

12. HUMAN FACTORS ENGINEERING FOR PERSONNEL ACTIVITIES

Human factors engineering (HFE) is conducted as part of design development to provide reasonable assurance that the potential for human error is considered and minimized to the extent practical by facilitating appropriate personnel actions and inhibiting operator errors.

12.1 IDENTIFICATION OF PERSONNEL ACTIONS

Control of the operations of the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) relies to a great extent on automated systems to ensure consistent production quality and facility safety. In general, the operations staff is expected to perform the following types of tasks:

- Initiate batch or continuous operations
- Monitor the progress of the operations
- Perform or initiate performance of quality control checks at preprogrammed hold points in the process
- Monitor and confirm the status of confinement systems, fluid systems, and other facility systems
- Respond to or recover from off-normal conditions.

Personnel actions are facilitated by the automated control systems that are provided. Automated controls are provided by normal, protective, and safety control subsystems of the AP and MP Systems, the Utility Control System, and the Emergency Control System. These systems are designed with a tiered backup-type architecture. The MFFF control systems are described in Section 11.6.

The normal control subsystems constitute the operators' primary system interface and controls plant systems within normal parameters. The normal control subsystems do not have a safety function and are not considered principal structures, systems, and components (PSSCs).

The safety control subsystems perform monitoring and control functions necessary to meet various 10 CFR 70.61 performance requirements, and are identified as PSSCs. The safety control subsystem operates independently of the normal control subsystems. Actions associated with safety control functions have precedence over and override normal and protective control actions. A description of the normal controllers and safety controllers is in Sections 11.6.3.3.1 and 11.6.3.3.3.

The emergency control system provides two redundant, independent, and hardwired control divisions, which automatically intervene and take control of the operation of principal structures, systems, and components "PSSCs" in the event of certain accident conditions. A description of the emergency controllers is found in Section 11.6.3.3.4.

The personnel and equipment protective (PEP) control subsystem is not a PSSC. It is designed to satisfy the industrial safety requirements of 29 CFR 1910 and to protect the equipment. The PEP control subsystem has no human-system interface (HSI) that allows an operator to bypass its

functionality. The operators are not required to interface with nor be cognizant of the protective control system except to perform maintenance or to monitor its sensors or resultant actions. The operators have no direct access to the controllers and cannot routinely intervene in their operation. Monitoring of the PEP control system's sensors and actions is performed through the normal control system HSI. A description of the personnel and equipment protective controllers is found in section 11.6.3.3.2.

With respect to the operation of principal SSCs involved with confinement, the operator selects operational configurations and adjusts control settings as dictated by ambient conditions. Major components are started or taken out of service manually by operators as necessary to balance equipment run time or to perform maintenance.

There are no design basis events that require immediate operator action to mitigate the consequences to below the performance criteria of 10 CFR 70.61. Errors in operator actions have been anticipated in the system design while considering other deterministic design basis accident assumptions and scenarios.

Operators primarily perform monitoring activities in response to emergency conditions. The AP and MP processes are designed to shut down during upset conditions.

An Integrated Safety Analysis (ISA) will include evaluation of internal, man-made-external, and natural phenomena hazards. A subset of the events analyzed within the ISA involves personnel actions that have the potential to result in adverse consequences. The ISA will include evaluation of operator actions and in-actions as well as errors of omission and commission.

If an operational upset occurs during normal operations, the operations staff first confirms that the operation of SSCs is within the safety limits and ensures that the control system has initiated appropriate action (e.g., start redundant fan, initiate process shutdown). If events lead to intervention of the safety control system, restoration of control to the normal control system is a manual action.

At this stage of design, very few if any personnel actions are expected to be relied on for safety. Specific actions required to prevent or mitigate design basis events will be identified during final design and included in the appropriate procedures.

12.2 HFE DESIGN PLANNING

HFE design includes the identification of HFE programmatic goals and scope and a description of the plans for HFE review, including HFE team makeup and the processes for conducting HFE reviews. The ISA process will identify the sensors, instruments, and actuators that are relied on for safety. The appropriate HSI requirements will be identified, and the human performance requirements will be established during the detailed design process. Activities associated with the maintenance or operation of the instruments, sensors and actuators relied on for safety will be evaluated for Human Factors attributes.

12.2.1 Goals and Scope of Human Factors Engineering Program

HFE principles are applied to the MFFF design based on the guidelines of IEEE 1023 (1988), *IEEE Guidelines for the Application of Human Factors Engineering to Systems and Equipment, and Facilities of Nuclear Power Generating Facilities*. The goals of the HFE program are as follows:

- Include HFE principles in the design of the MFFF such that personnel activities that are relied on for safety do not challenge the performance capabilities of the operators
- Verify that the design is appropriate with respect to HFE principles prior to construction of the MFFF
- Demonstrate the adequacy of the human factors design by integrated system validation and, if necessary, final HFE/human-system interface (HSI) verification of personnel activities during construction and startup of the MFFF
- Document the HFE process including analysis, findings, and deviations
- Institute procedures that ensure the HFE principles are appropriately applied to changes to the baseline design as described in section 15.2.1 of the CAR.

The scope of HFE during the design phase of the MFFF is to apply HFE criteria to the design of principal SSCs that have associated personnel activities for operation, testing, or maintenance. HFE is also applied to system interfaces and the supporting equipment and systems that control the environment in which the personnel activities will be performed. Aspects of the design that reduce the risk of errors or challenges to principal SSCs are evaluated.

During the construction and startup of the MFFF, a formal review will be conducted to verify and validate the personnel activities and to ensure that the HFE design was appropriately applied to the facility and that procedures and training in support of facility operations are appropriate. The personnel responsible for conducting HFE design reviews are discussed later in this chapter.

12.2.2 Organizational Responsibilities

The MFFF Engineering Manager is responsible for the implementation of the HFE program, and authorizes the HFE team to recommend and coordinate actions to ensure HFE principles are adequately reflected in the design. The HFE team, represented by appropriate controls engineering and operations experience, verifies the implementation of HFE design criteria as part of the review of the final design. The team is supplemented as appropriate during construction and startup by additional operations and maintenance personnel.

12.2.3 HFE Process

HFE is applied to the MFFF in a multiple-phase approach. Three distinct phases, corresponding to preliminary design, final design, and construction and startup, are used for HFE. The phased approach is used to provide efficiencies during the design process and to incorporate the considerable operating experience of the La Hague and MELOX facilities. HFE is risk-informed, and is conducted commensurate with the safety significance, complexity, and degree

of human-system interaction. The HFE approach provides for the appropriate review of operating experience and ongoing participation in design reviews by operations personnel. During detailed design, detailed task analysis is completed, along with HSI design, inventory, and characterization, and HFE verification and validation in support of construction and startup.

12.2.3.1 Preliminary Design

The MFFF is based on the proven design of COGEMA's MELOX and La Hague facilities. During the preliminary design of the MFFF, the control system architecture, control philosophies, and HSIs were developed with emphasis on the proven control methods from MELOX and La Hague. The original design and ongoing evolution of these facilities incorporated various degrees of human factors methods and reflect several years of safe operation. To supplement their use as a "reference design," operational experience is incorporated into the design through a combination of lessons-learned evaluations (focusing on operability and maintainability issues, and involving current operations and maintenance personnel) and review of the design on an ongoing basis by experienced operations staff.

Functional allocation of tasks is based on the design and operation of the two reference facilities, as reflected by the establishment of the design based on the existing designs and the continued involvement of operations staff in reviews of the design as it evolves. As stated in Section 12.1, the MFFF is an automated facility and the tasks assigned to humans involve primarily initiating, verifying, and monitoring system status.

12.2.3.2 Final Design

Criteria for HFE are identified in MFFF design basis documents and will be applied throughout the final design for aspects of operation and maintenance of the MFFF. The task analysis will be completed during final design, and will reflect the personnel activities relied on for safety identified as part of the development of the ISA. During the detailed design of the human-system interface, inventory and characterization of the interfaces will be performed. Evaluation of the characteristics of the human-system interfaces will use the review criteria of NUREG-0700, Rev. 2, as the basis, as applicable for a fuel fabrication facility.

The design will be verified in accordance with the configuration management and design control processes discussed in Chapter 15, through review of design documents including task analyses, HSI design, inventory, and characterization, and other elements of the design involving personnel action. Elements of the HSI subject to HFE review include the overall work environment, work space layout, control panel and console design, control and display device layout, and information and control interface design details, as applicable. HFE review also applies to the development of operating, maintenance, and test procedures, as well as the development and/or consideration of training to those procedures, as appropriate.

HFE results will be factored into the Integrated Safety Analysis (ISA) appropriately. HFE results include:

- The MFFF HFE design review plan describing the methodology used to implement HFE activities during final design

- Summary of the system functions, analysis of personnel activities, and human-system interface inventory and characterization
- Information regarding exceptions taken to HFE criteria and the justification for those exceptions as appropriate.

HFE results will be reflected in the ISA Summary accompanying the license application for the possession and use of SNM.

12.2.3.3 Construction

The final personnel activities review will be performed during startup testing. The HFE review team will be supplemented by additional operations, maintenance, and engineering personnel as appropriate. The procedures for the final personnel activities review will be developed during the construction phase. NUREG-0700, Rev. 2, will be used as the guideline for the review, as applicable to a fuel fabrication facility. Procedures developed during the construction phase will be integrated into the configuration management program such that changes to principal SSCs during construction will be evaluated for aspects of personnel activities.

The final review will be an integrated system validation of personnel activities relied on for safety including, but not limited to, human-system interfaces, procedure development, training development, staffing, and maintenance tasks. The human performance activities identified in the functional allocations and task analysis will be updated to reflect the final results of the ISA.

HFE information will be maintained as part of ISA documentation, and will include a summary description of the methodologies and findings of the human-system interface verification and validation, including task verification, design verification, and integrated system validation. Additionally, the configuration management system will capture summary resolution of significant HFE issue resolution occurring as a result of design reviews or audits, assessments, or incident investigations (see Chapter 15). HFE discrepancies and accepted design solutions or corrective actions, along with schedule for implementation of the solutions, as appropriate, are documented in accordance with QA procedures.

As part of ISA documentation associated with personnel activities relied on for safety, this information is also subject to configuration management controls as discussed in Section 15.2. Changes to the facility design or operating procedures (i.e., as a result of design changes or conclusions of incident investigations or deficiencies identified during audits or assessments) are reviewed in accordance with the appropriate configuration management procedures, which will include review against HFE criteria. This ongoing maintenance of the HFE design basis ensures the appropriate human factors considerations continue to be reflected in the design and operation of the facility.

12.2.4 Issue Tracking

As indicated above, HFE issues identified as a result of this verification are processed as design review comments and tracked to resolution in accordance with configuration management and design control procedures. Deviations from the HFE design criteria are documented, justified, and approved.

12.3 OPERATING EXPERIENCE

As a result of the selection of existing facilities with successful operating histories as a reference design for the MFFF, and the ongoing involvement of operations and engineering personnel from these facilities in the development of design, no additional formal operating experience review is anticipated. During the design phase, the relevant operational experiences of similar facilities is incorporated into the MFFF design. During the operational phase of the MFFF, the operational experiences of the MFFF will become part of the continuing review of the facility as specified in Section 6.3 of IEEE Std 1023.

12.4 FUNCTION AND TASK ANALYSIS

Operational tasks are well established for the existing facilities for the purposes of preliminary design. Additional task analysis will be conducted during detailed design as discussed in Section 12.2.3.

12.5 HSI DESIGN, INVENTORY, AND CHARACTERIZATION

HSI design, inventory, and characterization are initially based on the MELOX and La Hague designs. Additional detail will be developed during detailed design, as discussed in Section 12.2.3.

12.6 OTHER CONSIDERATIONS

Staffing, procedure development, and training will be addressed in the HFE plan developed as part of detailed design. HFE verification and validation is discussed in Section 12.2.3. Final HFE/HSI design verification, if necessary, will be conducted during startup. Additional details will be discussed in the license application for possession and use of SNM.