

## 3.4 Human Factors Engineering

### Design Description

#### 1.0 System Description

The HFE program design process is employed to design the control rooms and the human-system interfaces (HSI) and associated equipment while relating the high-level goal of plant safety into individual, discrete focus areas for the design.

The HFE program enables a design which supports the goal of providing plant operators and technicians safe and efficient access to the required information and controls to monitor and manage the plant processes and equipment. The HFE program also establishes the time and performance criteria for required equipment operations via human reliability analyses (HRA) and recognized guidelines.

The HFE and Control Room Design Team establishes design guidelines, defines program-specific design processes, and verifies that the guidelines and processes are followed. The scope of the HFE program includes the following:

- Location and accessibility requirements for the control rooms and other control stations.
- Layout requirements of the control rooms, including requirements regarding the locations and design of individual displays and panels.
- Basic concepts and detailed design requirements for the information displays, controls, and alarms for HSI control stations.
- Coding and labeling conventions for control room components and plant displays.
- HFE design requirements and guidelines for the screen-based HSI, including the actual screen layout and the standard dialogues for accessing information and controls.
- Requirements for the physical environment of the control rooms (e.g., lighting, acoustics, heating, ventilation and air conditioning (HVAC)).
- HFE requirements and guidelines regarding the layout of operator work stations and work spaces.
- Corporate policies and procedures regarding the verification and validation (V&V) of the design of HSI.

The HFE and Control Room Design Team is also responsible for program concepts for staffing requirements.

The HFE program applies to the design of the main control room (MCR), the Technical Support Center (TSC), the Instrumentation and Control Service Center (I&CSC), the remote shutdown station (RSS), and local control stations (LCS) associated with operation or maintenance. The design of LCS is accomplished concurrent with the applicable system design and follows guidelines established by the HFE and Control Room Design Team.

The scope of the HFE program includes HSI that are related to plant process monitoring and control, as well as input to procedures and training associated with monitoring and controlling instrumentation and control (I&C) systems. The I&C systems include those required during normal operating modes as well as those required during tests, inspections, surveillances, maintenance, abnormal, emergency, and accident conditions. HSI associated with non-I&C systems (e.g., manual valve operators and other LCS) follow guidelines established by the HFE and Control Room Design Team.

## **2.0 Design Features**

- 1.0 HFE operating experience review (OER) is performed in accordance with the U.S. EPR Human Factors Operating Experience Review Implementation Plan.
- 2.0 Functional requirements analysis is performed in accordance with the U.S. EPR Functional Requirements Analysis and Functional Allocation Implementation Plan.
- 3.0 Functional allocation decisions are made based on a set of automation criteria which is defined and validated in accordance with the U.S. EPR Functional Requirements Analysis and Functional Allocation Implementation Plan.
- 4.0 A task analysis is performed in accordance with the U.S. EPR Task Analysis (TA) Implementation Plan.
- 5.0 The staffing and qualification analysis, which includes an evaluation of the number and qualifications of personnel needed to operate, maintain, and test the U.S. EPR based on HSI design features, is performed in accordance with the U.S. EPR TA Implementation Plan.
- 6.0 Human reliability analysis evaluates the potential for, and mechanisms of, human errors that may affect plant safety. Integration of human reliability analysis findings with HFE design is performed in accordance with the U.S. EPR Implementation Plan for the Integration of Human Reliability Analysis (HRA) into the Human Factors Engineering (HFE) Program.
- 7.0 HSI design is performed in accordance with the U.S. EPR Human System Interface Design Implementation Plan.

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- 8.0 The selection of the minimum inventory of MCR and RSS fixed alarms, displays, and controls is performed in accordance with the U.S. EPR Human System Interface Design Implementation Plan.
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  - 11.0 HFE verification and validation is performed in accordance with the U.S. EPR Human Factors Verification and Validation (V&V) Implementation Plan.
  - 12.0 Design implementation is performed in accordance with the U.S. EPR HFE Design Implementation Plan.
  - 13.0 Integrated System Validation scenarios are developed in accordance with the U.S. EPR Human Factors V&V Implementation Plan and contain similar content as scenario examples for the U.S. EPR.

### **Inspection, Tests, Analyses, and Acceptance Criteria**

Table 3.4-1 lists the HFE ITAAC.

**Table 3.4-1—Human Factors Engineering ITAAC**  
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<b>Commitment Wording</b>		<b>Inspections, Tests, Analyses</b>	<b>Acceptance Criteria</b>
1.0	HFE operating experience review (OER) is performed in accordance with the U.S. EPR Human Factors Operating Experience Review Implementation Plan.	An analysis of the output summary report will be performed. {{DAC}}	An output summary report concludes that the lessons learned from the operating experience review have been incorporated into the HSI design. The output summary report addresses the scope and results of the OER process including: <ul style="list-style-type: none"> <li>• A list of databases used for searching.</li> <li>• A list of analyzed documents.</li> <li>• A list of significant issues found along with their implementation status at the time of the report.</li> <li>• The report includes documentation that shows the operating experience review process was conducted in accordance with the U.S. EPR Human Factors Operating Experience Review Implementation Plan.</li> </ul> {{DAC}}

**Table 3.4-1—Human Factors Engineering ITAAC**  
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Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
2.0	Functional requirements analysis is performed in accordance with the U.S. EPR Functional Requirements Analysis and Functional Allocation Implementation Plan.	An analysis of the output summary report will be performed. {{DAC}}	An output summary report includes: <ul style="list-style-type: none"> <li>• A list of functions in-scope for meeting plant safety objectives.</li> <li>• Details of the differences between functional requirements for safety functions between predecessor designs and the U.S. EPR.</li> <li>• Technical justification and design basis for each difference between predecessor and U.S. EPR functional requirement.</li> <li>• The report includes documentation that shows the functional requirements process was conducted in accordance with the U.S. EPR Functional Requirements Analysis and Functional Allocation Implementation Plan.</li> </ul> {{DAC}}

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Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
3.0	Functional allocation decisions are made based on a set of automation criteria which is defined and validated in accordance with the U.S. EPR Functional Requirements Analysis and Functional Allocation Implementation Plan.	An analysis of the output summary report will be performed. {{DAC}}	An output summary report includes: <ul style="list-style-type: none"> <li>• The complete set of automation criteria used including the established control hierarchy between automatic and manual actions.</li> <li>• A list of the functions automated for predecessor EPRs and the differences between the predecessors and the U.S. EPR.</li> <li>• Technical justification for each difference in functional allocation.</li> <li>• The report includes documentation that shows the functional requirements process was conducted in accordance with the U.S. EPR Functional Requirements Analysis and Functional Allocation Implementation Plan.</li> </ul> {{DAC}}

**Table 3.4-1—Human Factors Engineering ITAAC**  
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Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
4.0	A task analysis is performed in accordance with the U.S. EPR Task Analysis (TA) Implementation Plan.	An analysis of the TA output summary report will be performed. {{DAC}}	<p>The TA output summary report includes a description of how iterations of TA for procedure development, the procedures themselves, and training programs result in an HSI design that supports in-scope control, information, and support requirements.</p> <p>The TA output summary report includes:</p> <ul style="list-style-type: none"> <li>● Identification of specific tasks that are needed to accomplish the analyzed functions that are allocated to personnel covering the modes of operation.</li> <li>● Information, control, and support requirements defined for each task.</li> <li>● An inventory of alarms, displays, and controls necessary for operators to perform the tasks.</li> <li>● Identification of risk-significant human actions (HA) and their incorporation into the design.</li> <li>● Determination of necessary number and skill levels of crew members.</li> <li>● Documentation of necessary changes to the crew compliment as specified in the initial staffing assumption for the U.S. EPR design.</li> <li>● Allocation of monitoring and control tasks for crew members.</li> </ul>

**Table 3.4-1—Human Factors Engineering ITAAC**  
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Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
			<ul style="list-style-type: none"> <li>The report includes documentation that shows the task analysis process was conducted in accordance with the U.S. EPR Task Analysis Implementation Plan. This includes the functional branch tree database which contains the results of TA as described in the U.S. EPR Task Analysis Implementation Plan.</li> </ul> <p>{{DAC}}</p>
5.0	<p>The staffing and qualification analysis includes an evaluation of the number and qualifications of personnel needed to operate, maintain, and test the U.S. EPR based on HSI design features as described in the TA Implementation Plan.</p>	<p>An analysis of the output summary report will be performed.</p> <p>{{DAC}}</p>	<p>The output summary report of the U.S. EPR staffing and qualifications analyses demonstrates that the HSI design supports the number, roles, and responsibilities of the plant operating staff to meet the demands of the processes of the plant.</p> <p>The output summary report includes documentation that shows the staffing and qualifications analysis was conducted in accordance with the U.S. EPR Task Analysis Implementation Plan.</p> <p>{{DAC}}</p>



**Table 3.4-1—Human Factors Engineering ITAAC**  
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<b>Commitment Wording</b>		<b>Inspections, Tests, Analyses</b>	<b>Acceptance Criteria</b>
6.0	Human reliability analysis evaluates the potential for, and mechanisms of, human errors that may affect plant safety. Integration of human reliability analysis findings with HFE design is performed in accordance with the U.S. EPR Implementation Plan for the Integration of Human Reliability Analysis (HRA) into the Human Factors Engineering (HFE) Program.	An analysis of the output summary report will be performed. {{DAC}}	An output summary report documents the list of risk-important human actions (HA) and summarizes how those HA and the associated tasks and scenarios were addressed during the various parts of the HFE design process including validation of HRA assumptions. The output summary report includes documentation that shows the HRA process was conducted in accordance with the U.S. EPR Implementation Plan for the Integration of Human Reliability Analysis (HRA) into the Human Factors Engineering (HFE) Program. {{DAC}}
7.0	HSI design is performed in accordance with the prescribed process described in the U.S. EPR Human System Interface Design Implementation Plan.	An analysis of the output summary report will be performed. {{DAC}}	An output summary report: <ul style="list-style-type: none"> <li>• Demonstrates that the HSI design was performed in accordance with the U.S. EPR Human System Interface Design Implementation.</li> <li>• Documents the HSI descriptions including how the design requirements and design characteristics were met.</li> <li>• Documents the outcome of tests and evaluations performed in support of V&amp;V of HSI design.</li> </ul> {{DAC}}

**Table 3.4-1—Human Factors Engineering ITAAC**  
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Commitment Wording		Inspections, Tests, Analyses	Acceptance Criteria
8.0	The selection of the minimum inventory of MCR and RSS fixed alarms, displays, and controls is performed in accordance with the U.S. EPR Human System Interface Design Implementation Plan.	An analysis will be performed on the final HSI design results documents. {{DAC}}	An output summary report concludes that the HSI design process for the minimum inventory was conducted in accordance with the implementation plan and contains: <ul style="list-style-type: none"> <li>● The detailed HSI description including its form, function and performance requirements and characteristics.</li> <li>● The basis for the HSI requirements and design characteristics.</li> <li>● The outcomes of tests and evaluations.</li> <li>● The minimum inventory of MCR and RSS station fixed alarms, displays, and controls.</li> <li>● Verification that the as-built MCR and RSS contain the minimum inventory and validation that the minimum inventory supports operator performance of EOP actions and PRA critical actions to bring the reactor to a safe shutdown condition and to maintain it in that condition.</li> </ul> {{DAC}}
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**Table 3.4-1—Human Factors Engineering ITAAC**  
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<b>Commitment Wording</b>		<b>Inspections, Tests, Analyses</b>	<b>Acceptance Criteria</b>
11.0	HFE verification and validation is performed in accordance with the U.S. EPR Human Factors Verification and Validation (V&V) Implementation Plan.	An analysis of the output summary report will be performed. {{DAC}}	An output summary report: <ul style="list-style-type: none"> <li>• Demonstrates that the V&amp;V was performed in accordance with the U.S. EPR Human Factors Verification and Validation (V&amp;V) Implementation Plan.</li> <li>• Demonstrates that the design enables plant personnel to successfully perform their tasks to achieve plant safety and other operation goals.</li> <li>• Provides results of V&amp;V activities and conclusions from these activities.</li> </ul> {{DAC}}
12.0	Design implementation is performed in accordance with the U.S. EPR HFE Design Implementation Plan.	An analysis of the output summary will be performed. {{DAC}}	An output summary report demonstrates: <ul style="list-style-type: none"> <li>• The design implementation was performed in accordance with the U.S. EPR HFE Design Implementation Plan for validation that the as-built design conforms to the standard design resulting from the HFE V&amp;V process.</li> <li>• Issues identified in the HFE issues tracking database have been addressed.</li> </ul> {{DAC}}

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<b>Commitment Wording</b>		<b>Inspections, Tests, Analyses</b>	<b>Acceptance Criteria</b>
13.0	<p>Integrated System Validation scenarios are developed in accordance with the U.S. EPR Human Factors V&amp;V Implementation Plan and contain similar content as scenario examples for the U.S. EPR.</p>	<p>An analysis of the output summary report will be performed.</p>	<p>An output summary report demonstrates:</p> <ul style="list-style-type: none"> <li>● V&amp;V scenarios developed based on sampling dimensions described in the U.S. EPR Human Factors V&amp;V Implementation Plan.</li> <li>● V&amp;V scenarios incorporated scenario definition, performance measure, test design, and data analysis, and interpreted in accordance to the U.S. EPR Human Factors V&amp;V Implementation Plan.</li> <li>● HFE scenarios are performed on a validation test bed in accordance with the U.S. EPR Human Factors V&amp;V Implementation Plan.</li> </ul> <p>{{DAC}}</p>