CHAPTER 18

HUMAN FACTORS ENGINEERING

18.1 Overview

Human factors engineering deals with designing and implementing resources and environments that help people perform tasks more reliably. Traditionally, human factors engineering includes the consideration of:

- Anthropometric or physical fit of humans to either their task-assisting machines or to their surroundings (for example, height, reach, and visual limitations)

- Biomechanical fit of the physical capabilities and limitations of humans relative to the requirements of their tasks (for example, lifting limits and push-pull limits)

- Biophysical fit of the physiological capabilities and limitation of humans to their environment (for example, tolerance to heat or cold, harmful chemicals, and noise)

More recently, the human factors engineering discipline also models human error. Human errors include:

- Errors of execution or "slips"
- Errors of intention or "mistakes" (Reference 1)

Slips are errors in which a person's intentions are correct, but an incorrect method for executing the action is chosen. Mistakes are errors in which the person forms an incorrect intention but then correctly executes it. Slips tend to be the result of poorly designed physical interfaces (for example, switches on a control board that look or feel alike) or of a poorly designed work environment (for example, temperatures that cause worker exhaustion). Mistakes are cognitive or mental errors. Human factors engineering includes cognitive systems engineering. This discipline focuses on the design of interfaces between humans and machines that support the operator decision-making activities that are required by the task. Cognitive systems engineering is particularly important when designing an interface for operators that control a real-time process, such as a nuclear power plant.

The rapid changes in digital computer and color graphics display technology offer the AP1000 design team an opportunity to improve the real-time decision support for the AP1000 operating staff. The AP1000 has a plant-wide network that provides pre-processed plant data to those members of the plant's staff who have need of it. The real-time process control interface between the plant's staff and the plant's process equipment is the instrumentation and control (I&C) equipment driving graphical display devices in an integrated Human System Interface. Cognitive systems engineering is applied in the design of the human system interface.

The layout and environmental design of the main control room and the remote shutdown room, and the supplementary support areas, such as the technical support center, are sites of application of the traditional disciplines of human factors engineering.

Design input including decisions made in the design of the AP1000 that affect interfaces is provided. This includes input on the operating staff training program and on the development of the plant operating procedures.

Because of the rapid changes that are taking place in the digital computer and graphic display technology employed in a modern human system interface, design certification of the AP1000 focuses upon the process used to design and implement human system interfaces for the AP1000, rather than on the details of the implementation. As a result, this chapter describes the processes used to provide human factors engineering in the design of the AP1000.

This chapter describes the application of the human factors engineering disciplines to the design of the AP1000. [*The basis for the human factors engineering program is the human factors engineering process specified in Reference 2*.]* Figure 18.1-1 illustrates the elements of the human factors engineering program. These elements correspond to the elements specified in Reference 2 and Reference 10. The organization of this chapter parallels these elements. In addition to the elements of the program review model, this chapter includes a description of the minimum inventory of controls, displays, and alarms present in the main control room and at the remote shutdown workstation. The following provides an annotated outline of the chapter. A number of References are identified which were developed for the AP600 Design Certification. Since the AP1000 operating philosophy and approach are the same for AP600 and AP1000, the References identified below are applicable to AP1000.

Section 18.2, Human Factors Engineering Program Management—presents the AP1000 human factors engineering program plan that is used to develop, execute, oversee, and document the human factors engineering program. This program plan includes the composition of the human factors engineering design team.

Section 18.3, Operating Experience Review—and Reference 3 present the results of a review of applicable operating experience. This operating experience review identifies, analyzes, and addresses human factors engineering-related problems encountered in previous designs.

Section 18.4, Functional Requirements Analysis and Allocation—and Reference 4 present the results of the functional requirements analysis and function allocation process applied to the AP1000. The functional requirements analysis defines the plant's safety functions, decomposes each safety function, compares the safety functions and processes with currently operating Westinghouse pressurized water reactors, and provides the technical basis for those processes that have been modified. The function allocation documents the methodology used to arrive at the AP1000 level of automation for the plant functions, processes, and systems involved in maintaining plant safety, and documents the results and rationale for function allocation decisions.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

Section 18.5, Task Analysis—presents the scope and implementation plan for task analysis. The task analysis provides one of the bases for the human system interface design; provides input to procedure development; provides input to staffing, training, and communications requirements of the plant; and ensures that human performance requirements do not exceed human capabilities.

Section 18.6, Staffing—and Reference 5 provide input from the designer for the determination of the staffing level of the operating crew in the AP1000 main control room.

Section 18.7, Integration of Human Reliability Analysis with Human Factors Engineering—and [*Reference 6 present the implementation plan for the integration of human reliability analysis with the human factors engineering program.*]*

Section 18.8, Human System Interface Design—presents the implementation plan for the design of the human system interface.

Section 18.9, Procedure Development—Reference 7 provides input for the development of plant operating procedures, including information on the AP1000 emergency response guidelines and emergency operating procedures.

Section 18.10, Training Program Development—Reference 8 provides input from the designer on the training of the operations personnel who participate as subjects in the human factors verification and validation.

Section 18.11, Human System Interface Verification and Validation Program—[*Reference 9 presents a programmatic level description of the human factors verification and validation*.]*

Section 18.12, Inventory—presents the minimum inventory of controls, displays, and alarms present in the main control room and at the remote shutdown workstation. The design basis and the selection criteria used to identify the minimum inventory are presented.

Section 18.13, Design Implementation—In accordance with Reference 2, this issue is addressed under Section 18.11 as "Issue Resolution Verification" and "Final Plant HFE Verification."

Section 18.14, Human Performance Monitoring—Human performance monitoring applies after the plant is placed in operation.

18.1.1 References

1. Reason, J. T., "Human Error," Cambridge, U.K., Cambridge University Press, 1990.

[*2. NUREG-0711, "Human Factors Engineering Program Review Model," U.S. NRC, July 1994*.]*

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

3. WCAP-14645, "Human Factors Engineering Operating Experience Review Report for the AP1000 Nuclear Power Plant," Revision 3.

4. WCAP-14644, "AP600/AP1000 Functional Requirements Analysis and Function Allocation," Revision 1.

5. WCAP-14694, "Designer's Input To Determination of the AP600 Main Control Room Staffing Level," Revision 0, July 1996.

[*6. WCAP-14651, "Integration of Human Reliability Analysis with Human Factors Engineering Design Implementation Plan," Revision 2, May 1997.*]*

7. WCAP-14690, "Designer's Input To Procedure Development for the AP600," Revision 1, June 1997.

8. WCAP-14655, "Designer's Input to The Training of The Human Factors Engineering Verification and Validation Personnel," Revision 1, August 1996.

[*9. WCAP-15860, "Programmatic Level Description of the AP1000 Human Factors Verification and Validation Plan," Revision 2, October 2003.*]*

10. NUREG-0711, Revision 1, "Human Factors Engineering Program Review Model," May 2002.

*NRC Staff approval is required prior to implementing a change in this information; see DCD Introduction Section 3.5.

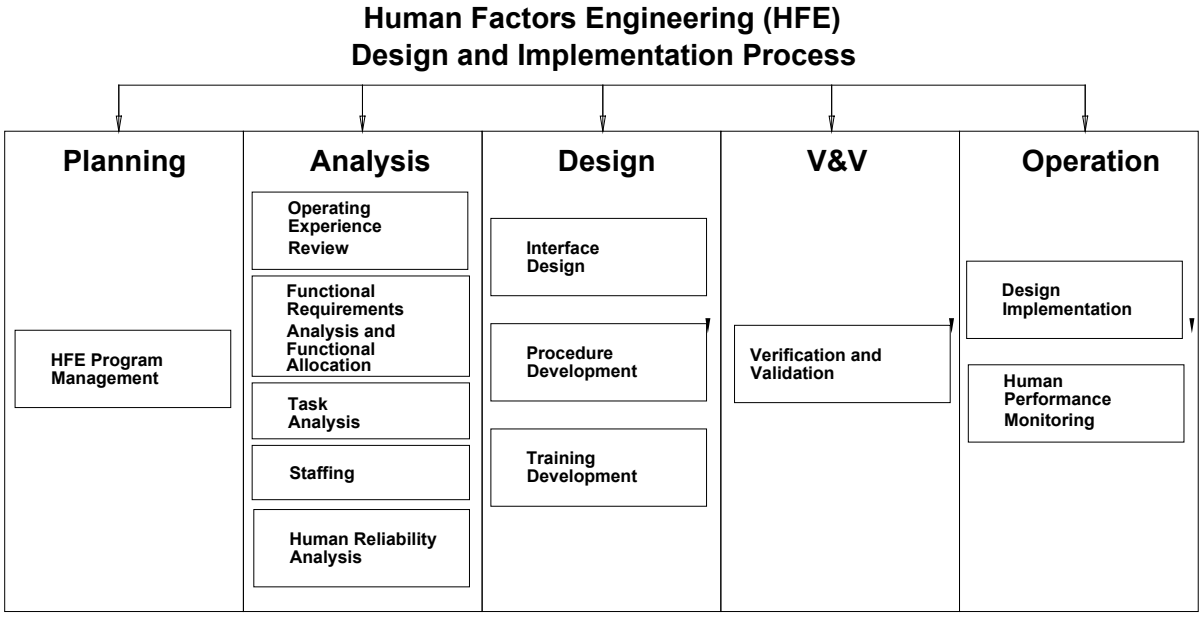

Figure 18.1-1

Human Factors Engineering (HFE)
Design and Implementation Process