12.0 HUMAN FACTORS ENGINEERING FOR PERSONNEL ACTIVITIES

12.1 CONDUCT OF REVIEW

This chapter of the draft Safety Evaluation Report (DSER) contains the staff's review of the human factors engineering (HFE) plans, processes, and analyses performed by the applicant in Chapter 12 of the Construction Authorization Request (CAR). The objective of this review is to: 1) establish that HFE is being applied to personnel activities identified as a principle structure, system, component (PSSC) (PSSCs and items relied on for safety (IROFS) include activities of personnel that are relied on to prevent potential accidents that could exceed the performance requirements in 10 CFR 70.61), consistent with the findings of the CAR, and 2) determine whether PSSCs and their design bases identified by the applicant provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents. The staff evaluated the information provided by the applicant for HFE by reviewing Chapter 12 of the CAR, other sections of the CAR, and supplementary information provided by the applicant. The review of HFE was closely coordinated with the review of the instrumentation and control and electrical aspects of accident sequences described in the Safety Assessment of the Design Bases (see Chapter 5 of this DSER), and review of other plant systems.

The staff reviewed how the information in the CAR addresses the following regulation:

- Section 70.23(b) of 10 CFR states, as a prerequisite to construction approval, that the design bases of the PSSCs and the quality assurance program be found to provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents.

The scope of the HFE review included: (1) a description of the safety-significant personnel actions, the associated human system interfaces, and the consequences of incorrectly performing or omitting actions for each personnel activity, (2) the applicant's plans for the HFE design review, (3) review of operating experience at existing facilities that are similar to the proposed MFFF, (4) function and task analysis, (5) human-system interface (HSI) design, inventory, and characterization, (6) staffing, (7) procedure development, (8) training program development, and (9) verification and validation.

The staff used applicable portions of Chapter 12.0 in NUREG-1718 as guidance in performing the review.

12.1.1 Identification of Personnel Actions

The applicant discussed the nature of personnel actions at the proposed Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) in Section 12.1 of the CAR. Control of the operations of the MFFF relies to a great extent on automated systems to ensure 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.

- Recover from off-normal conditions.

In Reference 12.3.3, RAI 224(June 21, 2001 letter to applicant), the NRC staff request the applicant to discuss the human factors/human performance activities associated with maintenance of automated systems which would be used in the MFFF, and identify any safety significant human-system maintenance interfaces. In References 12.3.4 and 12.3.5, RAI 224 (August 31, 2001, and January 7, 2002 letters from applicant), the applicant provided supplemental information which stated that the ISA process will identify the sensors, instruments, and actuators that are classified as IROFS. The appropriate human-system interface requirements and the human performance requirements will be established as part of its application for a 10 CFR Part 70 operating license. Activities associated with the maintenance or operation of the instruments, sensors, and actuators which the applicant later classifies as IROFS will be evaluated for human factors attributes using the criteria of Institute of Electrical and Electronics Engineers (IEEE) Std 1023, "IEEE Guidelines for the Application of Human Factors Engineering to Systems and Equipment," and Facilities of Nuclear Power Generating Facilities, recognizing that there are conditions, systems, operating requirements, and consequences unique to a nuclear power plant and not found in a fuel fabrication facility. The applicant also committed to using the Design Review Checklist in NUREG/CR-6636, "Maintainability of Digital Systems: Technical Basis and Human Factors Guidelines," as part of its application for a 10 CFR Part 70 operating license. In DSER References 12,3,4 and 12.3.5, RAI 232, the applicant also stated that NUREG-0700 and all of the NUREG/CR references in Chapter 12.0 of NUREG-1718 would be used as appropriate as part of its application for a 10 CFR Part 70 operating license for human performance activities associated with maintenance of MFFF automated systems. The staff reviewed this supplemental information and finds it acceptable because it provides the clarification requested regarding the human performance activities associated with maintenance at the MFFF.

In Reference 12.3.3, RAI 225 (June 21, 2001 letter to applicant), the U.S. Nuclear Regulatory Commission (NRC) staff requested the applicant to describe the criteria and basis used for determining that the protective control subsystem does not constitute a significant human-system interface, and to define what "significant" means. In References 12.3.4, 12.3.5, and 12.3.6, RAI 225 (August 31, 2001, January 7, 2002, and February 11, 2002, letters from the applicant), the applicant provided supplemental information which stated that the protective control subsystem is designed to satisfy industrial safety requirements and is not a principal SSC, and provided additional information describing the design of the protective control subsystem's HSI. The applicant more explicitly defined what is meant by "significant human-system interface" for the protective control subsystem, given that industrial safety requirements are important, considered and evaluated the potential for personnel errors of commission that might result in overriding or defeating safety systems, and to provided a cross-reference(s) to appropriate parts of Chapter 11 of the CAR. The staff reviewed this supplemental information and finds it acceptable because it provides the clarification requested regarding the protective control system, its human system interface, and potential personnel errors of commission.

The applicant stated in CAR section 12.1 that the MFFF would have a high level of automation with operators mainly monitoring the operation of systems and exercising supervisory control only when necessary. In Reference 12.3.3, RAI 226 (June 21, 2001 letter to the applicant), the applicant was asked to describe how staff are alerted to undesirable conditions at control stations that are not normally staffed, and what criteria are used to decide when appropriate operations staff need to be at these remote locations for appropriate and timely response. In Reference 12.3.4, RAI 226 (August 31, 2001) the applicant provided supplemental information stating that the performance of systems in automated areas would be constantly monitored by automated supervisory systems. One of the attributes of the functional units which would be monitored by the supervisory systems is the state of an automated activity. If the activity is not concluded in an anticipated state or within an expected time, or if a continuous process is not within allowed limits, an alarm would be generated in the control room for that functional unit.

The design of the MFFF establishes several different control rooms and control of the various functional units of the MFFF are grouped together into these control rooms. If a functional unit is in operation, the control room associated with that functional would be occupied. If none of the functional units assigned to a particular control room are operating, that control room would probably not be occupied. For example, control outputs for the fissile material mass accounting system would not be needed if there are no movements into, out of, or within a glovebox; similarly, the mass measurement system and mass limit alarms would not be meaningful in this situation. Signals for functions appropriate only to an operational unit would be transmitted to the control room that is assigned to that function. Signals appropriate to a facility function, such as the heating, ventilation, and air conditioning system, will be transmitted to the D301 control room, which would be continuously occupied.

Control room D301 would contain supervisory monitoring capability for MFFF features and systems that require full time monitoring. Monitoring of conditions that must be made continuously available at all times to the operations staff would be provided in the D301 control room or, in the case of IROFS, would also be made available in the emergency control rooms, D318 (train A) and D319 (train M).

Staffing evaluations will be completed as part of its application for a 10 CFR Part 70 operating license and will be derived from the staffing requirements that exist in the La Hague and MELOX facilities. The applicant will provide this information in the operating license application for MFFF. The staff reviewed this supplemental information and finds it acceptable because it provides the clarification requested regarding alerting staff to undesirable conditions at control stations not normally staffed, which control rooms would be staffed, and the development of staffing requirements derived from La Hague and MELOX.

In CAR section 12.1, the applicant stated that, in general, omission of an operator action would not result in adverse conditions, and that errors in operator actions would generally be bounded by what the other design deterministic design basis assumptions are. In Reference 12.3.3 (June 21, 2001 letter to the applicant), the applicant was asked to clarify what is meant by, “in general,” and to describe by example what the other deterministic design basis assumptions are. In References 12.3.4, 12.3.5, and 12.3.6, RAI 227 (August 31, 2001, January 7, 2002, and February 11, 2002 letters from the applicant)), the applicant provided supplemental information stating that no scenario has been identified where omission of an operator action would result in adverse conditions, and errors in operator actions have been anticipated in the system design while considering other deterministic design basis accident assumptions and scenarios. The applicant also more explicitly defined what is meant by “other deterministic design basis

accident assumptions and scenario," and considered and evaluated the potential for personnel errors of commission that might result in overriding or defeating safety systems. The staff reviewed this supplemental information and finds it acceptable because it provides the clarification requested regarding other deterministic design basis assumptions and potential for personnel errors of commission.

12.1.2 HFE Design Planning

The applicant discussed HFE design planning in Section 12.2 of the CAR. 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 processes for conducting HFE reviews. HFE principles are applied to the MFFF design based on the guidelines of IEEE-1023, "IEEE Guidelines for the Application of Human Factors Engineering to Systems and Equipment, and Facilities of Nuclear Power Generating Facilities." In Reference12.3.3, RAI 228 (June 21, 2001 letter to the applicant), the NRC staff asked the applicant to verify a commitment in an April 25, 2001, meeting with the NRC staff, to use NUREG-0711 to further guide their human factors design basis development work during construction and evaluate a subsequent revision to IEEE-1023. In References 12.3.4 and 12.3.5, RAI 228 (August 31, 2001 and January 7, 2002 letters from the applicant), the applicant provided supplemental information which stated that NUREG-0711 would continue to be reviewed for HFE criteria that may be applicable to the design of the HSI for the control systems of PSSCs in the MFFF. The applicant also stated that they would evaluate any future revision to IEEE-1023 for applicability to the design of the MFFF. The NRC staff reviewed this supplemental information and finds it acceptable because it provides the clarification requested on the use of IEEE-1023 and NUREG-0711.

In Reference 12.3.3, RAI 229 (June 21, 2001 letter to the applicant), the NRC staff requested the applicant to identify and describe what "facility baseline design" means, or cross-reference to other appropriate Chapter(s) of the CAR. In Reference 12.3.4, RAI 229 (August 31, 2001 letter from the applicant), the applicant provided supplemental information which stated that "facility baseline design" is synonymous with the technical basis defined in the configuration management policies, Section 15.2.1 of the CAR. The staff reviewed this supplemental information and finds it acceptable because it defines what was meant by "facility baseline design."

In Reference 12.3.3, RAI 230 (June 21, 2001 letter to the applicant), the NRC staff requested the applicant to identify and describe the aspects of the MFFF design that reduce the risk of errors or challenges to structures, systems, and components (SSCs), and how these aspects are evaluated. In References 12.3.4 and 12.3.6, RAI 230 (August 31, 2001, and February 11, 2002 letters from the applicant), the applicant provided supplemental information which stated that the MFFF is designed to maximize the use of automation, thus minimizing human operations and interactions with the MFFF SSCs. By reducing these interactions, the probability of a human caused error being introduced is reduced. The applicant also stated that they would consider both human errors of omission and commission in their evaluation of the probability of human error and describe these results as part of the license application. The staff reviewed this supplemental information and finds it acceptable because it provides both a process and rationale for maximizing the use of automation to reduce the probability of human errors of omission or commission.

In CAR section 12.2.2, the applicant also provided a description of how the HFE team will conduct its activities and where the team resides within the organization, with organizational

roles and responsibilities clearly defined. The applicant discussed the activities of each of three phases of the HFE Process: Preliminary Design, Final Design, and Construction and Startup. In the Preliminary Design phase, the MFFF 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 MFFF 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 MFFF design on an ongoing basis by experienced operations staff. In Reference 12.3.3, RAI 231, the NRC staff asked the applicant to describe, by example, how operating experience of the La Hague and MELOX facilities is incorporated in the MFFF design process, and to provide example lessons-learned evaluations that show how the MFFF as a proposed next generation facility effectively incorporates this operating experience. The applicant provided a presentation with examples of significant MELOX and La Hague operating events involving human performance to the NRC staff in a meeting at NRC on October 11, 2001. In Reference12.3.6, RAI 231, the applicant submitted supplemental information to document their October 11, 2001, meeting presentation and provided additional examples of significant MELOX and La Hague operating events involving human performance. The staff reviewed this supplemental information and finds it acceptable because it provides the clarification requested regarding specific examples of operating experience at MELOX and La Hague which are being incorporated in MFFF design.

As part of the application for a 10 CFR Part 70 operating license, criteria for HFE will be 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 as part of the application for a 10 CFR Part 70 operating license, and will reflect the personnel activities relied on for safety as identified as part of the development of the ISA. During the detailed design of the HSIs, 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. 1, as the basis. In Reference 12.3.3, RAI 224 (June 21, 2001 letter to applicant), the NRC staff asked the applicant to commit to reviewing and evaluating future revisions of NUREG-0700 for applicability to the MFFF when available, given that Rev. 2 is likely to be issued before the applicant's request for an operating license is submitted to NRC. In Reference 12.3.5, RAI 224 (January 7, 2002 letter from the applicant), the applicant made this commitment.

12.1.3 Operating Experience

The applicant discussed operating experience in Section 12.3 of the CAR, as well as in Section 12.2 of the CAR (see Section 12.1.2 of this DSER above). In Section 12.3 of the CAR, the applicant states that as a result of 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 MFFF design, no additional formal operating experience review is anticipated. In Reference 12.3.3, RAI 233, the NRC staff requested that the applicant clarify what is meant by "no additional formal operating experience review is anticipated" for the MFFF based on the operational experience at the La Hague and MELOX facilities previously incorporated in the MFFF design. Lessons-learned from operating experience should be a continuing activity throughout construction, detailed design, and operation. In Reference 12.3.6, RAI 233, the applicant provided supplemental information which

stated that there would be ongoing involvement of operations and engineering personnel from the MELOX and La Hague facilities in the development and design of the MFFF, thus providing a capability for evaluating and including results of operating experience as appropriate for the MFFF. The staff reviewed this supplemental information and finds it acceptable because it is one way to incorporate ongoing operational experience into the MFFF design.

12.1.4 Function and Task Analysis

The applicant discussed function and task analysis in Section 12.4 of the CAR, as well as in Sections 12.2.3.1 and 12.2.3.2. Operational tasks are well established for the MELOX and La Hague facilities for the purposes of preliminary design of the MFFF. The MFFF is an automated facility and the tasks assigned to humans involve primarily initiating, verifying, and monitoring system status. The task analysis will be completed as part of the application for a 10 CFR Part 70 operating license and will reflect the personnel activities relied on for safety identified as part of the ISA.

12.1.5 HSI Design, Inventory, and Characterization

The applicant discussed HSI design, inventory, and characterization in Section 12.5 of the CAR, as well as in Section 12.2.3. HSI design, inventory, and characterization for the MFFF are initially based on the MELOX and La Hague designs. As part of the application for a 10 CFR Part 70 operating license, detailed design of the HSI, inventory and characterization of the interfaces will be completed.

12.1.6 Other Considerations

The applicant discussed staffing, procedure development, and training in Section 12.6 of the CAR stating that these issues will be addressed in the HFE plan to be developed as part of the application for a 10 CFR Part 70 operating license. HFE verification and validation is discussed in Sections 12.2.3, 12.2.3.2, and 12.2.3.3 of the CAR. As part of the application for a 10 CFR Part 70 operating license, HFE verification and validation activities will be conducted to support construction and startup. HSI design will be verified in accordance with the configuration management and design control processed discussed in Chapter 15 of the CAR. A final personnel activities review will be performed during startup testing. This review will be an integrated system validation of personnel activities relied on for safety including, but not limited to, HSIs, procedure development, training development, staffing, and maintenance tasks. The human performance activities identified in the functional allocations and task analysis will be update in the license application to reflect the results of the ISA.

12.1.7 Design Bases of the PSSCs

In Chapter 5 of the CAR, the applicant has identified administrative controls and HSI's as PSSCs, to be implemented by appropriate procedures, training, and management measures. These PSSCs are the Human Factors PSSCs for the MFFF. The applicant has stated that the MFFF is being designed to maximize the use of automation, thus minimizing human operations and interactions with the MFFF SSCs. By reducing these interactions, the probability of a human caused error being introduced is reduced. The applicant has also committed to using, as appropriate, the following standards and NRC NUREG's as additional design bases for reducing human error:

- IEEE Std. 1023, IEEE Guidelines for the Application of Human Factors Engineering to Systems and Equipment and Facilities of Nuclear Power Generating Facilities.

- NUREG-0700, Human-System Interface Design Review Guideline.

- NUREG-0711, Human Factors Engineering Program Review Mode.

12.2 EVALUATION FINDINGS

In Chapter 12 of the CAR, the applicant describes the general design philosophy (hierarchy of controls) and defense-in-depth practices (double contingency protection for criticality events; single failure criterion including redundancy, independence, separation, and fail safe for PSSCs; plus other non-credited PSSCs) applied during the preliminary design of the MFFF. Based on that information and the discussion provided in the sections above for human factors engineering for personnel activities, the staff conclude's that the applicant's human factors engineering plans, processed, and analyses provide reasonable assurance that the design bases of the relevant PSSCs identified by the applicant will protect against natural phenomena and the consequences of potential accidents, and are thus adequate to approve the CAR, pursuant to 10 CFR 70.23(b). The applicant will be required to submit more detailed evaluation of human factors engineering as part of its application for a MFFF operating license.

12.3 REFERENCES

12.3.1 Code of Federal Regulations, *Title 10, Energy,* Part 70, "Domestic Licensing of Special Nuclear Material.

12.3.2 Department of Defense (U.S.) (DOD). MIL-STD-1472D, "Human Engineering Design Criteria for Military Systems, Equipment and Facilities." DOD: Washington, D.C.

12.3.3 Giitter, J., U.S. Nuclear Regulatory Commission, letter to P. Hastings, Duke Cogema Stone & Webster, RE MOX Fuel Fabrication Facility Construction Authorization - Request for Additional Information, June 21, 2001.

12.3.4 Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Response to Request for Additional Information - Construction Authorization Request, August 31, 2001.

12.3.5 Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Clarification of Responses to NRC Request for Additional Information, January 7, 2002.

12.3.6 Hastings, P., Duke Cogema Stone & Webster, letter to U.S. Nuclear Regulatory Commission, RE Clarification of Responses to NRC Request for Additional Information, February 11, 2002.

12.3.7 Institute of Electrical and Electronics Engineers (IEEE). Std. 1023, "IEEE Guidelines for the Application of Human Factors Engineering to Systems and Equipment and Facilities of Nuclear Power Generating Facilities." IEEE: 1988.

12.3.8 Nuclear Regulatory Commission (U.S.), Washington, D.C. “Domestic Licensing of Special Nuclear Material (10 CFR Part 70).” *Federal Register*: Vol. 64, No. 146. pp. 41338-41357. July 30, 1999.

12.3.9 Nuclear Regulatory Commission, (U.S.) (NRC). NUREG-0700, Rev.1, Vol.1-3, “Human-System Interface Design Review Guideline,” NRC: Washington, D.C. 1996

12.3.10 -----. NUREG-0711, “Human Factors Engineering Program Review Model.” NRC: Washington, D.C. 1994

12.3.11 -----. NUREG/CR-6633, “Advanced Information Systems Design: Technical Basis and Human Factors Review Guidance.” NRC: Washington, D.C. March 2000.

12.3.12 -----. NUREG/CR-6634, “Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance.” March 2000.

12.3.13 -----. NUREG/CR-6635, “Soft Controls: Technical Basis and Human Factors Review Guidance.” NRC: Washington, D.C. March 2000.

12.3.14 -----. NUREG/CR-6636, “Maintainability of Digital Systems: Technical Basis and Human Factors Review Guidance.” NRC: Washington, D.C. March 2000.

12.3.15 -----. NUREG/CR-6637, “Human Systems Interface and Plant Modification Process: Technical Basis and Human Factors Review Guidance.” NRC: Washington, D.C. March 2000.