3.2 Human Factors Engineering

Design Description

The AP1000 human-system interface (HSI) will be developed and implemented based upon a human factors engineering (HFE) program. Figure 3.2-1 illustrates the HFE program elements. The HSI scope includes the design of the operation and control centers system (OCS) and each of the HSI resources. For the purposes of the HFE program, the OCS includes the main control room (MCR), the remote shutdown workstation (RSW), the local control stations, and the associated workstations for each of these centers. The HSI resources include the wall panel information system, alarm system, plant information system (nonsafety-related displays), qualified data processing system (safety-related displays), and soft and dedicated controls. Minimum inventories of controls, displays, and visual alerts are specified as part of the HSI for the MCR and the RSW.

The MCR provides a facility and resources for the safe control and operation of the plant. The MCR includes a minimum inventory of displays, visual alerts and fixed-position controls. Refer to item 8.a and Table 2.5.2-5 of subsection 2.5.2 for this minimum inventory.

The remote shutdown room (RSR) provides a facility and resources to establish and maintain safe shutdown conditions for the plant from a location outside of the MCR. The RSW includes a minimum inventory of displays, controls, and visual alerts. Refer to item 2 and Table 2.5.4-1 of subsection 2.5.4 for this minimum inventory. As stated in item 8.b of subsection 2.5.2, the protection and safety monitoring system (PMS) provides for the transfer of control capability from the MCR to the RSW.

The mission of local control stations is to provide the resources, outside of the MCR, for operations personnel to perform monitoring and control activities.

Implementation of the HFE program includes activity 1 below. The MCR includes design features specified by items 2 through 4 below. The RSW includes the design features specified by items 5 through 8 below. Local control stations include the design feature of item 9.

1. The HFE verification and validation program is performed in accordance with the HFE verification and validation implementation plan and includes the following activities:

   a) HSI Task support verification
   b) HFE design verification
   c) Integrated system validation
   d) Issue resolution verification
   e) Plant HFE/HSI (as designed at the time of plant startup) verification

2. The MCR includes reactor operator workstations, supervisor workstation(s), safety-related displays, and safety-related controls.

3. The MCR provides a suitable workspace environment for use by MCR operators.

4. The HSI resources available to the MCR operators include the alarm system, plant information system (nonsafety-related displays), wall panel information system, and nonsafety-related controls (soft and dedicated).

5. The RSW includes reactor operator workstation(s) from which licensed operators perform remote shutdown operations.

6. The RSR provides a suitable workspace environment, separate from the MCR, for use by the RSW operators.

7. The HSI resources available at the RSW include the alarm system displays, the plant information system, and the controls.

8. The RSW and the available HSI permit execution of tasks by licensed operators to establish and maintain safe shutdown.

9. The capability to access displays and controls is provided (controls as assigned by the MCR operators) for local control and monitoring from selected locations throughout the plant.

Inspections, Tests, Analyses, and Acceptance Criteria

Table 3.2-1 specifies the inspections, tests, analyses, and associated acceptance criteria for the HFE program, MCR, RSW, and local control stations.

Table 3.2-1
Inspections, Tests, Analyses, and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. The HFE verification and validation program is performed in accordance with the HFE verification and validation implementation plan and includes the following activities:		
a) HSI Task support verification	a) An evaluation of the implementation of the HSI task support verification will be performed.	a) A report exists and concludes that: Task support verification was conducted in conformance with the implementation plan and includes verification that the information and controls provided by the HSI match the display and control requirements generated by the function-based task analyses and the operational sequence analyses.
b) HFE design verification	b) An evaluation of the implementation of the HFE design verification will be performed.	b) A report exists and concludes that: HFE design verification was conducted in conformance with the implementation plan and includes verification that the HSI design is consistent with the AP1000 specific design guidelines (compiled as specified in the third acceptance criteria of design commitment 3) developed for each HSI resource.
c) Integrated system validation	c) (i) An evaluation of the implementation of the integrated system validation will be performed.	c) (i) A report exists and concludes that: The test scenarios listed in the implementation plan for integrated system validation were executed in conformance with the plan and noted human deficiencies were addressed.

Table 3.2-1 (cont.)
Inspections, Tests, Analyses, and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
	c) (ii) Tests and analyses of the following plant evolutions and transients, using a facility that physically represents the MCR configuration and dynamically represents the MCR HSI and the operating characteristics and responses of the AP1000 design, will be performed: – Normal plant heatup and startup to 100% power – Normal plant shutdown and cooldown to cold shutdown – Transients: reactor trip and turbine trip – Accidents: - Small-break LOCA - Large-break LOCA - Steam line break - Feedwater line break - Steam generator tube rupture	c) (ii) A report exists and concludes that: The test and analysis results demonstrate that the MCR operators can perform the following: – Heat up and start up the plant to 100% power – Shut down and cool down the plant to cold shutdown – Bring the plant to safe shutdown following the specified transients – Bring the plant to a safe, stable state following the specified accidents
d) Issue resolution verification	d) An evaluation of the implementation of the HFE design issue resolution verification will be performed.	d) A report exists and concludes that: HFE design issue resolution verification was conducted in conformance with the implementation plan and includes verification that human factors issues documented in the design issues tracking system have been addressed in the final design.
e) Plant HFE/HSI (as designed at the time of plant startup) verification	e) An evaluation of the implementation of the plant HFE/HSI (as designed at the time of plant startup) verification will be performed.	e) A report exists and concludes that: The plant HFE/HSI, as designed at the time of plant startup, is consistent with the HFE/HSI verified in 5.a) through 5.d).

Table 3.2-1 (cont.)
Inspections, Tests, Analyses, and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
2. The MCR includes reactor operator workstations, supervisor workstation(s), safety-related displays, and safety-related controls.	An inspection of the MCR workstations and control panels will be performed.	The MCR includes reactor operator workstations, supervisor workstation(s), safety-related displays, and safety-related controls.
3. The MCR provides a suitable workspace environment for use by the MCR operators.	i) See Tier 1 Material, subsection 2.7.1, Nuclear Island Nonradioactive Ventilation System. ii) See Tier 1 Material, subsection 2.2.5, MCR Emergency Habitability System. iii) See Tier 1 Material, subsection 2.6.3, Class 1E dc and UPS System. iv) See Tier 1 Material, subsection 2.6.5, Lighting System. v) See Tier 1 Material, subsection 2.3.19, Communication System.	i) See Tier 1 Material, subsection 2.7.1, Nuclear Island Nonradioactive Ventilation System. ii) See Tier 1 Material, subsection 2.2.5, MCR Emergency Habitability System. iii) See Tier 1 Material, subsection 2.6.3, Class 1E dc and UPS system. iv) See Tier 1 Material, subsection 2.6.5, Lighting System. v) See Tier 1 Material, subsection 2.3.19, Communication System.
4. The HSI resources available to the MCR operators include the alarm system, plant information system (nonsafety-related displays), wall panel information system, and nonsafety-related controls (soft and dedicated).	An inspection of the HSI resources available in the MCR for the MCR operators will be performed.	The HSI (at the time of plant startup) includes an alarm system, plant information system (nonsafety-related displays), wall panel information system, and nonsafety-related controls (soft and dedicated).
5. The RSW includes reactor operator workstation(s) from which licensed operators perform remote shutdown operations.	An inspection of the RSW will be performed.	The RSW includes reactor operator workstation(s).

Table 3.2-1 (cont.)
Inspections, Tests, Analyses, and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
6. The RSR provides a suitable workspace environment, separate from the MCR, for use by the RSW operators.	i) See Tier 1 Material, subsection 2.7.1, Nuclear Island Nonradioactive Ventilation System. ii) See Tier 1 Material, subsection 2.6.5, Lighting System. iii) See Tier 1 Material, subsection 2.3.19, Communication System.	i) See Tier 1 Material, subsection 2.7.1, Nuclear Island Nonradioactive Ventilation System. ii) See Tier 1 Material, subsection 2.6.5, Lighting System. iii) See Tier 1 Material, subsection 2.3.19, Communication System.
7. The HSI resources available at the RSW include the alarm system displays, the plant information system, and the controls.	An inspection of the HSI resources available at the RSW will be performed.	The as-built HSI at the RSW includes the alarm system displays, the plant information system, and the controls.
8. The RSW and the available HSI permit execution of tasks by licensed operators to establish and maintain safe shutdown.	Test and analysis, using a workstation that physically represents the RSW and dynamically represents the RSW HSI and the operating characteristics and responses of the AP1000, will be performed.	A report exists and concludes that the test and analysis results demonstrate that licensed operators can achieve and maintain safe shutdown conditions from the RSW.
9. The capability to access displays and controls is provided (controls as assigned by the MCR operators) for local control and monitoring from selected locations throughout the plant.	An inspection of the local control and monitoring capability is provided.	The capability for local control and monitoring from selected locations throughout the plant exists.

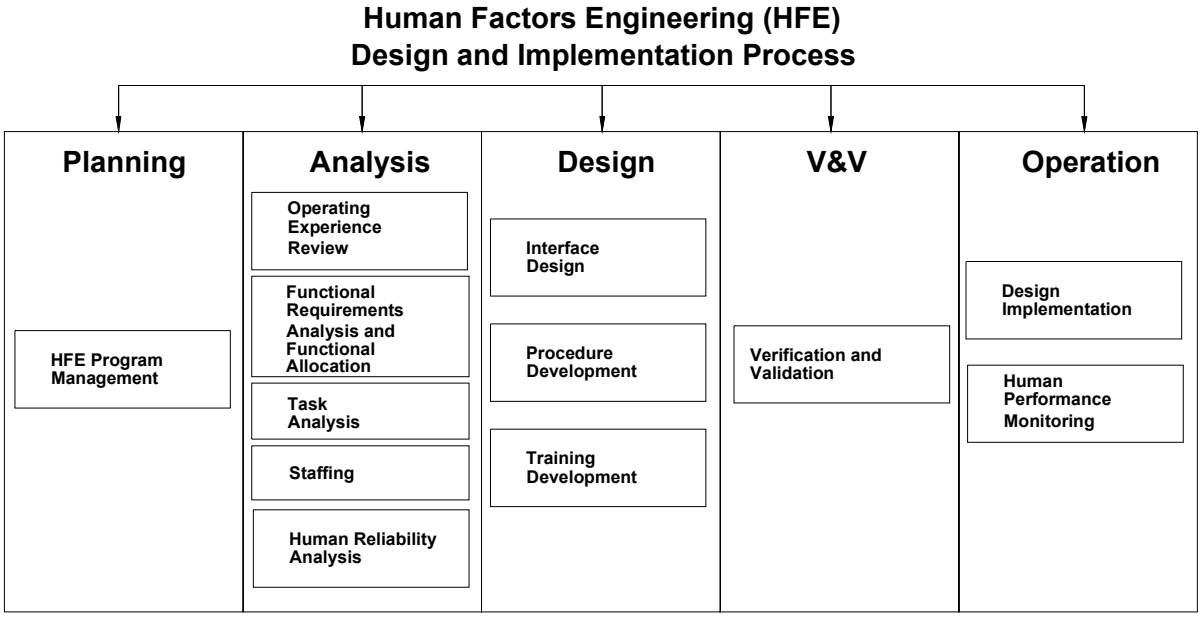

Figure 3.2-1
Human Factors Engineering (HFE)
Design and Implementation Process