3.4 Human Factors Engineering

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.

3.4.1 Scope

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 HSIs.

The HFE and Control Room Design Team is also responsible for program concepts for development of operating procedures, staffing requirements, and designer's input to the training program.

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 LCSs is accomplished concurrent with the applicable system design and follows guidelines established by the HFE and Control

Room Design Team. The HFE and Control Room Design Team also participates in the design of the Emergency Operations Facility (EOF).

The scope of the HFE program includes HSIs 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. HSIs associated with non-I&C systems (e.g., manual valve operators and other LCSs) follow guidelines established by the HFE and Control Room Design Team.

The HFE program has the following features:

1. HFE operating experience review is performed in accordance with the prescribed process. Results of the operating experience review are incorporated in the HSI design.

2. Functional requirements are translated from the predecessor design engineering documentation.

3. Functional allocation decisions are made based on a set of automation criteria which is defined and validated with the prescribed process.

4. A task analysis is documented by validation of operating procedures containing HAs that the PRA found to be risk significant.

5. 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.

6. 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 prescribed process.

7. HSI interface design is performed in accordance with the prescribed process to translate the function and task requirements into HSI characteristics and functions.

8. The process for HSI design describes minimum inventory criteria and the methodology for selecting and validating the final minimum inventory.

9. HFE integration with procedure development is performed so that procedures are technically accurate, comprehensive, explicit, conform with HFE ease of use principles, and validated (i.e., the user can comply with the requirements of each step).

10. HFE integration with training program development is performed so that a methodical analysis of job and task requirements and a systematic approach to training are used to provide plant personnel with required knowledge, skills, and attributes to perform assigned tasks.

11. HFE verification and validation establishes that the design of the HSI meets design requirements and that the HSI is effective in supporting the performance of personnel tasks.

12. Design implementation verifies that the as-built design conforms to the standard design resulting from the HFE V&V process and that issues defined as human engineering discrepancies identified in the HFE Issues Tracking Database are addressed.

3.4.2 Inspection, Tests, Analyses and Acceptance Criteria

Table 3.4-1— Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria provides the ITAAC for the HFE program.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
1	HFE operating experience review is performed in accordance with the prescribed process. Results of the operating experience review are incorporated in the HSI design.	a. An evaluation of the process for conducting operating experience review has been performed.	a.1 The process provides a method to: • Identify predecessor/related plants. • Identify recognized industry HFE issues. • Identify OE of related HFE technology. • Identify issues identified by plant personnel. • Identify risk-important human actions requiring special attention during the design process. • Analyze, document, track, and review issues.
		b. An evaluation of the output summary has been performed.	b.1 The output summary demonstrates that the lessons learned from the reviewed operating experience have been incorporated into the HSI design.
2	Functional requirements are translated from the predecessor design engineering documentation.	a. An evaluation of the output summary (included with the V&V documentation) has been performed.	a.1 The output summary includes: • A list of functions in-scope for meeting plant safety objectives. • Details of the differences between functional requirements for safety functions between predecessor designs and the U.S. EPR. • Technical justification and design basis for each difference between predecessor and U.S. EPR functional requirement.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
3	Functional allocation decisions are made based on a set of automation criteria which is defined and validated with the prescribed process.	a. An evaluation of the process for allocating functions has been performed.	a.1 The process provides: • A structured method to allocate functions to human and machine resources. • A method to document and keep the function allocation current over the life of the plant. • A method to identify the technical basis for all function allocations.
		b. An evaluation of the output summary (included with the V&V documentation) has been performed.	b.1 The output summary includes: • The complete set of automation criteria used including the established control hierarchy between automatic and manual actions. • A list of the functions automated for predecessor EPRs and the differences between the predecessors and the U.S. EPR. • Technical justification for each difference in functional allocation.
4	A task analysis is documented by validation of operating procedure guidelines containing HAs that the PRA found to be risk significant.	a. An evaluation of the output summary (included with the V&V documentation) has been performed.	a.1 The output summary includes a description of how iterations of the procedure development task analyses, the procedures themselves, and training programs result in an HSI design that supports in-scope control, information, and support requirements.
			a.2 The draft operating procedure guidelines identify functions needed to complete the given series of tasks.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
5	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.	a. An evaluation of the output summary (included with the V&V documentation) has been performed.	a.1 The output summary describes: • How staffing assumptions were validated. • How minimum staffing meets regulatory requirements while maintaining roles and responsibilities.
6	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 prescribed process.	a. An evaluation of the process for integration of human reliability analysis with HFE design activities has been performed.	a.1 The process provides a method for: • Identifying risk-important human actions. • Addressing risk-important human actions in the HFE program. • Validating HRA assumptions.
		b. An evaluation of the output summary has been performed.	b.1 The output summary documents: • The results of the human reliability analysis and how HFE design efforts were affected. • The validation of the human reliability analysis through plant-specific control room mockup or simulator.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
7	HSI design is performed in accordance with the prescribed process to translate the function and task requirements into HSI characteristics and functions.	a. An evaluation of the process for HSI design has been performed.	a.1 The process: • Allows for incorporation of personnel task requirements. • Considers system requirements, regulatory requirements, and other requirements in the HSI design. • Includes development of a concept of operations. • Includes development of a functional requirement specification. • Provides a method to develop the HSI design. • Includes development of design guidance (i.e., a style guide). • Provides a method to develop the HSI detailed design and integration. • Provides a method for determining the minimum inventory of alarms, displays, and controls. • Describes a method to determine the complete list of accident monitoring instrumentation • Provides a method for developing HSI tests and evaluations. • Describes how the HSI design is documented.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
		b. An evaluation of the output summary has been performed.	b.1 The output summary: • Demonstrates that the HSI design was performed in accordance with the prescribed process. • Documents the HSI descriptions including how the design requirements and design characteristics were met. • Documents the outcome of tests and evaluations performed in support of V&V of HSI design.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
8	The process for HSI design describes minimum inventory criteria and the methodology for selecting and validating the final minimum inventory.	a. An evaluation of the criteria and the process for selecting and validating the final minimum inventory has been performed.	a.1 The methodology for selecting the final minimum inventory includes: • The selection criteria. • How the functions and tasks that need to be supported by the minimum inventory are identified. • The technical requirements that apply to the design of the minimum inventory including those imposed by regulatory requirements including those for qualification, independence, and accessibility. • How the plant-specific PRA is used to identify operator actions or tasks that are risk-important. • How the guidance related to defining post-accident monitoring variables is addressed. • The operator actions credited in the safety analysis or plant-specific EPGs for safety and non-safety success paths. • How the diversity and defense-in-depth evaluation is used to identify any specific operator actions credited for coping with common cause failures of the protection systems. • The criteria that are used to determine which SICS components need to be spatially dedicated, continuously visible, continuously available, or accessible by taking only one action (i.e., MCR design and concept of operations).

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
			a.2 The methodology for verifying the completeness of the minimum inventory in the MCR and the RSS includes: • How generic technical guidelines or design-specific guidelines are used for developing EOPs. • How task analysis activities related to procedure development describe the operator actions necessary to bring the reactor to safe shutdown. • How the risk-important operator actions identified through the plant-specific HRA are incorporated into the HSI design. • How the critical operator actions credited for diversity and defense-in-depth are incorporated into the HSI design. • How the full-scope simulator is utilized in the verification process.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
9	HFE integration with procedure development is performed so that procedures are technically accurate, comprehensive, explicit, easy to use, and validated (i.e., the user can comply with the requirements of each step).	a. An evaluation of the process for HFE integration with procedure development has been performed.	a.1 The process for HFE integration with procedure development describes: • The basis or starting point for procedure development (i.e., how the TA and procedure development interrelate). • The content of procedures. • How the HSI style guide integrates with the procedure writer's guide. • How procedures are verified and validated. • The justification for use of electronic operating procedures instead of paper-based procedures.
		b. An evaluation of the output summary has been performed.	b.1 The output summary: • Addresses the final set of procedures and support equipment developed using the established methodology. • Includes the results of verification and validation activities as they relate to procedure development. • Describes how procedures will be maintained and updates controlled. • Gives a description of how operators access and use procedures, especially during operational events including: • Storage of procedures. • Ease of operator access to the correct procedures.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
10	HFE integration with training program development is performed so that a methodical analysis of job and task requirements and a systematic approach to training are used to provide plant personnel with required knowledge, skills, and attributes to perform assigned tasks.	a. An evaluation of the process for HFE integration with training program development has been performed.	a.1 The process describes training program scope including: • Categories of personnel to be trained. • Specific plant conditions, operational activities (e.g., operations, maintenance, testing and surveillance), and HSIs which effect training scenarios and methods.
		b. An evaluation of the output summary has been performed.	b.1 The output summary addresses: • The roles of organizations that contributed to the training program. • How learning objectives were developed and translated into the use of associated knowledge, skills, and attributes. • The use of resources (e.g., lectures, simulators, computer-based training, schedule) for training. • Methods used to evaluate effectiveness of the program.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
11	HFE verification and validation establishes that the design of the HSI meets design requirements and that the HSI is effective in supporting the performance of personnel tasks.	a. An evaluation of the process for conducting HFE V&V has been performed.	a.1 The process provides a method: • For sampling operational conditions. • For identifying appropriate sampling dimensions. • To identify scenarios. • To inventory and characterize the HSI defined in the scope of the HSI design review. • To verify that the HSI provides alarms, information, and control capabilities required for personnel tasks. • To verify that the characteristics of the HSI and the environment in which it is used conform to HFE guidelines. • To evaluate the integrated system to determine whether it acceptably supports safe operation of the plant. • To address and resolve human error discrepancies.
		b. An evaluation of the output summary has been performed.	b.1 The output summary: • Demonstrates that the V&V was performed in accordance with the prescribed process. • Demonstrates that the design conforms to HFE design principles. • Demonstrates that the design enables plant personnel to successfully perform their tasks to achieve plant safety and other operation goals. • Provides results of V&V activities and conclusions from these activities.

Table 3.4-1—Human Factors Engineering Inspections, Tests, Analyses, and Acceptance Criteria (11 Sheets)

	Commitment	Inspection, Analysis or Test	Acceptance Criteria
12	Design implementation validates that the as-built design conforms to the standard design resulting from the HFE V&V process and that issues defined as human engineering discrepancies identified in the HFE Issues Tracking Database are addressed.	a. An evaluation of the process for conducting design implementation has been performed.	a.1 The process provides a method: • For evaluating aspects of the design that were not addressed in the V&V step of the design process. • To validate that the final as-built HSIs conform to the design that resulted from the HFE design process and V&V activities.
		b. An evaluation of the output summary has been performed.	b.1 The output summary demonstrates that: • The design implementation was performed in accordance with the prescribed process. • Appropriate issues identified in the HFE issues tracking database have been adequately addressed.