Enclosure 3:

"Human Factors Engineering Design Implementation Implementation Plan," RP-0914-8544-NP, Revision 0, nonproprietary version

Human Factors Engineering Design Implementation

Implementation Plan

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NuScale Nonproprietary

NuScale Power, LLC

1100 NE Circle Blvd Suite 200

Corvallis, Oregon 97330

www.nuscalepower.com

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1.0 Introduction

1.1 Purpose

This document provides the implementation plan (IP) for design implementation (DI) within the NuScale plant human factors engineering (HFE) program. DI demonstrates that the HFE program "as-built" design (human-system interface (HSI), facility configuration, procedures, and training program) accurately reflects the verified and validated design for those design features not evaluated during human factors verification and validation (V&V). Features evaluated during DI generally include those which cannot be accurately simulated:

- Ergonomic considerations such as lighting and background noise
- HSIs outside of the main control room (MCR) but within the NuScale plant HFE program scope

Human engineering discrepancies (HEDs) generated after completion of V&V are resolved during DI in accordance with the process described in the HFE Program Management Plan (Reference 8.2.1).

Any reevaluation or HFE program activity iterations that are needed after V&V are conducted and documented during DI.

1.2 Scope

For the control room and each local control station (LCS), (DI) confirms the aspects of the HFE design not addressed in V&V including that

- the software and hardware configurations match the verified and validated HSIs (alarms, controls, indications, and procedures)
- the facility configuration of the as-built design matches the aspects of the facility that were simulated during the integrated system validation (ISV)
- other aspects of the facility that were not simulated but are relevant to the overall HFE program are evaluated using an appropriate V&V method

Control rooms include main control room (MCR), technical support center (TSC), remote shutdown facility (RSF), and emergency operations facility (EOF) as described in the HFE Program Management Plan (Reference 8.2.1).

1.3 Abbreviations and Definitions

Table 1-1. Abbreviations

Term	Definition
DI	design implementation
EOF	emergency operations facility
HED	human engineering discrepancy
HFE	human factors engineering
HFEITS	human factors engineering issue tracking system
HPM	human performance monitoring
HSI	human-system interface

Term	Definition
IHA	important human action
IP	implementation plan
ISV	integrated system validation
LCS	local control station
MCR	main control room
RSF	remote shutdown facility
SME	subject matter expert
TSC	technical support center
V&V	verification and validation

2.0 Design Implementation Assessments

DI uses the following methods to verify that the final HSIs, facility configuration, procedures, and training conform to the planned design which resulted from the HFE design process and V&V activities:

- configuration control
- HFE review
- plant walkdowns
- review of potential design changes

The DI assessments for software, hardware, and facility configurations confirm clear configuration-controlled design traceability for HSI components (alarms, controls, indications, and procedures) and peripheral equipment. The as-built configuration is compared to drawings, specifications, and other final design documents used for ISV to determine conformance. If the configuration is not confirmed, further HFE review is conducted to determine if the as-built HSI is *equivalent* to the HSI of the ISV.

The DI assessment for facility configuration is conducted by plant walkdown and includes

- physical configuration of workstations, panels, and displays
- visibility and sight lines
- accommodations for communication
- inclusion of emergency plan and personal protection equipment
- lighting
- background noise
- environmental controls/conditions (e.g., temperature and humidity)

The evaluation of aspects of the facility not simulated (e.g., LCSs) but relevant to the overall HFE program include

- a walkdown to confirm conformance to the documentation approved by the HFE team and that these components do not challenge conclusions of the V&V
- a subject-matter expert (SME) review of
  - the suitability of the LCS for executing the operating procedures where operating procedures direct use of that LCS (i.e., typically not computer-based procedures)
  - the suitability of those procedures
- an SME evaluation of training material used for control room and LCS HSIs to ensure it comprehensively includes the material provided to operators who participated in the ISV

Where configuration-controlled design traceability, HFE review for HSI equivalency to the HSI of the ISV, and/or plant walkdown do not confirm that the as-built HSIs, procedures, and training design is the planned design, an HED is generated. If an HED evaluation determines that a design change would potentially resolve the HED, a design change review is conducted to

determine the significance of the differences between planned and as-built. If the design change review concludes that the design change has no impact on the completed ISV, then a specific validation method (e.g., tabletop walkthrough, mockup, part-task simulator, or plant walkdown) is determined. If the ISV results are impacted by the design changes, the applicable portion(s) of ISV are repeated.

The design change review also determines the need to re-iterate or repeat other elements or activities of the HFE program and the extent of this rework.

3.0 Human Factors Engineering Issues Tracking System Resolution

HFE issues found during the DI activities described in Section 2.0 are documented, evaluated, and tracked as human engineering discrepancies (HEDs) within the HFE issues tracking system (HFEITS) (see HFE program management plan (Reference 8.2.1)). As described in the V&V implementation plan (Reference 8.2.4), HEDs from earlier HFE program elements and those generated during V&V activities are closed prior to ISV. HEDs generated during V&V that do not affect ISV acceptance criteria or conclusions and HEDs generated after completion of V&V are *resolved* during DI. Some HEDs are not resolved during HFE program activities and are on-going due to anticipated technology or other advancements; however, all HEDs are *closed* prior to DI completion.

4.0 Addressing Important Human Actions

Important human actions (IHA) are determined, addressed, and tracked as described in the Treatment of Important Human Actions IP (Reference 8.2.2).

IHAs are incorporated into the HSI (alarms, controls, indications, and procedures) design as described in the Human-System Interface Design IP (Reference 8.2.3).

As described in the Verification and Validation IP (Reference 8.2.4), IHAs are considered among the significant conditions, personnel tasks, and situational factors sampled during V&V activities as the ISV scenarios are developed. The ISV assesses the successful performance of the integrated crew and the HSI for IHAs. During V&V, HEDs are processed when discrepancies are found for any IHA. HEDs found during V&V are resolved during DI as described in Section 3.0.

5.0 Additional Considerations for Human Factors Engineering Aspects of Control Room Modifications

After completion of start-up testing and provisional turn over, a licensee institutes a human performance monitoring (HPM) program to evaluate impacts on human performance going forward. The HPM program evaluates design change proposals for HSI design, procedures, or training against the design bases established for the as-built design. The design change proposal evaluation considers HEDs in HFEITS regardless of which stage of the design in which they were initiated. HFE program activity results which are invalidated by design changes are re-conducted to support plant modification without reducing human performance (see Section 2.0).

A licensee's design change process is governed by regulatory requirements such as 10 CFR 50.59, "Changes, Tests, and Experiments".

6.0 Results Summary Report

At the conclusion of DI, results are compiled in a results summary report to demonstrate that the as-built design is confirmed in accordance with an appropriate V&V method.

The results summary report includes

- a results overview, including the principal findings
- DI execution methodology and appropriate results demonstration
  - identification of the documentation which shows configuration-controlled design traceability for HSIs, procedures, and training material not validated during V&V
  - identification of differences between planned and as-built HSI and facilities and the justification for allowing those differences or identification of the HEDs used to track the resolution of those differences
  - identification of any HSI features that were excluded from the V&V and the alternate method of V&V
  - results of any design change reviews including justification for the design change, any HFE program element re-performance or re-iteration, and the results of the changes or re-performance
  - a compilation of HED resolution and closures applicable to DI (i.e., not closed in previous HFE program elements) and a listing of HEDs not resolved to be tracked into plant operation stages
- a conclusion that DI has determined that the as-built HSIs and corresponding facilities are the same as those included in V&V or that differences or elements that were not included in the V&V do not adversely impact the V&V results

7.0 NUREG-0711 Conformance Evaluation

Table 7-1 indicates where each NUREG-0711, Revision 3 criterion is met in this IP.

Table 7-1. Conformance with NUREG-0711

Review Criteria Stated in NUREG-0711, Rev. 3	**DI IP Section No. and paragraph**
12.4 Review Criteria 12.4.1 Final HFE Design Verification for New Plants and Control Room Modifications (1) The applicant should evaluate aspects of the design that were not addressed in V&V by an appropriate V&V method. *Additional Information:* Aspects of the design addressed by this criterion may include design characteristics, such as new or modified displays for plant-specific design features.	Section 1.2, all paragraphs Section 2.0, all paragraphs
(2) The applicant should compare the final HSIs, procedures, and training with the detailed description of the design to verify that they conform to the planned design resulting from the HFE design process and V&V activities. This verification should compare the actual HSI, procedures, and training materials to design descriptions and documents. Any identified discrepancies should be corrected, or justified. *Additional Information:* Final design means the design existing in the actual plant.	Section 2.0, all paragraphs Section 3.0, all paragraphs
(3) The applicant should verify that all HFE-related issues in the issue-tracking system (Section 2.4.4) are adequately addressed.	Section 3.0, all paragraphs
(4) The applicant should provide a description of how the HFE program addressed each important HA.	Section 4.0, all paragraphs
12.4.2 Additional Considerations for Reviewing the HFE Aspects of Control Room Modifications In addition to any of the criteria above that are relevant to the modification being reviewed, the following should be addressed. 12.4.2.1 General Criteria for Plant Modifications (1) The applicant should provide reasonable assurance that the reactor fuel is safely monitored during the shutdown period while physical modifications to the control room are being made.	N/A, Section 5.0

Review Criteria Stated in NUREG-0711, Rev. 3	DI IP Section No. and paragraph
(2) The applicant should verify that modifications in the plant's procedures and training reflect changes in plant systems, personnel roles and responsibilities, and in HSIs resulting from the new systems.	N/A, Section 5.0
(3) Installation should be planned to minimize disruptions to work of plant personnel.	N/A, Section 5.0
(4) The applicant should verify that operations and maintenance personnel are fully trained and qualified to operate and maintain all modifications made to the plant before starting up with the new systems and HSIs in place.	N/A, Section 5.0
(5) The applicant should have a plan to monitor startup and initial operations after the modification to reasonably assure that: • operational and maintenance problems arising from personnel's interactions with the new systems, HSIs, and procedures are identified and addressed • personnel are sufficiently familiar with the new systems, HSIs, and procedures to support safe operations and maintenance • any negative transfer of training from the old removed HSIs to the corresponding new ones was identified and corrected • no new problems are created by coordinating tasks between the remaining old HSIs and new HSIs • no unanticipated negative effects on personnel interaction and teamwork have surfaced	N/A, Section 5.0
12.4.2.2 Modernization Programs Consisting of Many Small Modifications (1) The applicant should assure that each modification follows an HFE program that provides standardization and consistency (1) between old and new equipment, and (2) across the new systems being implemented.	N/A, Section 5.0
(2) The applicant should verify that new modifications fulfill a clear operational need, and do not interfere with existing systems. Additional Information: For example, the auditory alerts in a new HSI should not distract operators from addressing more important alarms.	N/A, Section 5.0

Review Criteria Stated in NUREG-0711, Rev. 3	DI IP Section No. and paragraph
12.4.2.3 Modernization Programs Consisting of Large Modifications during Multiple Outages (1) Interim configurations may exist for long times (e. g., a refueling cycle), and therefore, applicants should verify that they are acceptable from both engineering and operations perspectives and that they meet regulatory requirements. The applicant's evaluations should include: • PRA evaluations to ensure minimizing high-risk situations • FSAR evaluations to assure defense against design basis accidents • technical-specifications evaluations to determine if changes are needed • defense in depth evaluations to ensure meeting the criteria in RG 1.174	N/A, Section 5.0
(2) The applicant should perform task analysis for each interim configuration to verify that any task demands are known and do not degrade personnel performance.	N/A, Section 5.0
(3) The applicant should update the HRA to address any unique tasks that may impact risk, as well as any changes to existing tasks due to the interim configuration.	N/A, Section 5.0
(4) The applicant should verify that the HSIs needed to perform important tasks (as defined in Section 6) are consistent and standardized. Personnel should not have to use both old and new HSIs for different aspects of the same task.	N/A, Section 5.0
(5) The applicant should develop procedures for temporary configurations of systems and HSIs that personnel use when the plant is not shutdown.	N/A, Section 5.0
(6) The applicant should develop training for temporary configurations of systems, HSIs, and procedures that personnel can use when the plant is not shutdown.	N/A, Section 5.0

Review Criteria Stated in NUREG-0711, Rev. 3	DI IP Section No. and paragraph
(7) The applicant should consider the following aspects of V&V: • HFE Design Verification – Temporary configurations of the systems, HSIs, and procedures that operations and maintenance personnel employ when the plant is not shutdown should be reviewed to verify that their design is consistent with the principles of good HFE design (e.g., conforms to a plant-specific style guide or NUREG-0700). • HSI Task-Support Verification – Temporary configurations of the systems, HSIs, and procedures, which operations and maintenance personnel may use when the plant is not shutdown, should be reviewed to verify that their design supports the intended tasks. Additional Information: For example, if a temporary configuration of plant systems introduces special monitoring requirements, then the HSIs should give the necessary information. • ISV - Interim configurations should be validated if so warranted by the risksignificanceof the personnel tasks affected by them.	N/A, Section 5.0
12.4.2.4 Modernization Programs Where both Old and New Equipment are Left in Place (1) The applicant should identify and address negative effects on personnel performance due to control room or HSI clutter resulting from using old and new HSIs in parallel.	N/A, Section 5.0
(2) The applicant should identify and address negative effects on personnel performance resulting from the simultaneous presence of parallel alarms.	N/A, Section 5.0
(3) The applicant should identify and address negative effects on personnel performance resulting from differences in information from old and new systems on the same parameter or equipment.	N/A, Section 5.0
(4) The applicant should identify and address any safety concerns from providing controls that operators can access from two different HSIs. Additional Information: For example, a switch may be installed to select which HSI will control the equipment, thus preventing simultaneous control inputs.	N/A, Section 5.0

Review Criteria Stated in NUREG-0711, Rev. 3	DI IP Section No. and paragraph
12.4.2.5 Modernization Programs Where New Non-functional HSIs are in Place in Parallel with Old Functional HSIs (1) The applicant should evaluate the potential for negative effects on personnel performance due to control room or HSI clutter resulting from having old and new HSIs available in parallel. Where safety concerns are identified, the applicant should take measures to improve the HSIs.	N/A, Section 5.0
(2) The applicant should ensure that the non-functional state of HSIs is clearly indicated.	N/A, Section 5.0

8.0 References

8.1 Source Documents

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

8.1.2 *U.S. Code of Federal Regulations*, "Changes, tests and experiments," Section 50.59, Part 50, Title 10, "Energy," (10 CFR 50.59).

8.2 Referenced Documents

8.2.1 NuScale Human Factors Engineering Program Management Plan, RP-0914-8534.

8.2.2 NuScale Human Factors Engineering Treatment of Important Human Actions Implementation Plan, RP-0914-8539.

8.2.3 NuScale Human Factors Engineering Human-System Interface Design Implementation Plan, RP-0914-8540.

8.2.4 NuScale Human Factors Verification and Validation Implementation Plan, RP-0914-8543.