18.0 Human Factors Engineering

18.1 Human Factors Engineering Program Management

The human factors engineering (HFE) program management section describes the technical program for the U.S. EPR. The HFE program involves applying human factors principles to the design of the U.S. EPR human system interfaces (HSI) and engineering the incorporation of the HSI with the control and information systems. The program governs HFE design activities and provides guidance for certain aspects of the design of systems which interface with the control rooms via the HSI.

A COL applicant that references the U.S. EPR design will execute the NRC approved HFE program as described in this section.

18.1.1 Human Factors Engineering Program Goals, Assumptions and Constraints, and Scope

18.1.1.1 Goals

The goal of the HFE program is to provide the plant operators with task support and access to the information required to control plant processes and equipment safely and efficiently. The HFE program also establishes the time and performance criteria for required equipment operations via human reliability analyses and recognized guidelines.

18.1.1.2 Assumptions and Constraints

The U.S. EPR is an evolutionary PWR design based on years of operation and design experience from the precursor PWR plants (e.g., based on European N4 and Konvoi plants which are based on Westinghouse-designed PWRs currently operating in the U.S.). The U.S. EPR also uses similar control of system functions and instrumentation and control (I&C) concepts as the predecessor PWRs and the Olkiluoto 3 (OL3) EPR.

The assumptions and constraints that apply to the U.S. EPR HFE program include the following:

1. The initial main control room (MCR) staffing level is similarly established based on experience with previous four loop PWR plants and takes into account the increased levels of automation and the minimum number of operators required by 10 CFR 50.54(m). For further details on staffing levels, see Section 18.5.

2. The platforms for both the safety-related and non-safety-related human machine interfaces (HMI)—safety information and control system (SICS) and process information and control system (PICS) respectively—were selected prior to determining all HFE requirements. Development activities for both platforms have been identified based on HFE requirements as defined for SICS and PICS.

3. For the U.S. EPR, the SICS platform concept involves extensive use of the qualified display system (QDS)—a series of touch-screen capable, seismically qualified, 1E supplied visual display units (VDU). The QDS is an AREVA NP product and development activities have been identified for the QDS to support these needs. Because the QDS will replace many conventional indications and controls and to maintain divisional separation requirements, each control QDS is assigned to manage a respective electrical division or mechanical train. This design creates potential additional burden on the operator when the SICS is used to monitor and control the plant.

4. To minimize differences between HMI platforms in the control rooms, local control stations (LCS) which allow for communication with computer-based HMIs (e.g., turbine-generator and emergency diesel generator controls) will be integrated with the PICS. As discussed in section 2.1.1 of ANP-10279 (Reference 2), LCSs will follow guidelines established by the HFE and Control Room Design Team.

Other assumptions and constraints related to standard features of EPR control rooms, HSI design, and the concept of operations are described in Section 18.7.2 of this FSAR and in Sections 3 and 4 of Reference 2.

The U.S. EPR HFE design process addresses the applicable review criteria specified in NUREG-0711 (Reference 1).

18.1.1.3 Applicable U.S. EPR Facilities

The HFE program scope includes the design of the MCR, the Technical Support Center (TSC), and the remote shutdown station (RSS). The design of ~~local control stations (~~LCS~~s)~~ is typically accomplished concurrent with the applicable system and follows guidelines established by the HFE and Control Room Design Team (see Section 18.1.2). In addition, the Instrumentation and Control Service Center (I&CSC), the central location for maintaining the digital I&C systems for the plant, is included in the application of the HFE program. A COL applicant that references the U.S. EPR design certification will be responsible for HFE design implementation for a new emergency operations facility (EOF) or changes resulting from the addition of the U.S. EPR to an existing EOF. The HFE and Control Room Design Team provides guidance to that design. Execution of the HFE program guidance described herein provides reasonable assurance that HFE principles are both comprehensively and properly applied for the design of the EOF. This HFE guidance also provides a level of consistency for all HSI facilities in the U.S. EPR.

18.1.1.4 Applicable Human System Interfaces, Procedures, and Training

The scope of the HFE program includes HSIs, procedures, and training associated with monitoring and controlling U.S. EPR plant processes and equipment through the system functions. These system functions include those required during the various normal operating modes as well as those required during tests, inspections,

surveillances, and maintenance, and during 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. See Section 18.1.3.2 for information on implementation of these guidelines.

HSIs for the U.S. EPR design are implemented in the following hardware and software with the following I&C systems:

- Process Information and Control System (PICS).
- Safety Information and Control System (SICS).
- LCSs.

Details of the design and the concept of operations associated with each of these HSIs can be found in Section 18.7 and associated references.

The U.S. EPR HFE program also includes the application of appropriate HFE principals and techniques to support the development of operating procedures for the applicable interfacing facilities (see Section 18.1.1.3) and the operator training program. A generic set of operational guidelines (i.e., not specific to owner and site requirements or constraints), for the U.S. EPR, is provided for use in the development of site-specific operating procedures. The requisite set of knowledge, skills, and attributes, and training objectives and goals required to operate a U.S. EPR are also provided for use in the development of a site-specific training program based on the Systematic Approach to Training (SAT) development protocol accredited by INPO. The training program and procedure development program are described in Sections 18.9 and 18.8, respectively.

18.1.1.5 Applicable Plant Personnel

The HFE program is tailored allowing licensed control room operators the capability to attain, view, assimilate, and act on process data in order to maintain plant safety. HFE principles are also applied to the tasks which relate to plant safety that are performed by ~~other~~ personnel as listed~~, including technicians, maintenance personnel, engineering support staff, and management~~.

Plant personnel addressed by the AREVA NP HFE program include licensed control room operators as defined in 10 CFR Part 55 and the following categories of personnel defined by 10 CFR 50.120.

- Non-licensed operators.
- Shift supervisor.
- Shift technical advisor.

- Instrument and control technicians.
- Electrical maintenance personnel.
- Mechanical maintenance personnel.
- Radiological protection technicians.
- Chemistry technicians.
- Engineering support personnel.

18.1.1.6 Effects of Modifications on Personnel Performance

The HFE program applies to the equipment supplied for the original configuration of the U.S. EPR. Modifications to the original interface configuration are required to adhere to the guidelines of Reference 1. Adverse effects caused by modifications on the overall system performance and the performance of personnel who use the equipment are minimized as described in Reference 1 and RG 1.174. Throughout the life of the plant, HFE issues resulting from plant modifications are documented and dispositioned as described in Section 18.12.

18.1.2 Human Factors Engineering and Control Room Design Team Organization

The HFE and Control Room Design Team is the multi-disciplinary team responsible for implementing the HFE program. The HFE and Control Room Design Team is responsible for overseeing certain aspects of the design and construction of the nuclear facility in accordance with 10 CFR 50.34(f)(3)(vii), as described in SRP Section 13.1.1, Management and Technical Support Organization. A description of the responsibilities, organizational placement and authority, and composition and qualifications of the HFE and Control Room Design Team is provided in Section 5.4.2.1 of the Human Factors Topical Report (Reference 2).

The HFE and Control Room Design Team is guided by the HFE program described herein for the proper development, execution, oversight, and documentation. The HFE and Control Room Design Team follows the same design processes as other engineering disciplines and is accountable for the quality of the HSI and control room layout to meet the requirements of the AREVA QAP Topical Report (Reference 3).

18.1.3 Human Factors Engineering Processes and Procedures

The HFE and control room design is performed in accordance with the U.S. EPR QAP described in Reference 3. As described in Section 5.1 of Reference 2, the AREVA NP generic design control process, as described in Section 5.1 of Reference 2, is used to execute the HFE and control room design. HFE-specific processes and procedures are further described in Section 5.3 of Reference 2.