSR
- S&Q IP and ReSR
- TIHA IP and ReSR
- HD IP and ReSR
- V&V IP and ReSR
- DI IP and ReSR
- HF V&V IP and ReSR
- HF V&V Scenarios
- Basic HSI
- Style Guide

Each HFE element's ReSR is documented as the element is completed, as shown in Figure 4-2.

The review and comment system retains all documents described above for the life of the program and allows controlled access to the designer and reviewer.

**4.5 Subcontractor Human Factors Engineering Efforts**



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**4.6 Tracking Human Factors Engineering Issues**



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**Figure 4-4 Issue Tracking System**

#### **4.6.1 Method**

##### **4.6.1.1 Access to Issue Tracking System**

Although HFE designers and reviewers who participated in the design process have access to the HEDs, access to the ITS is limited to personnel authorized by the HFE design team leader. This ensures that the ITS database is not modified without the HFE design team leader's authorization.

##### **4.6.1.2 Human Engineering Discrepancies Entry**

Sources of HED, include the HSI test and evaluations and input from each HFE design program elements. HEDs are identified using criteria in the IP for each HFE program elements.

The entries to the ITS database include a unique entry number for each HED, a calendar date for each entry, and a description of the issue. The HED is formally evaluated by the HFE design team leader or authorized designee who is responsible for entering it into ITS database.

##### **4.6.1.3 Human Engineering Discrepancies Resolution**

Resolving HEDs includes identifying a cognizant-engineer for the oversight of the HED and the appropriate engineering group responsible for evaluating and resolving the issue, classifying the engineering issue, describing the resolution and related documents/drawings, identifying any additional HFE evaluation, and determining a calendar deadline for resolution. The criteria for the acceptance of the resolution are also included in the ITS.

##### **4.6.1.4 Human Engineering Discrepancies Closeout**

HEDs are closed if they are properly incorporated into the related HSI documents and drawings and approved by the HFE design team leader. An HED may also be closed when the issue has been determined not to require any actions and therefore does not require further tracking. HEDs that do not require action are also documented in the ITS.

HEDs are prioritized as follows:

- 1) Priority 1 HED

Direct safety consequences, including potential adverse effects on personnel performance. (e.g., the margin of plant safety may be reduced below an acceptable level, and must be corrected.)

2) Priority 2 HED

Not direct safety significant consequences but potential safety consequences to plant performance/operability, non-safety personnel performance/efficiency, or other factors affecting overall plant operability; corrected unless leaving the HED in an as-is condition is justified.

3) Priority 3 HED

Not Priority 1 and 2 and acceptable as-is. The HEDs which do not affect plant safety or operability are classified as Priority 3. Priority 3 HEDs, by definition, require no action other than tracking and trending to ensure there are no negative cumulative effects on human performance.

#### **4.6.1.5 Documentation**

HED resolutions that require a design changes are documented in the ITS and are summarized in the respective program element of the HFE program and in design documents/change orders.

The results of the HFE design program elements are documented in the respective ReSR, which includes summaries of the identified HEDs and their status. All Priority 1 HEDs and a summary of Priority 2 HEDs are included in the ReSR of HF V&V. The review result for the classification of priorities, and justifications for actions not being required for those HEDs which are prioritized as Priority 3, are documented in the ITS.

#### **4.6.1.6 Responsibility**

When an HED is identified and entered into the ITS, the HFE design team leader is responsible for assigning a cognizant-engineer to assess and resolve the HED and to and implement the resolution into the design. The HFE design team leader approves the official HED entry, resolution, and closeout of ITS issues.

### **4.7 Technical Program**

#### **4.7.1 Design Process Elements**

The development of implementation plans for the HFE design process, analyses, and evaluations for the following HFE elements is described in Figure 4-3. Each HFE program element, with the exception of the HFEPP, results in a ReSR being issued once the element has been completed according to its IP.

Evaluations and analyses using a full-scope MCR simulator, part-task simulator, mock-ups, and special tools and equipment are performed in support of the HFE program elements. Predecessor plant, predecessor design, and reference plant operations are also used, as described in the IPs, to provide inputs into the determination of the adequacy of the HSI design.

For use in the APR1400 HSI design, the prior resources, predecessor plant, predecessor design and reference plant are described in Section 8.

Testing and evaluation of HSI designs are conducted and documented throughout the HSI development process.



#### 4.7.2 Element Structure

Each IP has the same structure, which is based on the review criteria in NUREG-0711. In addition, a conformance matrix is developed to ensure that all review criteria are addressed by each IP and therefore addressed in the implementation of the IP. Appendix A of each IP contains the conformance table.

This HFEPP and each IP adopts the following structure:

1. Purpose
2. Scope
3. Methodology overview - Summary of the methodology that is applied to meet the criteria of NUREG-0711 including a description of the interfaces between the element and other elements of the HFE program
4. Implementation - Detailed description of the methodology and the implementation process, who performs the work, how it is evaluated, and what leads to the identification of an HED.
5. Implementation team - Composition of the elements team and their qualifications
6. Results summary report - Description of the ReSR
7. References
8. Definitions

Appendix A – Conformance matrix

#### 4.7.3 Element Input and Output

The HFE design program is composed of tightly coupled elements. These elements build on the results from earlier completed elements and feedback results that affect completed elements. Once an element is identified as closed and its ReSR is issued, the feedback is implemented through the HED process with any additional HFE analyses or testing that is performed during the design implementation.

The coupling between HFE elements is described in Section 3 of each HFE program element and also in the following subsections.

##### 4.7.3.1 Operating Experience Review Interfaces

The results of the OER are “lessons learned.” The lessons learned are input into the ITS as HEDs so they can be used as input into any/all of the HFE program elements.

The OER results in the identification of IHAs that are included in the TIHA program element. Issues that are identified as problematic are input into the V&V program element. The OER also results in the identification of issues are related to the Style Guide.

##### 4.7.3.2 Functional Requirements Analysis and Function Allocation Interfaces

The results of the OER are reviewed to ensure that any HFE problems identified in the predecessor plants are accounted for in the identification of APR1400 success paths and allocations. The plant conditions that led to these HFE issues are included in the FRA/FA.

The results of the OER are used to determine whether there is any operational evidence that allocations of predecessor plants or designs should be modified and to determine that the allocations of the success path control actions have appropriately considered any operating experience that may influence those allocations. A lack of operational issues with specific success paths supports maintaining the predecessor plants' allocations. Identification of an issue calls for a re-examination of the characteristics of the functions and a possible change in the allocation.

The FRA ensures that the plant conditions leading to the IHAs identified in the TIHA are analyzed and decomposed to identify the corresponding success path actions. The functional allocation (FA) confirms that those actions are appropriately allocated to humans, as assumed in the probabilistic risk assessment (PRA), transient and accident analysis (TAA), or diversity and defense in depth coping analysis (D3CA) using HFE allocation criteria. HEDs are generated for IHAs for which FA evaluation criteria, such as workload or complexity, exceed human performance capabilities; therefore the FA concludes that an IHA should be automated (i.e., not allocated to humans). These HEDs are resolved in subsequent program elements in conjunction with the personnel responsible for those plant analyses.

The IHAs identified in the TIHA element are examined to confirm that the manual aspect of the allocation is correct. The TA uses the success path control actions to define the tasks to be analyzed. For actions assigned to humans, the TA defines the manual control tasks, including tasks that confirm the effectiveness of the manual actions. For actions assigned to a machine, the TA defines the supervisory and backup control tasks. The TA confirms the function allocations.

The TA also uses the allocations to define the tasks. For actions assigned to humans, the TA defines the manual control tasks. For actions assigned to a machine, the TA defines the supervisory and backup control tasks. The TA confirms the allocations through the basic task analysis (BTA) and through the additional task timing analysis (TTA).

The staffing and qualifications (S&Q) use the identified success paths to aggregate staffing numbers and qualifications from individual tasks to the accomplishment of critical functions.

The HD uses the identification of critical functions and success paths to define the HSI inventory for developing the graphical designs of the large display panel (LDP) and related function displays for critical function monitoring (CFM) and success path monitoring (SPM). The FRA identifies the key parameters and components that are monitored for those critical functions and success paths.

#### **4.7.3.3 Task Analysis Interfaces**

The OER identifies past human performance issues in operating plants and documents features of APR1400, including plant system changes and automation that preclude the need for the human actions that are described in the issue. However, for some human performance issues, HAs are maintained but OER credits APR1400 improvements for resolution, such as improvements in the HSI inventory or HSI design. The TA analyzes these HAs to confirm the OER resolution.

For IHAs the TIHA extracts human performance (HP) assumptions from the APR1400 PRA, the TAA and the D3CA. HP assumptions include HFE characteristics such as personnel availability, HSI locations, environmental and stress conditions, and time available to reach the final assumption that operators can reliably perform the action. The TA ensures the task as documented by the Task Narrative and HSI Inventory is consistent with these assumptions. The TA also ensures the task does not result in excessive workload or inadequate time margin.

The TA defines the tasks associated with the critical function control actions defined by the FRA/FA. For actions assigned to humans, the TA defines the manual control tasks, including tasks that confirm the effectiveness of the manual actions. For actions assigned to a machine, the TA defines the supervisory and backup control tasks. The TA confirms the allocations through the BTA and through an additional TTA

as may be required to reach a clear and confirmed conclusion.

The TA establishes operator staffing numbers and personnel qualifications on a task-by-task basis. HEDs are generated when the TA result is inconsistent with the staffing constraint defined in the HFEPP. With the exception of tasks with HEDs, the TA output is the initial minimum operator staffing starting point for the analysis conducted in the S&Q. The S&Q analysis operator staffing through the combination of multiple tasks since they are aggregated together during various plant evolutions. S&Q establishes overall operator staffing to accommodate all plant modes and abnormal conditions. The S&Q resolves any staffing-related HEDs from the TA.

The TA generates the complete HSI inventory and characteristics of that inventory for the tasks conducted by plant operators. The HSI inventory includes parameter indications, alarms, controls, and communications. For common plant components, the TA uses the HSI inventory standards established by the APR1400 Basic HSI (e.g., all motor-operated valves have thermal overload alarms) or identifies any required deviations. The HD creates selectable, spatially dedicated and continuously visible (SDCV) indications, alarms and controls that encompass that inventory within the HSI methods defined by the APR1400 Basic HSI. The HD uses the TA output to establish alarm priority and applicability logic. While the HD uses input from plant systems in designing system-oriented indications and controls, The HD uses the input from the TA to aggregate the indications and controls into a task-oriented HSI.

The task narrative and HSI inventory defined by the TA establish the information and control needs for each operative instruction or action in the procedures and their execution sequence.

Job-learning objectives for the training program are derived from the TA task narratives. The task evaluations identify unusual demands, including new or different tasks and tasks requiring a high degree of coordination, high workload, or special skills. The APR1400 HSI inventory, defined by the TA, is used as the basis for HSI design inventory and characterization task support verification, which is conducted during V&V to confirm the APR1400 HSI design.

#### **4.7.3.4 Staffing and Qualification Interfaces**

The OER is reviewed to determine whether any problems relative to the number and qualification of plant staff identified in the predecessor plants need to be accounted for in S&Q. The lack of operational issues with staffing supports maintaining the predecessor plants' numbers and qualifications.

The FRA/FA provides the identified functional success paths to aggregate staffing numbers and qualifications from individual tasks for the accomplishment of critical functions.

The TA establishes staffing and qualifications information on a task-by-task basis and provides that to S&Q. The S&Q combines the tasks into evolutions.

The TA database provides task-level data to be aggregated for analysis. The TA provides HEDs for issues identified on an individual task basis related to S&Q. Other HFE program elements also provide HEDs if a staffing or qualification concern is identified.

The TIHA provides the IHAs to S&Q for confirmation that the staffing numbers and qualifications are sufficient to perform the action.

The S&Q provides the staffing and qualifications needs to the HD program to design the MCR, RSR, and TSC to support the staffing. The S&Q also includes resolution of any staffing-related HEDs that affect the APR1400 Basic HSI or the APR1400 facilities. S&Q also confirms the staffing for local control actions. The HD designs the LCSs to accommodate that staffing.

The S&Q provides staffing numbers and qualifications as inputs to preparation of procedures by the COL

applicant.

S&Q provides staffing numbers and qualifications as inputs to the preparation of the training program by the COL applicant.

S&Q provides the number and qualification of plant staff as input to V&V to be used in performing the selected scenarios. Any issues with staffing result in an HED that is evaluated for potential changes in the number and qualification of staff or an alternate resolution.

#### 4.7.3.5 Treatment of Important Human Action Interfaces

The APR1400 OER identifies past HP issues in operating plants. OER highlights any HP issues that describe actions 'similar' to the risk important human actions (RIHAs) or deterministic important human actions (DIHAs) documented in the TIHA ReSR.

The OER evaluates the HFE characteristics of the RIHA related HP issues (e.g., operator staffing, action complexity, and HSI design) to ensure the problems identified in the OER are accurately reflected in the HFE characteristics documented in the TIHA ReSR. These HFE characteristics are assumed in the PRA to determine human error probability.

Similarly, the OER confirms that the time required to execute the DIHAs, as identified in the TIHA ReSR, reflects the HP issues for any actions documented in the OER that are 'similar' to the DIHAs. The time required assumed in the TAA and D3CA is a critical component in crediting the manual action for event mitigation.

For all IHAs, an OER action is considered similar to an IHA based on subject matter expert (SME) judgment. In general, an action is considered similar if the OER action has corresponding event circumstances (e.g., events occurring during low-power conditions) or the action itself has corresponding operator interfaces with the HSI (e.g., modulating a valve, responding to an alarm). OER generates HEDs for any similar actions whose HFE characteristics that may adversely affect human performance, as identified in the OER, are not included in the PRA, TAA, or D3CA, as documented in the TIHA ReSR.

The FRA portion of the FRA/FA identifies the critical safety functions and critical power production functions to support high-level power production and safety goals. The FRA also identifies the success paths used to control these critical functions during all plant operating modes in both normal and abnormal conditions. The FRA decomposes the success paths into the actions associated with key plant components. The actions are allocated to machine or humans during the FA based on the performance capabilities of each and the action requirements.

The FRA ensures that the plant conditions leading to the IHAs identified in the TIHA are analyzed and decomposed to identify the corresponding actions. The FA verifies that those actions are appropriately allocated to humans, as assumed in the PRA, TAA, or D3CA, using HFE allocation criteria. HEDs are generated for IHAs for which FA evaluation criteria, such as workload or complexity, exceed human performance capabilities, and the FA therefore concludes that an IHA should be automated (e.g., not allocated to humans). These HEDs are resolved in subsequent program elements in conjunction with the personnel responsible for those plant analyses.

The TA includes a BTA for all tasks, and a TTA for selected tasks.

A BTA is conducted for operator tasks to define the required HSI inventory and the HFE characteristics of that inventory. The BTA confirms the assumptions about HFE characteristics used in the PRA to determine human error probability, as documented in the TIHA ReSR for RIHAs. These confirmations include the availability of controls, indications, and alarms needed to conduct IHAs, the situation and performance-shaping factors, the action complexity, and the S&Q of the personnel performing the action.

The BTA also includes an evaluation to determine whether a TTA is needed. A TTA is conducted for all IHAs. The TTA confirms the assumptions used in the PRA and D3CA, as documented in the TIHA ReSR, and concludes that operators can execute DIHAs within the time available. The TTA assesses the operator workload when conducting these IHAs and confirms that the IHAs can be carried out within the time available.

The TA generates HEDs for any HFE conflicts with these previous plant analyses, including IHAs that result in excessive workload conditions or any IHAs that cannot be executed with adequate margin between the time available and the time required.

The staffing defined by the TA is used as the operating crew baseline for further evaluation in the APR1400 S&Q. S&Q examines staffing through the combination of multiple tasks, since the tasks are aggregated during various plant evolutions. S&Q establishes staffing to accommodate all plant modes and abnormal conditions.

S&Q re-examines the IHAs since they are aggregated in abnormal and emergency operating procedures, to identify any times when adverse synergistic effects are created by the combination of primary tasks and secondary tasks. The scenarios that encompass these IHAs are included in the S&Q evaluation. S&Q generates HEDs when adequate staffing cannot be confirmed to ensure successful completion of an IHA.

The HD implements the HSI characteristics for all IHAs assumed in the PRA, TAA, and D3CA, as documented in the TIHA ReSR and as confirmed in previous program elements (e.g., control availability from the MCR, prompting alarms to reduce time required for HAs).

For IHAs, performance-based testing is conducted during the HD to assess the adequacy of the HSI design in minimizing the potential for human errors, and to ensure that IHAs can be executed within the time available. HEDs are generated when an IHA cannot be executed with an adequate time margin.

Basic operation sequences and/or guidance are documented in plant design specifications. Procedure writers ensure that operating sequences and guidance are clearly defined for IHAs.

Training program developers ensure that training materials and the training program include guidance and special annotations for the IHAs design inventory and characterization verification, task support verification and integrated system validation (ISV), which are conducted during the V&V and encompass all IHAs.

The DI demonstrates that the as-built HSI design, including the HSI for IHAs, for each site-specific APR1400 reflects the HSI design output from V&V.

#### **4.7.3.6 Human-System Interface Design Interfaces**

In the OER, HFE issues are evaluated from the perspective of the APR1400 plant design and the Basic HSI known at the time of the OER evaluation. Based on these known designs, the OER concludes that many HFE issues are adequately addressed. The HD program element confirms that these “known” designs remain valid at the time the HD is implemented. The HD identifies HEDs for HFE issues where the known design cannot be confirmed and the HFE issue cannot be resolved by the APR1400 HSI developed during the HD. Outstanding issues may require APR1400 plant design changes to close the HED.

The OER also identifies HEDs for HFE issues that are not considered resolved by the APR1400 plant design or the APR1400 Basic HSI. The OER HEDs are evaluated during the FRA/FA, TA and/or S&Q program elements, as appropriate. HED resolutions may require changes to the Basic HSI or specific HSI inventory that is included in the HSI, and these HEDs are therefore closed through HD implementation

activities.

The FRA identifies the critical safety functions and critical power production functions to support high-level power production and safety goals. The FRA also identifies the preferred normal and emergency success paths used to control the critical functions during all plant operating modes under both normal and abnormal conditions. The FRA identifies the key parameters and components that are monitored for critical functions and success paths. The HD uses these FRA outputs to define the HSI inventory for developing the graphical designs of the LDP and related function displays for CFM and SPM.

The TA generates requirements for a complete HSI inventory and the characteristics of the inventory for operator tasks under normal and abnormal plant conditions, including inspection test and repair of plant equipment. The inventory includes the indications, alarms, and controls needed for manual allocations, the indications and alarms to maintain situation awareness for automated allocations, and the indications and controls to manually backup automation. The HD uses these TA outputs to establish alarm designs (including priority and applicability logic), display and control designs, and procedure checking criteria. The HD uses the TA narratives to establish the grouping of HSI inventory necessary to perform related tasks. This grouping is used to create navigational links between related system displays, in the design of task displays, and in the design of the safety console. HEDs that identified discrepancies between the HSI inventory required by the TA and the APR1400 plant design are resolved during the HD.

TIHA identifies IHAs from the PRA, the TAA, and the D3CA and the HFE characteristics of the HSI assumed in these analyses to be available to support those IHAs (e.g., HSI accessibility from the MCR). These characteristics support the analysis conclusions regarding the ability for operators to reliably perform these IHAs within the time available. HD implements the HSI assumptions identified in the TIHA or identifies HEDs when those assumptions cannot be achieved within the HSI.

In addition, the Basic HSI defines HSI characteristics that promote HSI accessibility for IHAs. This includes SDCV high priority prompting alarms, and task displays to ensure the necessary plant information and controls for IHAs are available on the same display (to reduce screen navigation task burden). These HSI design attributes reduce the potential for human performance errors.

S&Q establishes the operating crew for all operating and shutdown modes, including normal, abnormal and emergency conditions. The HD program element designs the MCR, RSR and TSC to support that staffing. S&Q includes resolution of any staffing-related HEDs that affect the Basic HSI or the APR1400 facilities. S&Q also confirms the staffing defined by the TA for local control actions. The HD program element designs the LCSs to accommodate this staffing.

Procedure development (PD) generates conventional paper-based operating procedures for all operating and shutdown modes, including normal, abnormal, and emergency conditions. The HD converts the operating procedures executed from the MCR into CBPs in advance for the ISV. The inventory of CBP for the ISV scenarios includes additional procedures that are related to the ISV scenarios, but not actually needed to execute the ISV scenarios, to ensure the operator decisions are not influenced by the CBP inventory. Other paper procedures are converted to CBPs within the PD program element. PD is a COL applicant responsibility.

Operators are trained on the HSI, a key output of HD. Training is conducted in part using the simulator, whose functional specification is an HD output. PD is a COL applicant responsibility.

The functional designs of the HSI and APR1400 facilities are key outputs of the HD. These outputs are used to create the specification for the simulator, which is used during design verification and integrated system validation, both of part of the V&V program element.

The DI confirms that the site-specific as-built HSI design is the same as the HSI design that was confirmed during V&V. Therefore, the DI confirms the design traceability to the outputs of the HD.

#### **4.7.3.7 Human Factors Verification and Validation Interfaces**

Sampling of operational conditions uses inputs from the OER, TA time required and available, TIHA, and HSI design as selection criteria to form the bases for the selection of the HF V&V scenarios.

The task support verification uses the output from the TA for the identification of tasks assigned to the human and the required inventories to perform these tasks and from the HSI design for the actual HSI inventory to compare to the TA results.

The HFE design verification uses input from the HD and the final HSI design to compare to the Style Guide.

The ISV takes input from the S&Q and TIHA to establish what to test for and to set the pass/fail criteria. In order to ensure that the final validated design supports the IHAs that all human actions identified as IHAs are included in the scenarios, and that the HSI design that is evaluated in the ISV. The ISV also takes the output from the HSI design to specify the test facility and the operating procedures for direct use during the scenarios. The training program is used as guidance to establish the ISV training program for the plant personnel, and test participants.

The ISV evaluates, through testing, the design resolutions of the HEDs.

The V&V supplies a verified and validated design to the DI. It identifies, through the HED process, if an additional TA, S&Q, or TIHA analysis is required. If the earlier analyses (TA, S&Q, or TIHA) resulted in the issuance of the ReSR, any further testing requirements are performed during the DI.

The V&V also provides feedback on design failures to the HSI design, procedures, and training through the HED process.

#### **4.7.3.8 Design Implementation Interfaces**

The DI compares the as-built HSI design to the design as specified in the HD and the final design drawings and specifications. The DI performs V&V activities when the activities are identified as not have been performed during the V&V and closes HEDs that remain open.

**5. IMPLEMENTATION TEAM**

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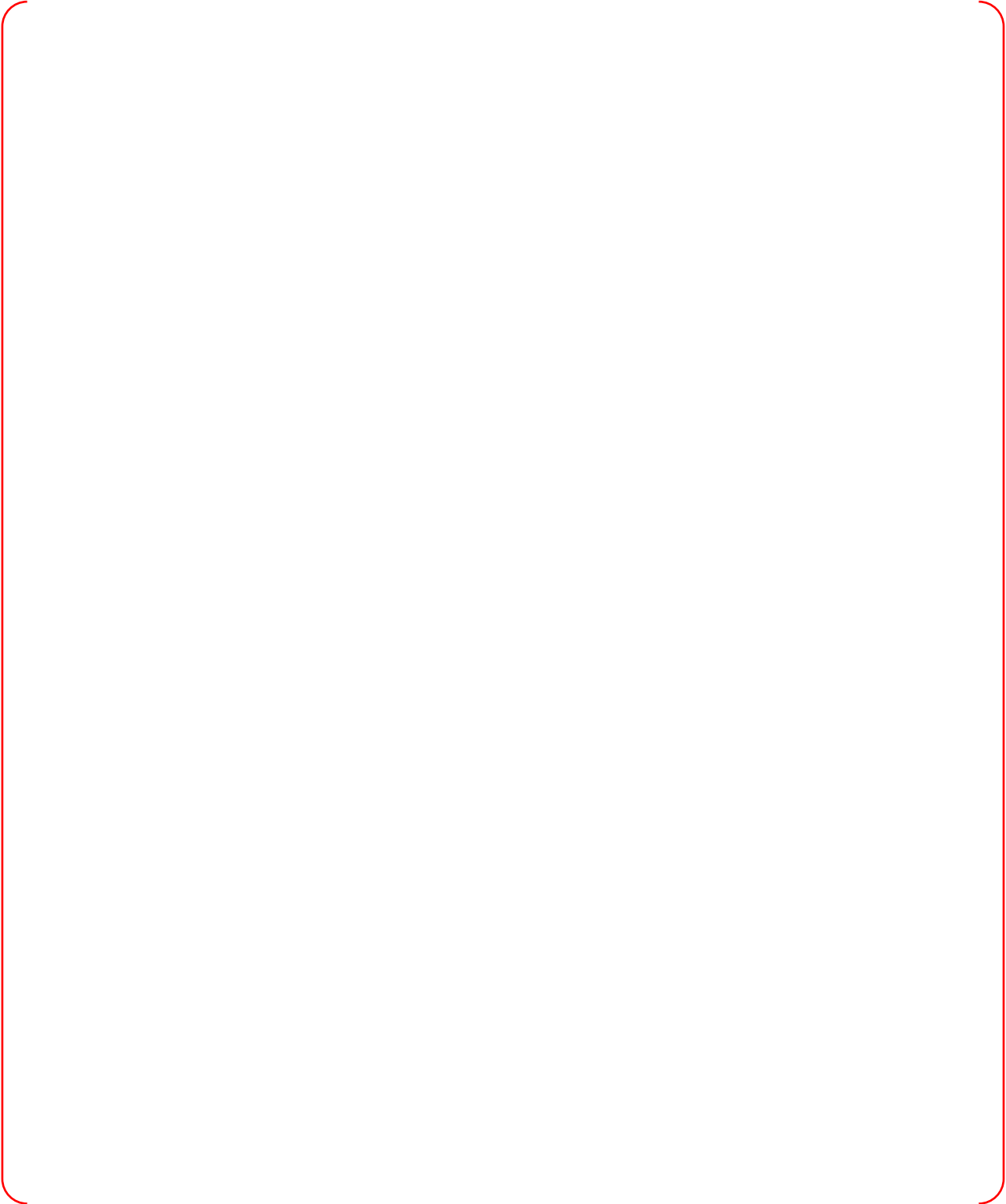








Standard format of resume is shown in Figure 5-1



**Figure 5-1 Standard Format of Resume**



**Figure 5-1 Standard Format of Resume**

## **6. RESULTS SUMMARY REPORT**

There is no ReSR for the HFEPP. Results of the other HFE program elements are documented in a ReSR, as described in Section 6 of each IP. All ReSRs' are available for review by the NRC.

## 7. REFERENCES

1. NUREG-0711, "Human Factors Engineering Program Review Model," Rev. 3, U.S. Nuclear Regulatory Commission, November 2012.
2. APR1400-E-I-NR-14002-P, "Operating Experience Review Implementation Plan," Rev.2, KHNP, January 2018.
3. APR1400-E-I-NR-14003-P, "Function Requirements Analysis and Function Allocation Implementation Plan," Rev.2, KHNP, January 2018.
4. APR1400-E-I-NR-14004-P, "Task Analysis Implementation Plan," Rev.3, KHNP, May 2018.
5. APR1400-K-I-NR-14005-P, "Staffing & Qualifications Implementation Plan," Rev.1, KHNP, March 2017.
6. APR1400-E-I-NR-14006-P, "Treatment of Important Human Actions Implementation Plan," Rev.3, KHNP, May 2018.
7. APR1400-E-I-NR-14007-P, "Human System Interface Design Implementation Plan," Rev.3, KHNP, May 2018.
8. APR1400-E-I-NR-14011-P, "Basic Human-System Interface," Rev.3, KHNP, May 2018.
9. APR1400-E-I-NR-14008-P, "Human Factors Verification and Validation Implementation Plan," Rev.3, KHNP, May 2018.
10. APR1400-K-I-NR-14009-P, "Design Implementation Plan," Rev.1, KHNP, March 2017.
11. APR1400-K-Q-TR-11005-NP, "Quality Assurance Program Description for APR1400 Design Certification," 2014.
12. APR1400 DC-QAM, "Quality Assurance Manual for APR1400 DC Project," Revision 6, July, 2015.
13. APR1400-E-I-NR-14012-P, "Style Guide," Rev.2, KHNP, January 2018.
14. Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Rev. 1, U.S. Nuclear Regulatory Commission, November 2002.
15. 10 CFR 50.120, "Training and Qualification of Nuclear Power Plant Personnel."



## **8. DEFINITIONS**

1. Acceptance criteria - Practical and reasonable objective pass/fail tests that is used to identify approved requirements. An acceptance criterion is qualitative or quantitative and defines sufficiency, not optimality.
2. Predecessor design - Previous NRC approved design that serves as a starting point for some aspects of the APR1400. Substantial portions of the system-level design are identical, but design details may be different. Engineering output and work results are applicable to the APR1400 if design differences are accounted for. The System 80+ is the APR1400 predecessor design.
3. Predecessor plant - Operating plant with the same general technical design from which experience and performance conclusions can be drawn and applied, as engineering input, during the APR1400 HSI design. Palo Verde Nuclear Generating Station and the KHNP OPR plants are the predecessor plants for the APR1400
4. Reference plant - Plant that is operating or under construction with the fewest differences from the APR1400. Significant plant information can be shown to be useful in understanding the APR1400 design. Shin-Kori 3&4 are the APR1400 reference plants.

**APPENDIX A NUREG-0711 REV. 3 CONFORMANCE TABLE**

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
<b>2.4 Review Criteria</b>	
<p><b>2.4.1 General HFE Program Goals and Scope</b></p> <p>(1) <i>HFE Program Goals</i> – The applicant should state the general objectives of the program in "human-centered" terms. As the HFE program develops, they should be further defined and used as a basis for HFE tests and evaluations.</p>	1.0 Purpose
<p>(2) <i>Assumptions and Constraints</i> – The applicant should identify the design assumptions and constraints.</p>	4.1. Assumptions and Constraints
<p>(3) <i>HFE Program Duration</i> – The applicant’s HFE program should be in effect at least from the start of the design cycle through completion of initial plant startup test program.</p>	4.2 Program Duration 4.4.1 HFE Program, Milestones Schedules and Duration Figure 4-2
<p>(4) <i>Facilities</i> – The applicant’s HFE program should cover the main control room (MCR), remote shutdown facility (RSF), technical support center (TSC), emergency operations facility (EOF), and local control stations (LCSs). The 12 HFE elements should be applied to each of them, unless otherwise noted for a specific HFE element. However, applicants may apply the elements of the HFE program in a graded fashion to facilities other than the MCR and RSF, providing justification in the HFE program plan.</p>	2.0 Scope
<p>(5) <i>HSIs, Procedures and Training</i> – The applicant’s HFE program should address the design of HSIs and identify inputs to the development of procedures and training for all operations, accident management, maintenance, test, inspections, and surveillance tasks that operational personnel will perform or supervise.</p>	2.1 Applicable HSIs, Procedures and Training 4.4.2.1 General Processes and Procedures 4.4.2.2 HFE Design Process 4.7.3.3 TA Interfaces

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
<p>In addition, the HFE design process should identify training program input for the following personnel identified in 10CFR 50.120: instrument and control technician, electrical maintenance personnel, mechanical maintenance personnel, radiological protection technician, chemistry technician, and engineering support personnel. In addition, any other personnel who perform tasks directly related to plant safety should be included, such as information technology technicians who troubleshoot and maintain support systems and their HSIs.</p>	<p>2.1 Applicable HSIs, Procedures and Training</p>
<p>6) <i>Personnel</i> – The applicant’s HFE program should consider operations staffing and qualifications, including licensed control-room operators as defined in 10 CFR Part 55, and the following categories of personnel: non-licensed operators, shift supervisor, and shift technical advisor.</p>	<p>4.1 Assumptions and Constraints. 4.4.2.2 HFE Design Process 4.7.3.4 S&amp;Q Interfaces</p>
<p>7) Additional Considerations for Reviewing the HFE Aspects of Plant Modifications</p>	<p>N/A</p>
<p><b>2.4.2 HFE Team and Organization</b> In this document, the term "HFE team" means the primary organization(s) responsible for the applicant’s HFE program. However, we do not assume that HFE is the responsibility of a single organizational unit, or that there is an organizational unit called the “HFE team.” (1) Responsibility – The applicant’s team should be responsible for:</p> <ul style="list-style-type: none"> <li>• developing all HFE plans and procedures</li> <li>• overseeing and reviewing all activities in HFE design, development, test, and evaluation, including the initiation, recommendation, and provision of solutions through designated channels for problems identified in implementing the HFE work</li> <li>• verifying that the team’s recommendations are implemented</li> <li>• assuring that all HFE activities comply with the HFE plans and procedures</li> <li>• scheduling work and milestones</li> </ul>	<p>4.3.1 HFE Design Team Responsibilities</p>

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
<p>(2) Organizational Placement and Authority – The applicant should describe the primary HFE organization(s) or function(s) within the engineering organization designing the plant or modification. The organization should be illustrated to show organizational and functional relationships, reporting relationships, and lines of communication. The applicant also should address the following:</p>	<p>4.3.1 HFE Design Team Responsibilities            4.3.2 HFE Design Team Organizational Placement and Authority            5.0 Implementation Team</p>
<ul style="list-style-type: none"> <li>When more than one organization is responsible for HFE [such as instrumentation and control (I&amp;C) and operations], the lead organizational unit answerable for the HFE program plan should be identified. If organization changes are expected over time (e.g., from design through construction to startup) necessary transitions between responsible organizations should be described.</li> </ul>	<p>4.3.1 HF Design Team Responsibilities            4.3.2 HFE Design Team Organizational Placement and Authority            4.3.3 HFE Organization Composition</p>
<ul style="list-style-type: none"> <li>The team should have the authority and organizational placement to reasonably assure that all its areas of responsibility are completed, and to identify problems in establishing the overall plan or modifying its design.</li> </ul>	<p>4.3.2 HFE Design Team Organizational Placement and Authority            5.0 Implementation Team</p>
<ul style="list-style-type: none"> <li>The team should have the authority to control further processing, delivery, installation, or use of HFE products until the disposition of a nonconformance, deficiency, or unsatisfactory condition is resolved.</li> </ul>	<p>4.3.2 HFE Design Team Organizational Placement and Authority            5.0 Implementation Team</p>
<p>(3) Composition – The applicant’s HFE design team should include the expertise described in the appendix to this report.</p>	<p>5.0 Implementation team</p>
<p>(4) Team Staffing – The applicant should describe team staffing in terms of job descriptions and assignments of team personnel.</p>	<p>4.3.1 HFE Design Team Responsibilities            4.3.2 HFE Design Team Organizational Placement and Authority            5.0 Implementation Team</p>

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
<p>2.4.3 HFE Process and Procedures</p> <p>(1) General Process Procedures – The applicant should identify the process through which the team will execute its responsibilities. It should include procedures for the following:</p> <ul style="list-style-type: none"> <li>• assigning HFE activities to individual team members</li> <li>• governing the internal management of the team</li> <li>• making decisions on managing the HFE program</li> <li>• making HFE design decisions</li> <li>• controlling changes in design of equipment</li> <li>• reviewing of HFE products</li> </ul>	<p>4.3.3 HFE Organizational Composition</p> <p>4.4.2.1 General Process Procedures</p>
<p>(2) Process Management Tools – The applicant should identify the tools and techniques (e.g., review forms) the team uses to verify that they fulfilled their responsibilities.</p>	<p>4.4.2.3 Process Management Tools</p>
<p>(3) Integration of HFE and Other Plant or Modification Design Activities – The applicant should describe the process for integrating the design activities (i.e., the inputs from other design work to the HFE program, and the outputs from the HFE program to other plant design activities). The applicant should also discuss the iterative aspects of the HFE design process.</p>	<p>4.4.3 Integration of the HFE program with Other Plant Design</p>
<p>(4) HFE Program Milestones – The applicant should identify HFE milestones that show the relationship of the elements of the HFE program to the integrated plant design, development, and licensing schedule. A relative program schedule of HFE tasks should be available for the NRC staff's review showing relationships between the HFE elements and the activities, products, and reviews.</p>	<p>4.4.1 HFE Program Milestones, Schedule and Duration</p>
<p>(5) HFE Documentation – The applicant should identify the HFE documentation items, such as ReSRs and their supporting materials, and briefly describe them, along with the procedures for their retention and for making them available to the NRC staff for review.</p>	<p>4.4.4 HFE Documentation</p> <p>6. Results Summary Reports</p>

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
<p>(6) Subcontractor HFE Efforts – The applicant should include HFE requirements in each subcontract contributing to the HFE program. The applicant should periodically verify the subcontractor's compliance with HFE requirements. The HFE plan should describe milestones and the methods used for this verification.</p>	<p>4.5 Subcontractor HFE Efforts</p>
<p><b>2.4.4 Tracking HFE Issues</b>            (1) Availability – The applicant should have a tracking system to address human factors issues that are:</p> <ul style="list-style-type: none"> <li>• known to the industry (defined in the Operating Experience Review element, see Section 3)</li> <li>• identified throughout the life cycle of the HFE aspects of design, development, and evaluation</li> <li>• deemed by the HFE program as human engineering discrepancies (HEDs) (see Section 11.4.4)</li> </ul>	<p>4.6 Tracking of HFE Issues</p>
<p>(2) Method – The applicant's method should:</p> <ul style="list-style-type: none"> <li>• establish criteria for when issues are entered into the system</li> </ul>	<p>4.6.1.1 Access to Issue Tracking System            4.6.1.2 HED Entry</p>
<ul style="list-style-type: none"> <li>• track issues until the potential for negative effects on human performance is reduced to an acceptable level.</li> </ul> <p>(3) Documentation – The applicant should document the actions taken to address each issue in the system; if no action is required, this should be justified.</p> <p>(4) Responsibility – After identifying an issue, the applicant's tracking procedures should describe individual responsibilities for logging, tracking, and resolving it, along with the acceptance of the outcome.</p>	<p>4.6.1.3 HED Resolution            4.6.1.4 HED Closeout            4.6.1.5 Documentation            4.6.1.6. Responsibility</p>

NUREG-0711 Rev. 3 Review Criteria	IP Section and Paragraph
<p><b>2.4.5 Technical Program</b></p> <p>(1) The applicant should describe the applicability and status of each of the following HFE elements:</p> <ul style="list-style-type: none"> <li>• Operating Experience Review</li> <li>• Functional Requirements Analysis and Function Allocation</li> <li>• Task Analysis</li> <li>• Staffing and Qualifications</li> <li>• Treatment of Important Human Actions</li> <li>• HSI Design</li> <li>• Procedure Development (Described in SRP, Chapter 13 submittal)</li> <li>• Training Development (Described SRP, Chapter 13 submittal)</li> <li>• Human Factors Verification and Validation</li> <li>• Design Implementation</li> </ul>	<p>3.0 Methodology Overview</p> <p>4.7.1 Design Process Elements</p> <p>4.7.3 Element Input and Output (all)</p> <p>4.7.4 DI Interfaces</p>
<ul style="list-style-type: none"> <li>• Human Performance Monitoring</li> </ul> <p><i>Additional Information:</i> The applicant should identify each applicable element of the HFE program. If the applicant determines that an HFE element is not applicable to the HFE program, the applicant should give a rationale.</p>	<p>4.4.1 HFE Program Milestones, Schedule and Duration</p> <p>4.4.1.1 Summary of Program Elements</p>
<p>(2) The applicant should identify the approximate schedule for completing any HFE activities that are unfinished at the time of the application.</p>	<p>4.4.1 HFE Program management, Schedule and Duration, Figure 4-2</p>
<p>(3) The applicant's plan should identify and describe the standards and specifications that are sources of the HFE requirements.</p>	<p>2.3 Applicable Codes and Regulations</p>
<p>(4) The applicant's plan should specify HFE facilities, equipment, tools, and techniques (such as laboratories, simulators, rapid prototyping software) that the HFE program will employ.</p>	<p>4.7.1 Design Process Elements</p>