



12.0 HUMAN FACTORS ENGINEERING FOR PERSONNEL ACTIVITIES

12.1 PURPOSE OF REVIEW

The purpose of this review is to establish that human factors engineering (HFE) is applied to personnel activities identified as safety-significant, consistent with the findings of the integrated safety analysis (ISA), and the determination of whether an item relied on for safety has special or unique safety significance. A graded approach commensurate with the complexity and integration and operation of the control systems is appropriate. The application of HFE to personnel activities ensures that the potential for human error in the facility operations was addressed during the design of the facility by facilitating correct, and inhibiting wrong, decisions by personnel and by providing means for detecting and correcting or compensating for error.

For the purposes of this chapter, the phrase "personnel activities" represents personnel activities identified as items relied on for safety (IROFS) and personnel activities that support safety, such as maintenance.

12.2 RESPONSIBILITY FOR REVIEW

Primary: Human Factors Specialist

Secondary: ISA Reviewer
 Primary Reviewer of SRP Section 15.4, "Training and Qualification of Plant Personnel"
 Primary Reviewer of SRP Section 15.5, "Plant Procedures"
 Instrumentation and Control (I&C) Reviewer

Supporting: Fuel Cycle Facility Inspector

12.3 AREAS OF REVIEW

The mixed oxide (MOX) facility relies heavily on automated systems employing advanced digital instrumentation and control technology. These systems may be complex, with potential negative impacts on human performance activities in both operations and maintenance. The scope of review for the HFE for personnel activities should be consistent with the results of the ISA and include, as appropriate:

- A. A description of the safety-significant personnel actions, the associated human systems interfaces (HSIs), and the consequences of incorrectly performing or omitting actions for each personnel activity.
- B. The applicant's plans for HFE design review, including the:
 - i. Goals and scope;
 - ii. Team composition, organizational authority, and responsibilities;

Human Factors Engineering for Personnel Activities

- iii. Process and procedures;
 - iv. Issues tracking; and
 - v. Functional description.
- C. Operating experience review;
 - D. Function and task analysis;
 - E. HSI design, inventory, and characterization;
 - F. Staffing;
 - G. Procedure development;
 - H. Training program development; and
 - I. Human factors verification and validation (V&V).

All nine areas of review (A–I) may not be necessary for a specific application. Areas of review should be based on the applicant's provisions to address personnel activities consistent with the ISA findings; the similarity of the associated HFE issues for similar type plants; and the determination of whether an item relied on for safety has special or unique safety significance.

12.4 ACCEPTANCE CRITERIA

12.4.1 Regulatory Requirements

Regulatory requirements for HFE for personnel activities are:

- A. 10 CFR 70.61(e), which requires a safety program to ensure that each item relied on for safety will be available and reliable to perform its intended function when needed.
- B. 10 CFR 70.64(b)(2), which requires features that enhance safety by reducing challenges to IROFS.

12.4.2 Regulatory Guidance

Staff and industry documents that may provide useful background information for consideration in applying HFE to MOX fuel fabrication facilities are listed in Section 12.7.

12.4.3 Regulatory Acceptance Criteria

The HFE for personnel actions should be acceptable if:

- A. Identification of Personnel Activities

Human Factors Engineering for Personnel Activities

The applicant appropriately identified the personnel activities such that the reviewer can understand the actions, the HSIs involved, and the consequences.

B. HFE Design Review Planning

The applicant's approach for planning HFE design review includes:

- i. Identification of appropriate goals and scope to ensure that HFE practices and guidelines are implemented during design, construction, and operation of the facility.
- ii. Implementation by an HFE team that has the appropriate composition, experience, and organizational authority to ensure that HFE is considered in the design of HSI for personnel activities. The HFE team's responsibilities include ensuring the proper development, execution, oversight, and documentation of the HFE function. Depending on the identification of personnel activities, it may be appropriate for the HFE team to consist of a single individual.
- iii. An HFE team that attains the HFE goals and scope through established processes and procedures and that tracks HFE issues.
- iv. An HFE function that ensures that all aspects of the personnel activities including the HSI are developed, designed, and evaluated on the basis of a structured approach using HFE.

C. Operating Experience Review (OER)

The applicant identified safety-related HFE events or potential events that have occurred in existing facilities that are similar to the proposed facility. The applicant:

- i. Reviewed the HFE-related events or potential events for relevance;
- ii. Analyzed the HSI technology employed for the relevant HFE events or potential events; and
- iii. Conducted (or reviewed existing) operator interviews and surveys on the HSI technology for the relevant HFE events or potential events.

D. Functional Allocation Analysis and Task Analysis

- i. Functional allocation analysis: The functional allocation analysis is based on the OER. Personnel activities are functionally allocated to take advantage of human strengths and to avoid demands that are not compatible with human capabilities.
- ii. Task analysis: The task analysis includes the task analysis scope, identification and analysis of critical tasks; detailed description of personnel demands (e.g., input,

Human Factors Engineering for Personnel Activities

processing, and output); iterative nature of the analysis; and incorporation of job design issues. The task analysis addresses each operating mode for each personnel activity (e.g., startup, normal operations, emergency operations, and shutdown). The task analysis results support the functional allocation.

E. HSI Design, Inventory, and Characterization

The HSI design incorporates the functional allocation analysis and task analysis into the detailed design of safety-significant HSI components (e.g., alarms, displays, controls, and operator aids) through the systematic application of HFE. The HSI design includes the overall work environment, the work space layout (e.g., control room and remote shutdown facility layouts), the control panel and console design, the control and display device layout, and information and control interface design details. The HSI design process ensures the application of HFE to the HSI required to perform personnel activities. The HSI design process excludes the development of extraneous controls and displays. The HSI design documentation includes a complete HSI inventory and the basis for the HSI characterization.

F. Staffing

Staffing is based on a review of the number and qualifications of personnel for each personnel activity during all plant operating conditions. The applicant conducts this review in a systematic manner that incorporates the functional allocation and task analysis results. Categories of personnel are based on the types of personnel activities. Staffing considerations include issues identified in the OER, functional allocation, HSI design, procedure development, and V&V.

G. Procedure Development

The applicant's procedure development for personnel activities incorporates HFE principles and criteria, along with all other design requirements, to develop procedures that are technically accurate, comprehensive, explicit, easy to utilize, and validated consistent with the acceptance criteria in Section 15.5.4 of this SRP. Because procedures are considered an essential component of the HSI design, they are derived from the same design process and analyses as the other components of the HSI (for example, displays, controls, operator aids) and subject to the same evaluation processes. Procedures include, as needed to support the personnel activity: generic technical guidance, plant and system operations, abnormal and emergency operations, tests (for example, preoperational, startup, and surveillance), and alarm response.

H. Training Program Development

The applicant's training program development addresses all personnel activities. The training program development indicates how the knowledge and skill requirements of personnel will be evaluated, how the training program development is coordinated with the other activities of the HFE design process, and how the training program will be

implemented in an effective manner consistent with human factors principles and practices. The training program development should address the areas of review and acceptance criteria described in Section 15.4.4 of this SRP and should result in a training program that provides personnel with the qualifications commensurate with the personnel activities.

I. Verification&Validation

V&V confirms that the design incorporates HFE to HSI in a manner that enables the successful completion of personnel activities. The V&V should be applied to personnel activities (see Item A) and HSI design (see Item E). The V&V process should consist of the following:

- i. HSI task support verification: HSI components are appropriately provided for personnel activities through HSI task support verification. The verification shows that each HSI identified the task analysis (see Item D(ii)) and that the HSI design (see Item E) is appropriately provided, yet minimizes the incorporation of information, displays, controls, and decorative features that unnecessarily complicate personnel activities.
- ii. HFE design verification: The HFE design verification shows that each HSI identified for a personnel activity incorporated HFE into the design. Deviations from accepted HFE principles and guidelines should be justified or documented for resolution/correction. If all HSI components are not addressed by HFE design verification, then an alternative multidimensional sampling methodology should be used to assure comprehensive consideration of the safety significance of HSI components. The sample size should be sufficient to identify a range of significant safety issues.
- iii. Integrated system validation: The applicant commits to a performance-based evaluation of the integrated design to ensure that the HFE/HSI supports safe operation of the plant. Integrated system validation is performed after HFE problems identified in HFE design activities are resolved or corrected because these may negatively affect performance and, therefore, validation results. Validation is performed by evaluating personnel activities using appropriate measurement tools. All personnel activities should be tested and found to be adequately supported in the design, including personnel activities outside the control room.
- iv. Human factors issue resolution verification: The applicant verifies that HFE issues identified during the design process were addressed and resolved. Issue resolution verification should be documented in the HFE issue tracking system established by the HFE team (see Item B). Issues that cannot be resolved until the HSI design is constructed, installed, and tested should be identified and incorporated into the final HFE/HSI design verification.
- v. Final HFE/HSI design verification: The applicant should commit to performing a final HFE/HSI design verification if the applicant cannot demonstrate that it has fully evaluated the actual installation of the final HSI design in the plant through the V&V activities described above. Final HFE/HSI design verification should demonstrate that

Human Factors Engineering for Personnel Activities

in-plant HFE design implementation conforms to the HFE design (see Item E) as modified V&V activities.

V&V activities should be performed in the order listed above, as necessary. However, the applicant may find that it is necessary to iterate in order to address design corrections and modifications that occur during V&V.

12.5 REVIEW PROCEDURES

12.5.1 Acceptance Review

The primary reviewer should perform an acceptance review to determine if the application adequately addresses the items in Section 12.3, "Areas of Review," for either the construction approval review or the review for a license to possess and use special nuclear material (SNM). Guidance specific to the construction approval review and the review for a license to possess and use SNM is provided below.

A. Construction Approval

Specifically, the safety assessment of the design basis should address Section 12.3(A)–(E) consistent with the level of design and the consequences of incorrectly performing the personnel activity consistent with the safety assessment of the design basis. Where information is under development or not yet available, the applicant may use a commitment to providing the material with the license application in lieu of the actual material.

B. License To Possess and Use SNM

Specifically, the safety assessment of the license application should fully address Section 12.3(A)–(I) consistent with the consequences of incorrectly performing the personnel activity.

If the primary reviewer verifies that the HFE for personnel activities is adequately addressed in either the construction approval review or the review for the license to possess and use SNM, the primary reviewer should accept the application for the safety evaluation in Section 12.5.2. If the primary reviewer identifies significant deficiencies in the material provided, the primary reviewer should request that the applicant submit additional information prior to the start of the safety evaluation.

12.5.2 Safety Evaluation

After determining that the application is acceptable for review in accordance with either Section 12.5.1.A (construction approval review) or 12.5.1.B (review for a license to possess and use SNM), the primary reviewer should perform a safety evaluation against the acceptance criteria described in Section 12.4. On the basis of its review, the staff may request that the

applicant provide additional information or modify the application to meet those acceptance criteria.

The primary reviewer should use a tiered approach for evaluating HFE for personnel activities. The upper tier is the program description level, such as missions or goals. The middle tier is when functions are allocated to tasks (personnel activities) for the purposes of specifying the alarms, information, and controls. The tasks are arranged into meaningful jobs and the HSI should be designed to best support job task performance. The lower tier is the detailed design (of the HSI, procedures, and training) and how they are incorporated into the facility design. Evaluation of the HFE design should be broad-based and include aspects of normal and emergency operations, testing, maintenance, etc., consistent with findings in the safety assessment of the design basis (application for construction approval) or in the ISA Summary (license application for operations).

Guidance specific to the application for construction approval and the license application for operations is provided below.

A. Construction Approval

In general, the primary reviewer should perform an upper-tier review for the safety assessment of the design basis. As the level of design permits, the primary reviewer should perform a middle-tier review on those personnel activities that are identified as preventing or mitigating accident consequences.

B. License To Possess and Use SNM

In general, the primary reviewer should perform a lower-tier review for personnel activities that prevent or mitigate "high-consequence" events, a middle-tier review for personnel activities that prevent or mitigate "intermediate-consequence" events, and a high-level review for any remaining HFE activities.

The primary reviewer should review the ISA Summary to ensure that personnel activities have been suitably characterized as IROFS. The extent to which HFE elements are applied should be based on the number, type, complexity, and potential consequences of the personnel activities.

The secondary reviewer should ensure that the types of personnel activities relied on for safety are appropriate. The primary reviewer should coordinate with the I&C reviewer for Chapter 11.0, "Plant Systems," to confirm that HFE principles are appropriately addressed in the I&C approach.

The supporting reviewers should assist in the tiered approach of the review so they may look at more specific examples of human factors engineering application.

When the safety evaluation is complete, the primary reviewer, with assistance from the other reviewers, should prepare the HFE input for the Safety Evaluation Report (SER), as described

Human Factors Engineering for Personnel Activities

in Section 12.6 using the acceptance criteria from Section 12.4. The secondary reviewer should coordinate the chemical safety input with the balance of the reviews and the SER.

12.6 EVALUATION FINDINGS

The primary reviewer should document the safety evaluation by preparing material suitable for inclusion in the SER. The primary reviewer should describe the review, explain the basis for the findings, and state the conclusions.

The staff could document the safety evaluation for the construction approval review as follows:

The staff reviewed the application of human factors engineering (HFE) to personnel activities for the application for construction approval for [insert facility name] according to Chapter 12.0 of NUREG-1718. The staff evaluated [insert a summary statement of the evaluation] and found [insert a summary of the findings].

The staff concluded that the applicant has established an adequate design basis, as it relates to HFE, that meets the requirements for construction approval in 10 CFR Part 70.

The staff could document the safety evaluation for the review for a license to possess and use SNM as follows:

The staff reviewed the application of human factors engineering (HFE) to personnel activities for the license application to possess and use SNM at [insert facility name] according to Chapter 12.0 of NUREG-1718. The staff evaluated [insert a summary statement of the evaluation] and found [insert a summary of the findings].

The staff concluded that the applicant applied HFE to personnel activities identified as items relied on for safety, consistent with the results of the ISA, and that its personnel activities meet the requirements associated with human factors given in 10 CFR Part 70.

12.7 REFERENCES

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

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

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

———. NUREG-0711, "Human Factors Engineering Program Review Model." NRC: Washington, D.C. 1994.

Human Factors Engineering for Personnel Activities

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

———. NUREG/CR-6634, "Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance." NRC: Washington, D.C. March 2000.

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

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

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

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.