

3.1 Human Factors Engineering

Design Description

The ABWR certified design's human-system interface (HSI) will be developed, designed, and evaluated based upon a human factors systems analysis and shall reflect human factors principles. The HSI scope applies to the main control room (MCR) and Remote Shutdown System (RSS). Further, within the MCR, the HSI scope includes that area which provides the displays, controls and alarms required for normal, abnormal and emergency plant operations.

The HSI design effort will be directed by a multi-disciplinary HFE Design Team comprised of personnel with expertise in human factors engineering (HFE) and in other technical areas relevant to the HSI design, evaluation and operations. The HFE Design Team shall develop a Program Plan to establish methods for implementing the HSI design through a process of human factor systems analysis as shown in Figure 3.1. Implementation of that process will be as follows:

- (1) A System Functional Requirements Analysis Implementation Plan will be developed which establishes that plant system functional requirements will be analyzed to identify those functions which must be performed to satisfy the objectives of each functional area. System functional requirements analyses, as corrected to account for nonconformances, will be conducted in conformance with the provisions of this plan. The functional analyses will determine the objectives, performance requirements and constraints of the design, and establish the functions which must be accomplished to meet the objectives and required performance.
- (2) An Allocation of Functions Implementation Plan will be developed to establish methods of allocating functions to personnel, system elements and personnel-system combinations. An analysis of the allocation of system functions, as corrected to account for nonconformances, will be conducted in conformance with the provisions of this Plan.
- (3) A Task Analysis Implementation Plan will be developed to establish methods for conducting the task analysis. The task analysis, as corrected to account for nonconformances, will be conducted in conformance with the provisions of this Plan and will be used to identify the behavioral requirements of the tasks the personnel are required to perform in order to achieve the functions allocated to them. The task analysis will identify the information and control requirements that form the basis for specifying the requirements for the displays, data processing and controls needed to carry out the tasks. The task analysis will also be used to maintain human performance requirements within human capabilities, as an input for developing personnel skill, personnel training, plant procedures and system communication requirements and as an input to the evaluation of established plant operations control room staffing levels.

- (4) A Human-System Interface Design Implementation Plan will be developed to establish methods for applying human engineering principles in the design definition and evaluation of the HSI. HSI design definition and evaluation, as corrected to account for nonconformances, shall be conducted in conformance with the provisions of this plan.
- (5) A Human Factors Verification and Validation Implementation Plan will be developed to establish methods for conducting an evaluation of the HSI design as an integral system using HFE evaluation principles, procedures and criteria. The HSI design, as corrected to account for nonconformances, will be evaluated as an integrated system in conformance with the provisions of this plan.
- (6) The as-built configuration of the MCR and RSS shall be in conformance with the certified and validated MCR and RSS designs.

Inspections, Tests, Analyses and Acceptance Criteria

Table 3.1 provides a definition of the instructions, tests, and/or analyses, together with associated acceptance criteria, which will be undertaken to demonstrate compliance with the HFE commitments for the certified design.

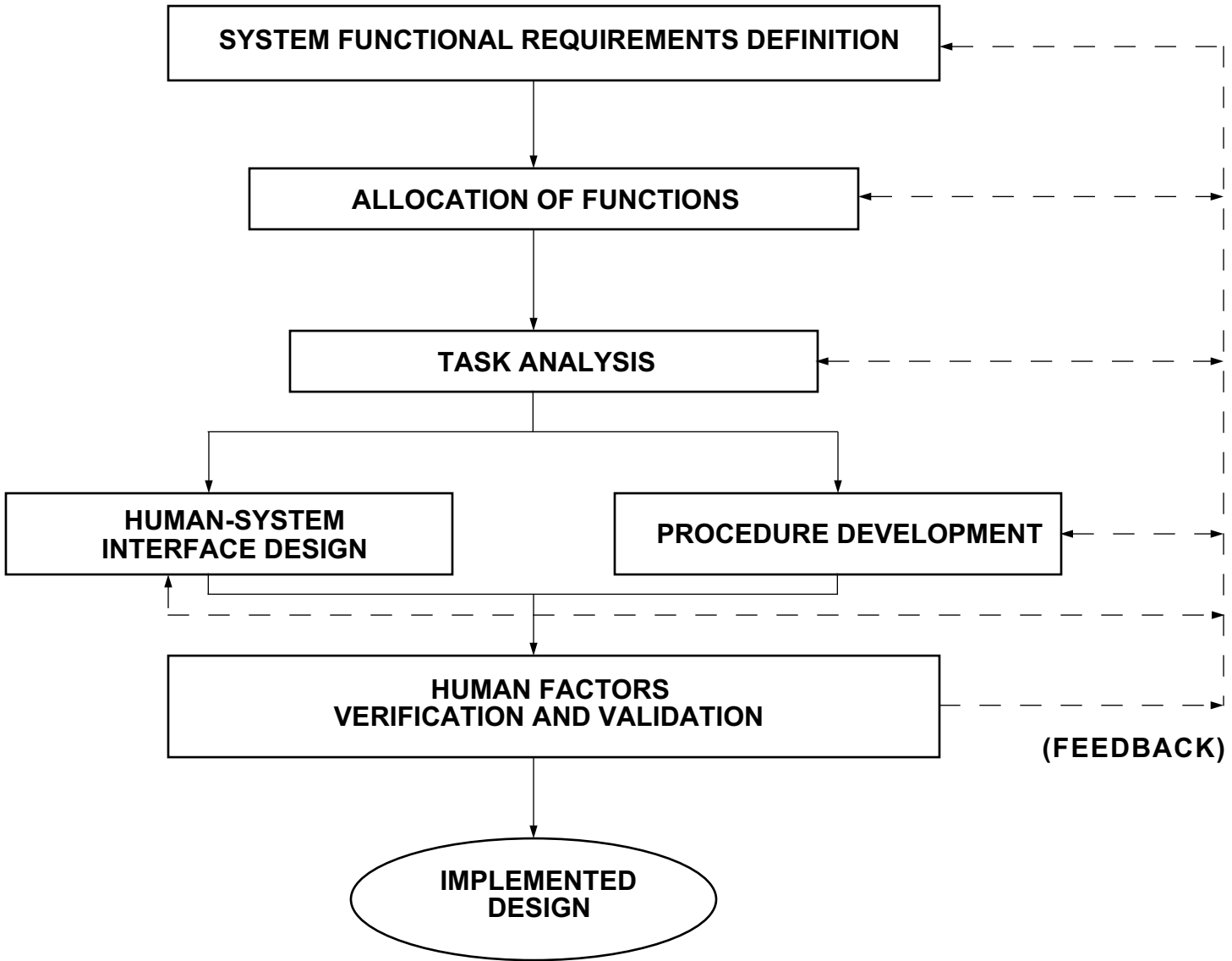


Figure 3.1 Human-System Interface Design Implementation Process

Table 3.1 Human Factors Engineering

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
<p>1.</p> <p>a. A multi-disciplinary HFE Design Team shall be established and be comprised of personnel with expertise in HFE and in other technical areas relevant to the HSI design, evaluation and operation.</p> <p>b. An HFE Program Plan shall be developed which establishes that the human-system interfaces shall be developed, designed, and evaluated based upon human factors systems analysis and shall reflect human factors principles. The HSI scope shall apply to the MCR and RSS.</p>	<p>1.</p> <p>a. The composition of the HFE Design Team shall be reviewed.</p> <p>b. The HFE Program Plan shall be reviewed.</p>	<p>1.</p> <p>a. The HFE design team shall be comprised of the following expertise:</p> <ul style="list-style-type: none"> (1) Technical Project Management (2) Systems Engineering (3) Nuclear Engineering (4) Control and Instrumentation Engineering (5) Architect Engineering (6) Human Factors (7) Plant Operations (8) Computer Systems Engineering (9) Plant Procedure Development (10) Personnel Training <p>b. The HFE Program Plan shall establish:</p> <ul style="list-style-type: none"> (1) Methods and criteria for the HSI development, design and evaluation in accordance with accepted human factors practices and principles. (2) Methods for addressing: <ul style="list-style-type: none"> (a) The ability of the operating personnel to accomplish assigned tasks. (b) Operator workload levels and vigilance.

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
1.b. Continued	1.b. Continued	<p>1.b. Continued</p> <p>(c) Operating personnel “situation awareness.”</p> <p>(d) The operators’ information processing requirements.</p> <p>(e) Operator memory requirements.</p> <p>(f) The potential for operator error.</p> <p>(3) HSI design and evaluation scope which applies to the MCR and RSS. The HSI scope shall address normal, abnormal and emergency plant operations, and test and maintenance interfaces that impact the functions of the operations personnel. The HSI scope shall also address the development of operating technical procedures for normal, abnormal and emergency plant operations and the identification of personnel training needs applicable to the HSI design.</p>

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
1.b. Continued	1.b. Continued	<p>1.b. Continued</p> <p>(4) The HFE Design Team as being responsible for:</p> <ul style="list-style-type: none"> (a) The development of HFE plans and procedures. (b) The oversight and review of HFE design, development, test, and evaluation activities. (c) The initiation, recommendation, and provision of solutions through designated channels for problems identified in the implementation of the HFE activities. (d) Verification of implementation of solutions to problems. (e) Assurance that HFE activities comply with the HFE plans and procedures. (f) Phasing of activities. <p>(5) The methods for the identification, closure and documentation of human factors issues.</p> <p>(6) The HSI design configuration control procedures.</p> <p>(7) The methods for reviewing HSI operating experience.</p>

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
<p>2.</p> <p>a. A System Functional Requirements Analysis Implementation Plan shall be developed which establishes that plant system requirements shall be analyzed to identify those functions which must be performed to satisfy the objectives of each functional area. System function analysis shall determine the objective, performance requirements, and constraints of the design, and establish the functions which must be accomplished to meet the objectives and required performance.</p>	<p>2.</p> <p>a. The System Functional Requirements Analysis Implementation Plan shall be reviewed.</p>	<p>2.</p> <p>a. The System Functional Requirements Analysis Implementation Plan shall establish:</p> <ol style="list-style-type: none"> (1) Methods and criteria for conducting the System Functional Requirements Analysis in accordance with accepted human factors practices and principles. (2) That system requirements shall define the system functions and those system functions shall provide the basis for determining the associated HSI performance requirements. (3) That functions critical to safety shall be identified. (4) That descriptions shall be developed for each of the identified functions and for overall system configuration design itself. Each function shall be identified and described in terms of inputs (observable parameters which will indicate system status), functional processing (control process and performance measures required to achieve the function), functional operations (including detecting signals, measuring information, comparing one measurement with another, processing

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
2.a. Continued	2.a. Continued	information, and acting upon decisions to produce a desired condition or result such as a system or component operation actuation or trip), outputs, feedback (how to determine correct discharge of function), and interface requirements so that subfunctions are related to larger functional elements.
b. An analysis of system functional requirements shall be conducted.	b. The analysis of the system functional requirements shall be reviewed.	b. The system functional requirements analysis, as corrected to account for nonconformances, is conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the System Functional Requirements Analysis Implementation Plan.

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
<p>3.</p> <p>a. An Allocation of Function Implementation Plan shall be developed which establishes the methods for allocating functions to personnel, system elements, and personnel-system combinations.</p>	<p>3.</p> <p>a. The Allocation of Function Implementation Plan shall be reviewed.</p>	<p>3.</p> <p>a. The Allocation of Function Implementation Plan shall establish:</p> <p>(1) The methods and criteria for the execution of function allocation in accordance with accepted human factors practices and principles.</p> <p>(2) That aspects of system and functions definition shall be analyzed in terms of resulting human performance requirements based on the user population.</p> <p>(3) That the allocation of functions to personnel, system elements, and personnel system combinations shall reflect:</p> <p>(a) Sensitivity, precision, time, and safety requirements.</p> <p>(b) Reliability of system performance.</p> <p>(c) The number and the necessary skills of the personnel required to operate and maintain the system.</p> <p>(4) That allocation criteria, rationale, analyses, and procedures shall be documented.</p>

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
3.a. Continued	3.a. Continued	(5) That analyses shall confirm that the personnel can perform tasks allocated to them while maintaining operator situation awareness, acceptable personnel workload, and personnel vigilance.
b. A functional allocation analysis shall be conducted.	b. The functional allocation analysis shall be reviewed.	b. The functional allocation analysis, as corrected to account for nonconformances, is conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the Allocation of Functions Implementation Plan.

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
<p>4.</p> <p>a. A Task Analysis Implementation Plan shall be developed which establishes that task analysis shall be conducted and used to identify the behavioral requirements of the tasks the personnel are required to perform in order to achieve the functions allocated to them. The task analysis shall be used to maintain human performance requirements within human capabilities; be used as an input for developing personnel skill, personnel training, and system communication requirements and as an input to the evaluation of established plant operations control room staffing levels; and form the basis for specifying the requirements for the displays, data processing and controls needed to carry out tasks.</p>	<p>4.</p> <p>a. The Task Analysis Implementation Plan shall be reviewed.</p>	<p>4.</p> <p>a. The Task Analysis Implementation Plan shall establish:</p> <ol style="list-style-type: none"> (1) The methods and criteria for conduct of the task analyses in accordance with accepted human factors practices and principles. (2) The scope of the task analysis which shall include operations performed at the operator interface in the MCR and at the RSS. The analyses shall be directed to the range of plant operating modes, including startup, normal operations, abnormal operations, transient conditions, low power and shutdown conditions. The analyses shall also address operator interface operations during periods of maintenance, test and inspection of plant systems and equipment, including HSI equipment. (3) That the analysis shall be used to identify which tasks are critical to safety.

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
4.a. Continued	4.a. Continued	<p>(4) That task analysis shall develop narrative descriptions of the personnel activities required for successful completion of the task.</p> <p>(5) That task analysis shall identify requirements for alarms, displays, data processing, and controls.</p> <p>(6) That task analysis results shall be made available as input to the personnel training programs.</p>
b. A task analysis shall be conducted.	b. The task analysis shall be reviewed.	b. The task analysis, as corrected to account for nonconformances, is conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the Task Analysis Implementation Plan.

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
<p>5.</p> <p>a. HSI Design Implementation Plan shall be developed which establishes that human engineering principles and criteria shall be applied in the design definition and evaluation of the HSI.</p>	<p>5.</p> <p>a. The HSI Design Implementation Plan shall be reviewed.</p>	<p>5.</p> <p>a. The HSI Design Implementation Plan shall establish:</p> <ol style="list-style-type: none"> (1) The methods and criteria for HSI design in accordance with accepted human factors practices and principles. (2) That the HSI design shall implement the information and control requirements: <ol style="list-style-type: none"> (a) developed through the task analyses, including the displays, controls and alarms necessary for the execution of those tasks identified in the task analyses as being critical tasks and, (b) defined in Table 2.7.1.a. (3) The methods for comparing the consistency of the HSI human performance, equipment design and associated workplace factors with that modeled and evaluated in the completed task analysis. (4) The HSI design criteria and guidance for control room operations during periods of maintenance, test and inspection. (5) The test and evaluation methods for resolving HFE/HSI design issues. These test and evaluation methods shall include the criteria to be used in selecting HFE/HSI design and evaluation tools.

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
<p>b. The HSI design shall be implemented.</p> <p>6.</p> <p>a. A Human Factors Verification and Validation (V&V) Implementation Plan shall be developed which establishes that the HSI design shall be evaluated as an integrated system using HFE evaluation principles, procedures and criteria.</p>	<p>b. The HSI design implementation shall be reviewed.</p> <p>6.</p> <p>a. The Human Factors V&V Plan shall be reviewed.</p>	<p>b. The HSI design implementation and analyses, as corrected to account for nonconformances, are conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the HSI Design Implementation Plan,</p> <p>6.</p> <p>a. The Human Factors V&V Implementation Plan shall establish:</p> <p>(1) The methods and criteria for conducting the Human factors V&V in accordance with accepted human factors practices and principles.</p> <p>(2) That scope of the evaluations of the integrated HSI shall include:</p> <p>(a) The HSI (including both the interface of the operator with the HSI equipment hardware and the interface of the operator with the HSI equipment's software driven functions).</p> <p>(b) The Plant and Emergency Operating Procedures.</p> <p>(c) The HSI work environment.</p>

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
6.a.Continued	6.a. Continued	<p>6.a. Continued</p> <p>(3) That evaluations of the HSI equipment shall be conducted to confirm that the controls, displays, and data processing functions identified in the task analyses are provided.</p> <p>(4) That integration of HSI equipment with each other, with the operating personnel and with the Plant and Emergency Operating Procedures shall be evaluated through the conduct of dynamic task performance testing. The dynamic task performance tests and evaluations shall have as their objectives:</p> <p>(a) Confirmation that the identified critical functions can be achieved using the integrated HSI design.</p> <p>(b) Confirmation that the HSI design and configuration can be operated using the established MCR staffing levels.</p>

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
6.a. Continued	6.a. Continued	6.a.(4) Continued <ul style="list-style-type: none">(c) Confirmation that the Plant and Emergency Operating Procedures provide direction for completing the identified tasks associated with normal, abnormal and emergency operations.(d) Confirmation that the time dependent and interactive aspects of the HSI equipment performance allow for task accomplishment.(e) Confirmation that the allocation of functions is sufficient to enable task accomplishment. (5) That dynamic task performance test evaluations shall be conducted over the range of operational conditions and upsets.

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
6.a. Continued	6.a. Continued	<p>6.a. Continued</p> <p>(6) The HFE performance measures to be used as the basis for evaluating the dynamic task performance test results. These performance measures shall address:</p> <ul style="list-style-type: none"> (a) Operating crew primary task performance characteristics, such as task times and procedure compliance. (b) Operating crew errors and error rates. (c) Operating crew situation awareness. (d) Operating crew workload. (e) Operating crew communications and coordination. (f) Anthropometry evaluations. (g) HSI equipment performance measures. <p>(7) The methods to confirm that HFE issues identified and documented have been resolved in the integrated HSI design.</p>

Table 3.1 Human Factors Engineering (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	Inspections, Tests, Analyses	Design Acceptance Criteria
6.a. Continued	6.a. Continued	6.a. Continued (8) The methods and criteria to be used to confirm that critical human tasks, as defined by the task analysis, have been addressed in the integrated HSI design.
b. A human factors engineering analysis of the integrated HSI design shall be conducted.	b. The analyses of the integrated HSI design shall be reviewed.	b. The human factors engineering analysis of the HSI design, as corrected to account for nonconformances, is conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the Human Factors V&V Implementation Plan.
7. The as-built configuration of the MCR and RSS shall be in conformance with the certified and validated MCR and RSS designs.	7. Inspections of the as-built MCR and RSS will be conducted.	7. An as-built evaluation report exists which concludes that the as-built MCR and RSS conform to the certified and validated MCR and RSS configurations, including layouts, environmental characteristics, the HSI, alarms, displays and controls.