Human Factors Engineering Project Management Plan

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Revision 0

NuScale Nonproprietary

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FIGURES

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TABLES

1.0 Introduction

1.1 Purpose

This document describes how NuScale Power effectively incorporates HFE into the plant design. As part of the engineering organization, the HFE team ensures the processes detailed in this plan are integrated into the analysis, development, design, and operation of the NuScale design. The HFE Project Management Plan describes the following:

- NuScale HFE project goals and scope
- HFE design team and organization
- HFE processes and procedures
- HFE Issues Tracking System (HFEITS)
- HFE element technical reports

This plan also describes how this HFE project and HFE design team composition complies with regulatory requirements and guidelines listed in Table 1-1, how the project incorporates the use of state-of-the-art human factors principles, including human-in-the-loop simulation and how the project supports the HFE elements. A detailed discussion of the HFE Project Management Plan requirements is contained in Section 3.0.

The HFE design team is an interdisciplinary team responsible for performing the HFE requirements defined in Table 1-1. The team is made up of technical and subject matter experts from across the NuScale design organization.

Table 1-1. HFE regulations and guidelines

Reference	Description
10 CFR 50.34(f)(2)(iii) (Reference 2.1.1)	Provide, for commission review, a control room design that reflects state-of-the-art human factor principles prior to committing to fabrication or revision of fabricated control room panels and layouts
10 CFR 52.47(a)(8) (Reference 2.1.2)	The information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v)
NUREG-0711 (Reference 2.1.3)	Human Factors Engineering Program Review Model
Regulatory Guide 1.174 (Reference 2.1.4)	An approach for using probabilistic risk assessment in risk-informed decisions on plant specific changes to the licensing basis

1.2 Abbreviations and Definitions

Table 1-2. Abbreviations

Term	Definition
CFR	U.S. Code of Federal Regulations
DCD	design control document

Term	Definition
FRA/FA	functional requirements analysis and function allocation
HED	human engineering discrepancy
HFE	human factors engineering
HFEITS	Human Factors Engineering Issues Tracking System
HRA	human reliability analysis
HSI	human-system interface
I&C	instrumentation and control
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulatory Commission (technical report of the United States Nuclear Regulatory Commission)
OE	operating experience
OER	operating experience review
ORD	owner requirements document
PRA	probabilistic risk analysis
TA	task analysis
TIHA	treatment of important human actions
URD	utility requirements document

2.0 References

2.1 Referenced Documents

2.1.1 *U.S. Code of Federal Regulations*, “Contents of Applications; Technical Information,” Section 50.34(f)(2)(iii), Part 50, Chapter I, Title 10, “Energy,” (10 CFR 50.34(f)(2)(iii)).

2.1.2 *U.S. Code of Federal Regulations*, “Contents of Applications; Technical Information,” Section 52.47(a)(8), Part 52, Chapter I, Title 10, “Energy,” (10 CFR 52.47(a)(8)).

2.1.3 U.S Nuclear Regulatory Commission, “Human Factors Engineering Program Review Model,” NUREG-0711, Revision 3, November 2012.

2.1.4 U.S Nuclear Regulatory Commission, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,” Regulatory Guide 1.174, Revision 2, May 2011.

2.1.5 *U.S. Code of Federal Regulations*, “Training and Qualifications of Nuclear Power Plant Personnel,” Section 50.120, Part 50, Chapter 1, Title 10 “Energy,” (10 CFR 50.120).

2.1.6 *U.S. Code of Federal Regulations*, “Operators’ Licenses”, Part 55, Chapter I, Title 10, “Energy,” (10 CFR 55).

2.1.7 Human Performance Monitoring Project Plan [in development].

2.1.8 NuScale Power, LLC, NuScale Quality Management Plan, NP-PL-0200-200.

2.1.9 NuScale Power, LLC, NuScale Design Control, NP-QP-0302-001.

3.0 Project Requirements

3.1 Human Factors Engineering Project Goals and Scope

The primary goal of the HFE project is to provide the NuScale design a “human-centered” approach for plant operators and technicians to control plant processes and equipment safely and efficiently so that the

- tasks can be accomplished by personnel within the required time frame and according to defined performance criteria (e.g., human-machine tasks to complete an action, human-human interaction).
- human-system interface (HSI), procedures, staffing and qualifications, training, management, and organizational arrangements support optimum performance and situational awareness.
- design will support personnel in maintaining vigilance over plant operations and provide acceptable workload levels (i.e., minimize periods of under- and over-load).
- design of the HSI will serve to minimize personnel errors and shall support error detection and recovery capability.

The scope of the HFE project and elements includes the main control room, remote shutdown facility, technical support center, emergency operations facility, HSI and computer-based operating procedures, and local control stations.

The following assumptions and constraints shape the HFE project:

- NuScale small modular reactor unit design
- multiple units controlled and operated (in multiple operating states) from a single main control room
- highly automated digital instrumentation and control (I&C) systems
- passive safety system design
- computer-based operating procedures

The HFE project remains in effect for each NuScale multi-unit plant through the combined operating license application process and up to the receipt of authorization for initial fuel loading in the first unit for each multi-unit plant.

The human-system interface design supports applicable facilities in plant operations, accident management, maintenance, testing, inspections, and surveillance tasks performed or supervised by operational personnel. The HSI design process represents the translation of function, allocation, and task requirements into HSI characteristics and implementation strategies. HSI design inputs include the following:

- operating experience
- functional requirements analysis and function allocation
- task analysis
- staffing and qualifications
- treatment of important human actions
- concept of operations
- I&C systems design

- alarm management
- system requirements
- HSI style guide

The HFE project supports procedure and training development in all activities performed or supervised by operational personnel, including accident management, maintenance, test, inspections, and surveillance tasks. In addition, the project provides appropriate inputs to the training programs for the personnel identified in 10 CFR 50.120 (Reference 2.1.5), including instrumentation and controls (I&C) technicians, electrical and mechanical maintenance personnel, radiological protection personnel, chemistry technicians, and engineering support personnel. Furthermore, any other personnel who perform tasks directly related to plant safety, such as information technology technicians who troubleshoot and maintain support systems and their HSIs are included.

The HFE project scope also includes operator staffing and qualifications, including licensed control room operators as defined in 10 CFR 55 (Reference 2.1.6) and the following categories of personnel: non-licensed operators, shift supervisor, and shift technical advisor.

Design changes, plant modifications and resultant changes to tasks, procedures, training and HSI are supported by the HFE Project Management Plan in accordance with an approved supplier's HFE project as provided for by the NuScale Quality Management Plan (Reference 2.1.8) or a combined license applicant's approved quality assurance plan until authorization for initial fuel loading. Changes made after HFE responsibilities have shifted from NuScale to the licensee are supported through human performance monitoring as described in the Human Performance Monitoring Project Plan [in development] (Reference 2.1.7).

3.2 Human Factors Engineering Design Team Organization and Responsibilities

The HFE design team is organized under the vice president of Operations and Engineering. The HFE design team project manager is responsible for the development and maintenance of the HFE project and reports to the vice president of Operations and Engineering. HFE project element leaders report to the HFE design team project manager.

HFE design team positions are filled from throughout the corporate organization in order to match the position's requirements with an individual's education, expertise, and experience. The HFE design team participants report, through the HFE element leaders, to the HFE design team project manager regarding all HFE activities. An organization chart of the HFE design team illustrating the reporting, functioning, and communicating structure is available for review.

The HFE design team has the responsibility and the authority to:

- develop HFE plans and procedures
- conduct analyses in support of the HFE project and HSI design process
- oversee and review all activities in HFE and HSI design, development, test, and evaluation
- determine where its inputs are required and access work areas and design documentation
- oversee and review the initiation, tracking, and closure of solutions of issues and human engineering discrepancies (HED) identified through the HFE process
- control HFE and HSI product processing, delivery, installation, or use until nonconformance, deficiency, or unsatisfactory conditions have been corrected
- verify that the team's recommendations have been implemented

- ensure that all HFE activities comply with the HFE technical report requirements and procedures
- schedule HFE activities and milestones

Table 3-1 identifies the HFE design team primary duties associated with their individual qualifications.

Table 3-1 HFE design team participant primary responsibilities

	OER	FRA/FA	TA	Staffing & Quals	Treatment Of Important HA	HSI	Procedure Development	Training Development	HFE V&V	Design Implementation	Human Performance Monitoring	Other Duties
Technical Plant Management												1, 2, 3
Systems Engineering	X	X	X		X				X			4
Nuclear Engineering		X	X						X			4
I&C Engineering	X			X	X	X	X	X	X	X	X	4
Architect Engineering		X	X						X			4
Human Factors Engineering	X	X	X	X	X	X	X	X	X	X	X	4, 5
Plant Operations	X	X	X	X	X	X	X	X	X	X	X	4, 5
Computer Systems Engineering					X				X			4
Plant Procedure Development			X		X		X	X	X			4
Personnel Training			X	X	X	X	X	X	X			4
Systems Safety Engineering					X							4
Maintainability/Inspection Engineering			X			X	X	X	X	X	X	4
Reliability/Availability Engineering					X	X			X			4

Other Duties
1. Develop project and element technical reports.
2. Develop and maintain HFE design schedule.
3. Manage the HFE analysis, design, validation, verification, implementation and problem resolution.
4. Perform the duties of HFEITS evaluator and owner as assigned.
5. Perform the duties of a HFE element leader as assigned.

The NuScale HFE project may use contract personnel to supplement the HFE design team to conduct HFE activities. All contract HFE activities shall be conducted within, and in accordance with, the NuScale HFE Project Management Plan or in accordance with an approved supplier's HFE project as provided for by the NuScale Quality Management Plan (Reference 2.1.8) or a combined license applicant's approved quality assurance plan.

3.3 Human Factors Engineering Design Team Qualifications

Human factors engineering design team participant minimum qualifications satisfy the qualifications of NUREG-0711 (Reference 2.1.3) as described in Appendix A.

3.4 Human Factors Engineering Process and Procedures

The HFE project is conducted in accordance with the NuScale Quality Management Plan (Reference 2.1.8) or a combined license applicant's approved quality assurance plan and subordinate plans and procedures, including the NuScale Design Control (Reference 2.1.9). The

design control process provides an integrated and iterative process of design, interdisciplinary review, and comment resolution through a series of design phases.

Appendix B describes the HFE design team integration into the iterative design process through the design review process.

The HFE design team shall execute its responsibilities in accordance with the governing quality plan and design control procedures, which address the following areas:

- assigning activities to individual team members
- governing the internal management of the team
- making decisions on managing the HFE project
- making HFE design decisions
- controlling changes in design of equipment
- reviewing and approving of HFE products identified in Table 3-2

Human factors engineering project tools and techniques used to fulfill responsibilities are also available to support the HFE elements. Specific tools and techniques used for each HFE element are described in the respective project reports. Human factors engineering project tools and techniques used include the following:

- design guidelines
- design verification checklists
- low fidelity aids such as mockups (computer aided drawings or physical representations of HSI)
- unit simulator (capable of supporting single unit HSI, training, and procedure evaluation and analysis but having little or no shared or multi-unit simulation capability)
- multi-unit control room simulator (capable of supporting single, shared, and multi-unit HSI, as well as training, procedure, and staffing evaluation and analysis)
- relational requirements management software (e.g., DOORS®)

A human factor engineering relative project schedule with milestones is integrated into the project design development schedule and is available for review. The significant HFE project milestones within the integrated plant design include:

- the HFE project management plan approval.
- each of the 11 element technical report approvals.
- availability of the control room simulator for integrated system verification.
- the staffing plan evaluation report.
- the control room staffing justification plan.
- availability of the control room simulator for operator training.

Human factors engineering documents that support design are quality records and retained in accordance with the NuScale Quality Management Plan (Reference 2.1.8) or a combined license applicant's approved quality assurance plan. All such documentation is available to the NRC staff for review upon request. Human factors engineering documentation includes design verification checklists, HFEITS records, and documentation identified in the HFE element technical reports

(e.g., results summary reports, guides, and training programs). Upon completion of the HFE activities described in each element technical report, the appropriate documentation shall be submitted or available for review as described in Table 3-2 below:

Table 3-2 HFE element completion documents

HFE Element	Submitted	Available	Documents
Operating experience review	X		Results summary report
Functional requirements analysis and function allocation	X		Results summary report
Task analysis	X		Results summary report
Staffing and qualifications	X		Results summary report
Treatment of important human actions	X		Results summary report
HSI design	1	2	1. Results summary report and 2. Style guide
Procedure development		X	Writer's guide, technical guide and plant procedures
Training program design		X	License and non-license training program
Human factors verification and validation	X		Results summary report
Design implementation	X		Results summary report
Human performance monitoring		X	Not applicable

3.5 Human Factors Engineering Issue Tracking

As illustrated in Figure B- 1, human factors engineering issues are identified and tracked in the HFEITS database throughout the life cycle of the HFE project for the NuScale design project. Although HFE issues may be discovered or revealed at any point in the HFE project process, Figure B- 2 illustrates that most HFE issues originate in the operating experience review (OER), HSI development, procedure development, training development and HFE verification and validation elements. HFEITS database is available to any member of the HFE design team. HFE issues include:

- human engineering discrepancies
- recognized industry HFE issues
- issues identified throughout the life cycle of the HFE project

Once a potential HFE issue has been identified, it is entered into the HFEITS database and is assigned a unique tracking number. Supporting documentation in electronic format may be attached to the database item. The issue is screened and evaluated to confirm potential degradation in human performance is identified. Issues found that do not degrade human performance are either closed or transferred to more appropriate corrective action processes.

Proposed corrective action to resolve the HFE issue is identified and assigned as necessary. Due dates for resolution of the overall evaluation or for each corrective action are established by the administrator. Issue close-out and transfer with proper documentation is approved by both the administrator and the HFE design team project manager.

For each HFE issue, the HFEITS documents the following:

- issue date
- any supporting information, such as attachments documenting the issue
- assigned issue owner and evaluator
- proposed resolution
- HFE design team acceptance or rejection
- actual resolutions
- actions taken
- affected documents

3.6 Individual Responsibilities Supporting Human Factors Engineering Issue Tracking System

3.6.1 HFE Design Team Project Manager

The HFE design team project manager has overall responsibility for administering and managing the HFE Issue Tracking System. The responsibilities are to

- provide oversight of HFE issue tracking
- approve issue evaluator and owner changes
- approve due date changes

3.6.2 HFEITS Administrator

The HFEITS administrator is assigned responsibility for managing the database. The administrator will not necessarily be a member of the HFE design team. The HFEITS administrator's responsibilities are to

- manage the HFEITS database
- maintain hardware and software for optimum performance
- manage database security
- add and remove users authorized to modify the database
- negotiate initial issue evaluator and owner assignments
- negotiate initial resolution and corrective action due dates
- track the issue resolution and corrective action due dates

3.6.3 Issue Evaluator

The issue evaluator's responsibilities are to

- evaluate issues
- identify the extent and significance of issues
- recommend issue owners
- recommend corrective actions
- recommend resolution due dates

3.6.4 Issue Owner

The issue owner's responsibilities are to

- resolve issues
- update HFEITS with proposed or completed actions
- update design documentation where appropriate

3.7 HFE Element Technical Reports

The NuScale HFE project is composed of the 11 elements identified by NUREG-0711 criteria (Reference 2.1.3) as shown in Table 3-1 and Table 3-2. Each element has schedule dates for technical report preparation, completion and submittal. These schedules are integrated into the project design development schedule, which are available for review. Each element's technical report shall provide the following information:

- description of the scope, inputs, analyses to be performed, outputs, and documentation
- description of the methodology for conducting HFE activities that satisfy NUREG-0711 criteria (Reference 2.1.3)
- description of the review and documentation requirements for subordinate documents that support the HFE products identified in Table 3-2

  For example, the operating experience review (OER) technical report shall describe the HFE design team review process, documentation and record requirements for each operational experience the team reviews.
- description of the expected results consistent with Table 3-2 (e.g., results summary report, guideline, training plans, product or deliverable) from executing the methodology that satisfy NUREG-0711 criteria (Reference 2.1.3)

See Table 3-2 for a summary of the associated technical report completion documentation.

Appendix A. Human Factors Engineering Design Team Qualifications

Human factors engineering design team participant minimum qualifications satisfy the qualifications of NUREG-0711 (Reference 2.1.3) as described below:

- **Technical Project Management**
  - bachelor's degree
  - five years of experience in nuclear power plant design or operations
  - three years management experience
- **Systems Engineering**
  - bachelor of science degree
  - four years of experience in at least three of the following areas of systems engineering: design, development, integration, operation and test and evaluation
- **Nuclear Engineering**
  - bachelor of science degree
  - four years of nuclear design, development, test, or operations experience
- **I&C Engineering**
  - bachelor of science degree
  - four years of experience in designing hardware and software aspects of process control systems
  - experience in at least one of the following areas of I&C engineering: design, power plant operations, and test and evaluation
  - familiarity with the theory and practice of software quality assurance and control
- **Architect Engineering**
  - bachelor of science degree
  - four years of experience in design of power plant control rooms
- **Human Factors Engineering**
  - bachelor's degree in human factors engineering, engineering psychology, or related science
  - four years of cumulative experience related to the human factors aspects of human computer interfaces. Qualifying experience should include at least the following activities within the context of large-scale, human-machine systems (e.g., process control): design, development, and test and evaluation
  - four years of cumulative experience related to the human factors aspects of workplace design. Qualifying experience should include at least two of the following activities: design, development, and test and evaluation
- **Plant Operations**
  - has or has held a senior reactor operator license
  - two years of experience in relevant nuclear power plant operations
- **Computer System Engineering**

- bachelor's degree in electrical engineering or computer science, or graduate degree in other engineering discipline (e.g., mechanical engineering or chemical engineering)
- four years of experience in the design of digital computer systems and real-time systems applications
- familiarity with the theory and practice of software quality assurance and control

- **Plant Procedure Development**
  - bachelor's degree
  - four years of experience in developing procedures for nuclear power plants
- **Personnel Training**
  - bachelor's degree
  - four years of experience in developing personnel training programs for power plants
  - experience in applying the systems approach to training
- **Systems Safety Engineering**
  - bachelor's degree in science
  - four years of experience in system safety engineering
- **Maintainability/Inspectability Engineering**
  - bachelor's degree in science
  - four years of cumulative experience in at least two of the following areas of power plant maintainability and inspectability engineering activity: design, development, integration, and test and evaluation
  - experience in analyzing and resolving plant system and/or equipment-related maintenance problems
- **Reliability/Availability Engineering**
  - bachelor's degree
  - four years of cumulative experience in at least two of the following areas of power plant reliability engineering activity: design, development, integration, test and evaluation
  - knowledge of computer-based, human-interface systems

Appendix B. NuScale and HFE Project Design Iteration And Integration

As illustrated in Figure B- 1, the HFE design team is integrated into the iterative design process through the design review process.

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