May 10, 2019

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Submittal of "Human-System Interface Style Guide," ES-0304-1381, Revision 3

REFERENCE: 1. Letter from NuScale Power, LLC to U.S. Nuclear Regulatory Commission, "NuScale Power, LLC Submittal of Sixth Set of Human Factors Engineering Documentation for Design Certification Application," dated December 29, 2016 (ML16364A359)

NuScale Power, LLC (NuScale) submitted Revision 1 of the "Human-System Interface Style Guide," ES-0304-1381, to the NRC (Reference 1). The purpose of this letter is to submit Revision 2 of the "Human-System Interface Style Guide" to the NRC. Revision 1 of the "Human-System Interface Style Guide" was not submitted to the NRC.

Enclosure 1 contains the proprietary version of the report entitled "Human-System Interface Style Guide." NuScale requests that the proprietary version be withheld from public disclosure in accordance with the requirements of 10 CFR § 2.390. The enclosed affidavit (Enclosure 3) supports this request. Enclosure 1 has also been determined to contain Export Controlled Information. This information must be protected from disclosure per the requirements of 10 CFR § 810. Enclosure 2 contains the nonproprietary version of the report entitled "Human-System Interface Style Guide."

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions, please contact Carrie Fosaaen at 541-452-7126 or at cfosaaen@nuscalepower.com.

Sincerely,

Thomas A. Bergman
Vice President, Regulatory Affairs
NuScale Power, LLC

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Enclosure 1: "Human-System Interface Style Guide," ES-0304-1381-P, Revision 3, proprietary version
Enclosure 2: "Human-System Interface Style Guide," ES-0304-1381-NP, Revision 3, nonproprietary version
Enclosure 3: Affidavit of Thomas A. Bergman, AF-0219-64503

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Enclosure 2:

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Human-Systems Interface Style Guide

May 2019

Revision 3

Docket: 52-048

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Abstract

The NuScale Human System Interface Style Guide represents more than just a collection of Human Factors Engineering requirements. The style guide is designed to supply the users of the document all of the information, requirements, functional specifications, and examples in one location. The NuScale Human System Interface Style Guide consists of three volumes and a set of Appendices as discussed below.

The style guide is a living document, meaning changes are expected to be made to it during the HSI design and Verification and Validation process.

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Executive Summary

The Human System Interface Style Guide was created to ensure the implementation of human factors engineering (HFE) and human system interface (HSI) principles in the development of user interface display pages, work locations and workstations at NuScale Power, LLC (NuScale). The inclusion of early and continuous HFE activities, as defined in this document, throughout the entire design process will result in safer and more efficient operation of the plant.

The primary users of this design standard are:

- The NuScale Plant Operations group
- Simulator plant modeling engineers
- HFE/HSI engineers
- Display page developers
- Instrument and Control (I&C) engineers
- System engineers

This style guide was developed primarily by integrating requirements and guidelines from NUREG-0700 (Reference 1.5.1). Other accepted commercial HSI and military HFE design standards were reviewed and are properly referenced.

This style guide fulfills the NUREG-0711 (Reference 1.5.2) requirement that directs NuScale to create a style guide to ensure HFE/HSI principles are followed.

The style guide is organized into three volumes and appendices.

Volume I addresses the scope, applicability, organization, format, purpose, use and updating of the style guide. Volume I also details the HFE element creation process and integration, compliance and deviation procedures including the iterative HSI test and evaluation.

Volume II addresses all user interface design elements that are common across all NuScale plant systems, work locations and workstations.

Volume III contains examples of the HSI Library.

The appendices addresses specific plant system user interface design elements and contains validation and compliance information for each individual system, plant wide concept (e.g., Operator Notification Strategy), work location and workstation design.

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1.0 Introduction

1.1 Purpose

This document contains the HFE/HSI guidance to be followed during work location and workstation design at NuScale Power, LLC (NuScale). The NuScale Plant Operations group will have the responsibility for releasing the style guide for use, future tailoring, supplementing and disseminating within individual work efforts of that organization. This document is considered a 'living' document which means that to allow iterative flexibility of the design process it will be continuously updated as needed. Version control will be provided through the use of DOORS.

1.2 Scope

This document provides a single, easy-to-use source of HFE/HSI guidance. It consolidates guidance from the source materials of several government and commercial agencies and provides one reference for HFE/HSI applications at NuScale. It primarily draws upon NUREG-0700 guidance but does selectively draw from other documents oriented to other agency missions and adapts and expands upon them to meet the needs of the NuScale Plants missions and systems. An example of this is the ANSI /HFES 100 and 200 HFE documents (References 1.5.3 and 1.5.4).

1.2.1 Promote Consistency

The style guide is intended to promote consistency and incorporate user interface best practices across the HFE/HSI design to increase the user's ability to successfully perform tasks and achieve operational goals The scope of this standard covers all aspects of the plant design including:

- the human system interface (display pages)
- environmental considerations including ambient noise levels, temperature, lighting
- communications including PA, telephones, microphones, email, text
- electronic document support including tech manuals, training, on-line help
- input devices such as touch screens, laptops, tablets, mice, trackballs, joysticks, cameras
- output devices such as laptops, tablets, printers, plotters, video screens
- hardware such as physical switches, knobs, gauges, analog and digital meters
- anthropometric and ergonomic considerations for the immediate work area

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The combined aspects of the plant design create the total user experience and contribute to the user's ability to efficiently, effectively and accurately complete tasks. The style guide is written to help optimize the interaction of these elements of design.

The style guide promotes consistency with both work location and workstation user interface design and is intended for use by the NuScale Power Plant Operations group as part of a comprehensive HFE process described in Section 2.2.

1.2.2 Increased Awareness of HFE and HSI

The HSI Style Guide helps increase awareness to the importance of integrating HFE and HSI processes into the design and development cycle of the overall plant design. The benefits of applying HFE and HSI processes early in the development cycle is that it will provide a cost advantage to the overall operations of the plant by providing a design that is streamlined from an operations and training perspective.

1.3 Applicability

The requirements and guidelines in this document are intended to be applied by the NuScale Plant Operations group to HFE/HSI design and development efforts at NuScale.

NuScale will enforce the requirements and guidelines in this document on vendor provided LCS's and control room locations to the maximum extent practicable.

1.4 Abbreviations and Definitions

Table 1-1. Abbreviations

Acronym	Definition
ACR	advanced control room
ANSI	American National Standards Institute
ARP	alarm response procedure
ATE	automated test equipment
BAS	boron addition system
BPSS	backup power supply system
CBP	computer-based procedure
CIE	Commission Internationale de l'Eclairage
CWS	circulating water system
DAS	data acquisition system
DOORS	dynamic object oriented requirements system
ELV	low voltage ac electrical distribution system
EMI	electromagnetic interference
EOF	emergency operations facility
EOP	emergency operating procedure
EPRI	Electric Power Research Institute
FCC	Federal Communications Commission

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Acronym	Definition
FRA/FA	functional requirements analysis/function allocation
GVD	group view display
HED	human engineering discrepancy
HFE	human factors engineering
HFEITS	human factors engineering issues tracking system
HRA	human reliability analysis
HSI	human-system interface
IHA	important human action
IP	implementation plan
I&C	instrumentation and control
LCS	local control station
LED	light-emitting diode
LOOP	loss of offsite power
LOS	line of sight
MCR	main control room
MTFA	modulation transfer function area
MPCD	minimum perceptible color difference
NPP	nuclear power plant
NRC	Nuclear Regulatory Commission
OER	operating experience review
P&ID	piping and instrumentation diagram
PA	public address
PAM	post-accident monitoring
PBP	paper-based procedure
PPS	plant protection system
PRA	probabilistic risk assessment
PZR	pressurizer
RCS	reactor coolant system
RPV	reactor pressure vessel
RSR	results summary report
RSS	remote shutdown station
RXM	reactor module system
SAR	safety analysis report
SART	silence, acknowledge, reset, and test
SBO	station blackout
SDCV	spatially-dedicated, continuously visible
SDI	safety display and indication
SG	steam generator
S&Q	staffing and qualifications
TA	task analysis
TSC	technical support center
UCS	uniform color space
UHF	ultra high frequency
VDU	video display unit
WBGT	wet-bulb globe temperature

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Table 1-2. Definitions

Term	Definition
DOORS	Dynamic Object Oriented Requirements software is designed to capture, trace, analyze, and manage requirements while maintaining compliance with industry standards and regulations.
Human engineering discrepancy (HED)	A human engineering discrepancy is an issue usually discovered during the verification and validation phase of the HFE program and may require engineering changes and verification. HEDs are identified as personnel task requirements (as defined in the task analysis) that are not fully supported by the human system interface (HSI), and the presence of HSI components that may not be needed to support personnel tasks. HEDs are also identified if the design is inconsistent (does not accommodate human capabilities and limitations) with HFE guidelines, such as NUREG-0700 or any NuScale HSI style guides.
Human factors	A body of scientific facts about human characteristics. The term covers all biomedical, psychological, and psychosocial considerations it includes, but is not limited to, principles and applications in the areas of human factors engineering, personnel selection, training, job performance aids, and human performance evaluation (see human factors engineering).
Human factors engineering (HFE)	The application of knowledge about human capabilities and limitations to plant, system, and equipment design. HFE ensures that the plant, system, or equipment design, human tasks, and work environment are compatible with the sensory, perceptual, cognitive, and physical attributes of the personnel who operate, maintain, and support it (see human factors).
HFE Design Team	Generic term for the Plant Operations organization which consists of Operators, Human Factor Engineers, and Simulator Developers. The HFE Design Team does not include Plant Personnel. The HFE Design Team is responsible for the human factors engineering associated with the NuScale design. Also referred to as the design team.
Human-system interface (HSI)	The human-system interface (HSI) is that part of the system through which personnel interact to perform their functions and tasks. In this document, "system" refers to a nuclear power plant. Major HSIs include alarms, information displays, controls, and procedures. Use of HSIs can be influenced directly by factors such as, (1) the organization of HSIs into workstations (e.g., consoles and panels) (2) the arrangement of workstations and supporting equipment into facilities such as a main control room, remote shutdown station, local control station, technical support center, and emergency operations facility and (3) the environmental conditions in which the HSIs are used, including temperature, humidity, ventilation, illumination, and noise. HSI use can also be affected indirectly by other aspects of plant design and operation such as crew training, shift schedules, work practices, and management and organizational factors.
Spatially dedicated, continuously visible (SDCV)	A display or portion of a display that is in a spatially dedicated location and is always visible. Conventional alarm tiles are an example of an SDCV alarm display.

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1.5 Reference Documents

1.5.1 U.S. Nuclear Regulatory Commission, "Human-System Interface Design Review Guidelines," NUREG-0700, Rev. 2. May 2002.

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

1.5.3 American National Standards Institute/Human Factors and Ergonomics Society, "Human Factors Engineering of Computer Workstations," ANSI/HFES 100-2007.

1.5.4 American National Standards Institute/Human Factors and Ergonomics Society, "Human Factors Engineering of Software User Interfaces," ANSI/HFES 200-2008, LaGrange Park, IL.

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

1.5.6 Agile, *What Is Agile? (10 Key Principles of Agile)*, Last modified February 10, 2007, http://www.allaboutagile.com/what-is-agile-10-key-principles/.

1.5.7 Scrum.org, What is Scrum?, Last modified 2016, https://www.scrum.org/Resources/What-is-Scrum.

1.6 Style Guide Organization

The style guide is organized in three volumes as described below.

1.6.1 Volume I

Volume I addresses the style guides purpose, scope, organization, document change processes, HFE process, appropriate implementation and integration of the style guide to be used by the NuScale Plant Operations group, Simulator Modeling Engineers, HFE/HSI Engineers, Display Page Developers and System Managers.

1.6.2 Volume II

Volume II is used to gain a general understanding of the basic elements in user interface designs and how to apply them to the design. By utilizing the foundational operational details collected in the functional requirements analysis/function allocation (FRA/FA) and task analysis (TA) along with appropriate Volume II information; the Plant Operations engineers can facilitate the design of the human interface and help form the baseline for the Volume III system/concept specific chapter.

The two major types of design guidance found in Volume II are requirements and guidelines. Both definitions are provided below.

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1.6.2.1 Requirements

Requirements are user interface specifications that must be implemented unless there is a justification to apply for a deviation.

Deviation from a requirement requires technical authority approval from the NuScale Plant Operations HFE design team.

1.6.2.2 Guidelines

Guidelines are user interface suggestions that represent best practices. It is highly advisable to follow the guidelines, but it is not required to do so, and failure to implement a guideline does not require a deviation request.

Deviation from a guideline does not require technical authority approval.

1.6.2.3 Overview of Volume II Sections

Each of the sections contains an HSI characterization and design review guidelines for the HSI topic addressed. A characterization is a description of the characteristics and functions of the HSI topic area that are important to human performance. The characterizations provide a conceptual framework for indicating the specific aspects of the HSI design for which information should be obtained and reviewed. The characterizations are sometimes broader in scope than the HFE guidelines themselves. This exists when a particular aspect of a topic was identified as important to human performance, but there was not a sufficient technical basis upon which to develop detailed design review guidelines.

Note: All tables and figures in Volume II were originally presented in NUREG-0700 (Reference 1.5.1).

The guidelines address the following aspects of these HSI systems:

Section 3.1 General HSI Information

This section provides HFE guidelines for the review of visual displays. This section also contains general guidelines as well as guidelines for; display formats, display format elements (such as labels, icons, symbols, color, text, and coding) and data quality and update rates, dialogue formats (such as menus, direct manipulation, and command language), navigation, display controls, entering information, system messages, and prompts. This section also contains guidelines concerning methods for ensuring the integrity of data accessed through the user interface. Guidelines cover prevention of inadvertent change or deletion of data, minimization of data loss due to computer failure, and protection of data, such as setpoints, from unauthorized access.

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Section 3.2 Plant Notifications

This section provides HFE guidelines for the review of the plant notifications design implementation. The guidelines address the selection of alarm conditions, choice of setpoints, alarm processing, alarm availability (such as filtering and suppression of alarms), unique aspects of the display of alarm information (such as organization, coding, and alarm message content), and alarm controls.

Section 3.3 Safety Display and Indication System

This section provides HFE guidelines for the review of displays of critical safety functions and safety parameters.

Section 3.4 Computer-Based Procedure System

This section provides HFE guidelines for the review of computer-based procedure systems, including the representation of information, the functional capabilities, users' interaction with the systems, backup provisions, and the integration of such system with other HSI elements.

Section 3.5 Communication System

This section provides HFE guidelines for the review of speech and computer-mediated communication between plant personnel (e.g., preparing, addressing, transmitting, and receiving messages).

Section 3.6 Workstation Design

This section provides HFE guidelines for the review of the design of workstation features such as control-display integration and layout, labeling, and ergonomics (e.g., vision and reach).

Section 3.7 Workplace Design

This section provides HFE guidelines for the review of general workplace considerations. Guidelines are provided both for the control room and for operator interface areas out in the plant. The guidelines address design features such as the overall layout of the workstations and other equipment such as group-view displays within the workplace, provision of support equipment such as ladders or tools, and environmental characteristics including temperature, ventilation, illumination, and noise.

Section 3.8 Hardware

This section provides HFE guidelines for the review of conventional control devices such as pushbuttons and various types of rotary controls, display-control integration, group-view displays including their functional and physical characteristics and user-system

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interaction aspects, the information display and user-system interaction aspects of soft control systems as well as guidelines for projectors, printers and hand held devices.

Section 3.9 Automation

This section provides HFE guidelines for the use of automation in the operator HSI.

Section 3.10 Plant Maintenance and Work Management

This section has been added as a place holder for future efforts.

1.6.3 Volume III

Volume III contains the NuScale HSI library. Each section is comprised of specific information about a system, location, or concept in a NuScale plant. The information that may be presented in each section is provided below in no specific order.

1. System Description.

2. Example of the display page.

3. Any additional information pertaining to the display page.

1.7 Guideline Format

The individual guidelines are presented in the standardized format shown below.

EXAMPLE: 3.1.2.1.10 Data Manipulation

The user should be able to manipulate information without concern for internal storage and retrieval mechanisms of the system.

Default values for the information to be entered in a particular task should be offered and displayed in the appropriate data field to speed entry.

Users should be permitted to define, change, or remove default values for any input field.

Each guideline is composed of the following parts:

Guideline Number – Within sections/subsections, individual guidelines are numbered consecutively from 1 to n. Each guideline has a unique number that indicates its section/subsection location. For example, in Guideline 3.1.2.1.10, Data Manipulation, the "3.1" reflects its location in Volume II, General HSI Information, the “.2” reflects the location within the chapter, Requirements and Guidelines, the “.1” reflects the section in that chapter, User Inputs and the final “.10” indicates that it is the tenth guideline in the section.

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Guideline Title – Each guideline has a unique, descriptive title.

Guideline Type and description – Each guideline type (requirement or guideline) will be stated along with the description of the criterion.

Additional Information – For some guidelines, additional information is provided which may address clarifications, examples, exceptions, details regarding measurement, figures, or tables. This information is intended to assist the reviewer in the interpretation or application of the guideline.

HSI Design Criteria – Each guideline contains a statement of an HSI characteristic with which the reviewer may judge the HSI's acceptability. The criterion is not a requirement, and characteristics discrepant from the review criterion may be judged acceptable as per the procedures in the review process.

Reference – The source document(s) from which the guideline was developed is shown in superscript, according to the suffix number of the NUREG, NUREG/CR, or technical report number (see below).

1.8 Supporting Appendices

The guidelines in the main sections of this document address the physical and functional characteristics of HSIs and not the unique design process considerations that may be important. The guidelines were based on a technical basis described in the source documents. However, in the development of the guidelines, there were aspects of the design of HSIs that were found to be important to human performance, but for which there was not a sufficient technical basis to develop detailed guidelines. Until the technical basis improves to the point where detailed guidelines can be developed, these issues can be addressed on a case-by-case basis during specific reviews. To support the latter, seven appendices were developed addressing these design process considerations.

Appendix A Language and Text

Appendix B Color Usage

Appendix C User Interfaces

Appendix D Display Page Design

Appendix E Plant Notifications

Appendix F Safety Display and Indication System

Appendix G HFE Design

Appendix H Automation and Computer-Based Procedures

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Appendix I Plant Maintenance and Work ManagementUpon completion of the project the appendices will remain as part of the style guide to be used by the HFE design team as resource documents to quickly reference design attributes or address concerns during testing. This approach will help drive consistency through the entire design process.

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2.0 Volume I

2.1 Users of the Style Guide

The style guide is will be utilized by a multi-faceted design team that brings unique skills and knowledge to the effort and works collaboratively and cohesively to reach the projects goals. The NuScale HFE design team includes former nuclear plant operators and supervisors, plant system engineers, instrumentation and controls engineers, human factors engineers and software developers that work collaboratively and cohesively to reach the projects goals. This unique membership combination provides representation from all user and designer perspectives. The design team will institute the style guide as discussed below.

Volume II shall be used to locate all general user interface design requirements and guidelines for everything from work location and workstation design to common display page elements that may not be specifically addressed by every system, concept or location present in Volume III.

The design team will create appendices to be used as resource documents to quickly reference design attributes or address concerns during design process. The appendices will address concepts or techniques that are employed on all systems such as display page navigation, operator notification, and take-control philosophy.

Volume III will document all system specific user interface design requirements (both common and system specific), verification and validation, usability testing results and any FRA/FA information deemed appropriate for the development and documentation of the work location or workstation.

2.2 The Human Factors Engineering Process

The NuScale HFE program is composed of the 11 elements required by NUREG-0711 (Reference 1.5.2) to ensure that HFE principles are applied to the development, design and evaluation of HSI, procedures, and training. The elements are described in the HFE Program Management Plan (Reference 1.5.5) and summarized below.

Each element and its associated activities are included in the integrated project development schedule, available for review. Each element's implementation plan (IP) or results summary report (RSR) provides:

- qualifications and experience of personnel performing the activities in that element
- description of the scope, inputs, analyses to be performed, outputs, and documentation
- description of the applicable methodology appropriate tools and facilities to be employed

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- description of the review and documentation requirements for subordinate documents that support HFE products

2.3 Compliance and Deviations from the Standard

The style guide contains system information (Volume III), requirements (indicated in the text by a “shall” notation) and guidelines (indicated in the text by a “should” notation). Deviation from a requirement in this document requires approval by the Plant Operations Manager. All deviations from requirements should have supporting rationale. Examples of supporting rationale include task analysis results, cost-benefit analyses, and usability test results.

Deviation from a guideline does not require responsible technical authority approval.

Delivery of the system specification Volume III chapter components should occur early in the development process, to understand if deviations from the style guide are necessary.

Engineers, designers, subcontractors and vendors will work with their responsible technical authority to determine the appropriate process for deviation submittal and review.

2.4 Updating the Style Guide

2.4.1 Implementing Changes

The NuScale Power HSI Style Guide will process changes through the Document Action Form (DAF) process, DI-8389-8516 and Processing Programs, Plans, Procedures, Documented Instructions, and Forms, CP-0603-8389.

2.5 HSI Design Process

Small modular reactors are generally intended to be operated as multiple module plants from a single control room. The NuScale main control room will be configured with a state-of-the-art HSI, which requires fewer operators per module than has been traditional for currently operating nuclear power plants (NPP) while maintaining plant safety margins. Development of this HSI involves extensive analysis and significant changes to the concept of operations found at current NPPs without unduly changing the nuclear licensed operator paradigm. It also relies on a collaborative design strategy and enables a rapid development cycle to allow for changes as the concept of operation evolves and integration of the various HSI building blocks (e.g., alarm management, computer-based procedures, and work control systems).

In order to develop an HSI design strategy that enables NuScale Power to successfully operate a 12-unit plant from a single main control room (MCR), the NuScale HFE group researched the Waterfall (linear task structured approach) and Agile (more open goal oriented approach) design models as potential HSI design strategy methods. The two models, shown below, were selected from research based on their successful use in

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commercial and military design communities to develop both hardware and software products.

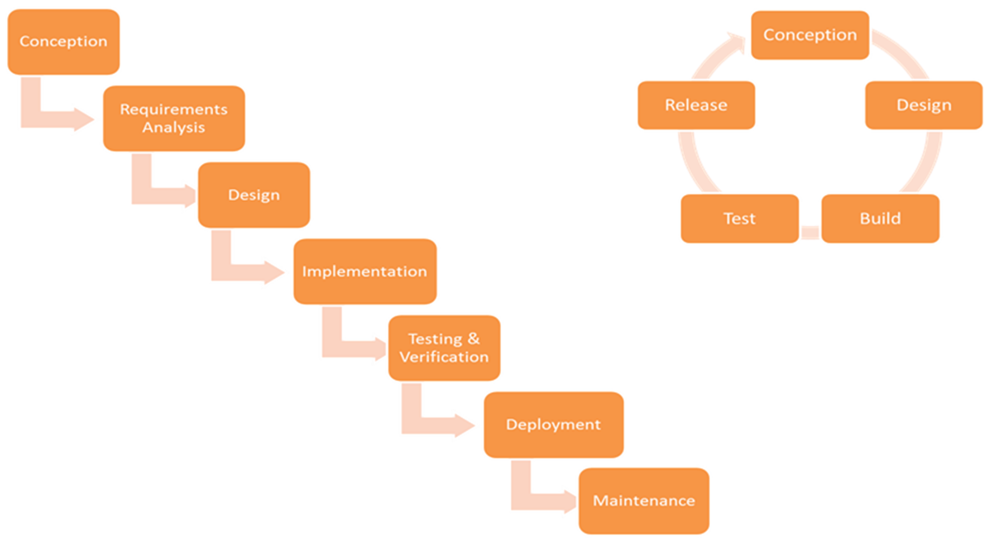

Figure 2-1. Comparison of Waterfall vs Agile Methodology

The Waterfall model is a linear or phased approach in which the design solution is developed up front and sent through the design process one step at a time until the product reaches design completion. At this point, changes to the end product, if possible, are incorporated.

The Agile model is a qualitative approach, relying on regular assessments to continually reevaluate and improve the solution. Integrated project teams work in short durations ‘sprints’ to deliver functioning components of a design. In these sprints, big deliverables are broken down into smaller, self-contained components that can be developed, implemented and assessed prior to completion.

Based on the method’s openness, rapid development cycle, and proven success, the NuScale HFE group selected the Agile model as the basis for the HSI design management strategy. There are various methodologies that incorporate the Agile philosophies based on the type of development process underway (Reference 1.5.6). The method NuScale chose to employ for the HSI display page effort is known as “scrum.” The scrum methodology concentrates particularly on how to manage tasks within a team-based development environment (Reference 1.5.7). Scrum is a way for teams to work together to develop a product, with each piece building upon previously created pieces. Building products one small piece at a time, encourages creativity, enables teams to respond to feedback and change, and build only what is needed by the operators of the plant. Scrum is the most popular and widely adopted Agile method

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because it is relatively simple to implement, promotes adaptive planning, rapid design evolution and a flexible yet documentable design process.

2.6 HSI Design Strategy Overview

The NuScale HSI design process started with creating a multi-faceted design team that brought unique skills and knowledge to the design effort. The NuScale HFE design team includes former nuclear plant operators and supervisors, NuScale plant system hardware engineers, simulator software developers, and human factors engineers. The design team followed the dynamic open flow of the Agile scrum design approach discussed above which gave the HSI effort the open, nonrestrictive design environment needed to rapidly develop the highly automated system designs and successfully deliver an effective single NuScale Power HSI design.

The design team began by applying the Scrum element of the “Sprint” meeting process to the HSI design effort. This process consisted of Sprint planning meetings, daily scrums, Sprint review meetings and Sprint retrospective meetings. For the NuScale HSI design effort the Scrum methodology stared with a “Weekly Scrum” philosophy due to the infancy of the simulator as well as the HSI design concepts. Much of what was discussed early in the effort resulted in at least week long tasks such as developing operator notification management concepts, icon libraries, display page templates, drill scenarios, etc. By applying the Scrum process this early in the project resulted in the design team building early cohesiveness such that when the design effort matured to "Daily Scrums" the design team’s ability to work together was well established.

Next, the design team built a simulator to carry out the Agile process of rapid development (sprints), test the evolving state-of-the-art HSI design, and validate the NuScale main control room manning concepts. Once the physical components of the simulator were in place, display screens, control consoles, and communications devices used by the plant operators and supervisors to interface with the plant and each other the design team began to develop the NuScale HSI.

Note: The creation of a high-fidelity simulator is at the center of three major work efforts. How the various aspects of the simulator design processes are interlinked is depicted below. The HSI portion being discussed in this document is highlighted in yellow.

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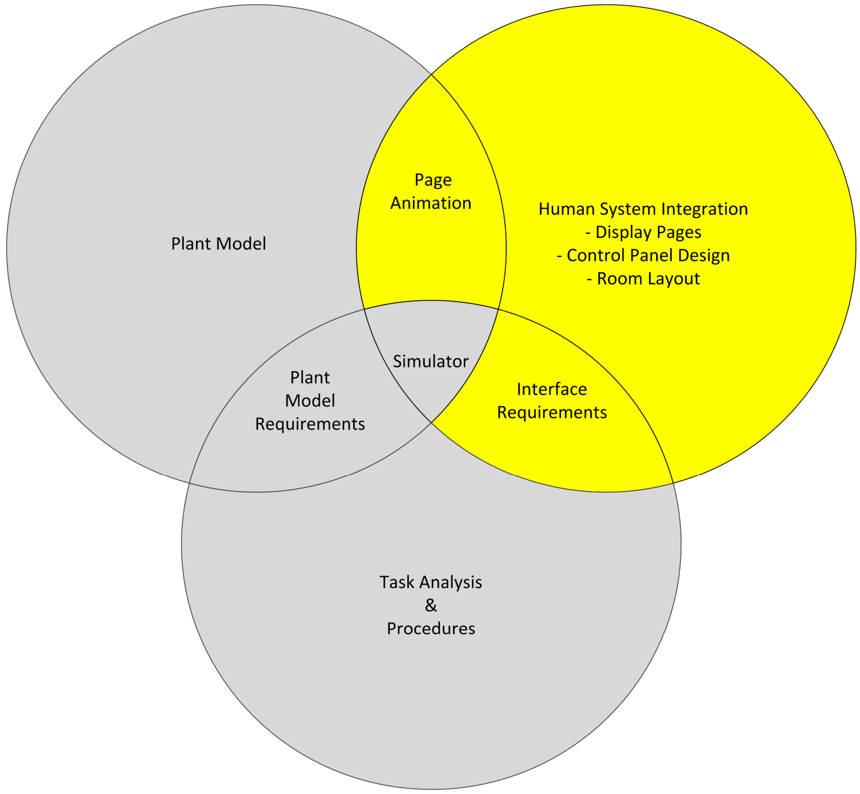

Figure 2-2. Simulator Venn diagram

2.7 Display Page Management Design

User-interface interaction and management refers to the means by which personnel provide inputs to an interface, receive information from it, and manage the tasks associated with access and control of information. User-interface interaction and management comprise a wide range of tasks operators undertake when accessing information and controls needed to operate the plant. Because the design characteristics of the HSI determine the specific nature of these tasks, there is no simple link between them and design characteristics. While a single interface task may be performed via many different user interfaces, NuScale will design a small set of plant HSI's to perform many types of interface tasks.

The demands of user-interface interaction and management often result from the particular design aspects of the HSI. For example, consider that NuScale will have three operators controlling twelve units from the main control room. The HSI design must allow for a smooth transition to and from any of the system pages as well as the common area systems. The HSI design must provide the proper amount of situational awareness and important off-normal information to the plant personnel without distracting or overwhelming them.

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The HSI characteristics that support user interface interaction management, where on the page the information should be located as well as alarm and navigation behaviors are described below.

2.8 General Design Review Considerations

This section contains the general characteristics and functions of the HSI that support user-interface interaction and management. It covers the selection of appropriate user input formats, such as direct manipulation and menus. It also contains guidelines on basic principles to limit the need for user input and on the performance of interface management tasks.

2.8.1 User Input Formats

User input format refers to the type of dialogue through which the user and the system interact. A variety of input formats can be used for user-interface interaction and management tasks.

Command Language Interfaces – Commands are instructions, entered by users via a keyboard or similar keyed device, that requests the computer system to perform specific operations. In a command language dialogue, the user interacts with the computer by entering commands, possibly with minimal prompting from the system. An important aspect of command language interfaces is that users usually must retrieve appropriate commands from memory.

Commands used for user-interface interaction and management may be categorized as action and destination commands. Action commands include instructions for specific computer operations such as manipulating information pertaining to interface management and navigating display systems. Some action commands for navigation include Previous/Next Display and Zoom In/Zoom Out; they allow users to move through an information structure in steps. Destination commands include codes for identifying and retrieving specific displays; they allow users to move directly from one location in the display network to another without accessing intervening locations (similar to navigation paths in hypertext systems). The number of destination commands may be high for a display system that contains a large number of selectable display pages.

Function Keys – Function keys are individual keys on a keyboard or pad that are dedicated to particular predefined operations, such as to call up a predefined display. When a function key is pressed, an instruction is sent to the computer system to perform that operation. An important consideration for function-key dialogues is the relationship between the keying operation and the functions executed. Single keying requires pressing an individual key. Double keying requires multiple keys to be pressed at once, such as when a function key must be pressed in combination with SHIFT, ALT, or CONTROL key. In addition, a function-key dialogue may have multiple modes, and, in each mode, a particular function key may perform a different operation.

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Macros/Programmable Function Keys – A macro-command consists of a series of commands that have been grouped and redefined as a single command. When the function key assigned to a particular macro-command is pressed, the series of commands is executed. A programmable function key is a key to which the user can assign functions; it can be assigned to a single function or a macro-command. Macro-commands and programmable function keys are special cases of the function-key dialogue. Their use enables a user to automate aspects of the interface management task.

Forms – A form is a display containing category labels and blank spaces where users enter data. In a form-filling dialogue, the user enters commands or information into the data fields. Forms facilitate the interface management task by reducing the need for the operator to memorize the types of information needed and the permissible entries for each. Command-entry forms are used to aid the user in composing commands. Information-entry forms are used for tasks requiring the user to specify information. Forms may have error checking features, which check entries to determine if they are in the permissible range. Forms may have default information already be entered into data fields to facilitate their use.

Direct Manipulation Interfaces – Direct manipulation interfaces allow users to act on visible objects to accomplish tasks, e.g., opening a display by clicking on its icon. A variety of icons may be used to manipulate plant displays. Icons shown on mimic displays represent specific plant components, systems, or functions. Clicking on them may provide access to information about these components and systems, or display an interface for their operation. Displays may contain a variety of computer-based interfaces, such as buttons and sliders, for performing interface management tasks. For example, interfaces for manipulating the presentation of display windows on display screens often contain buttons, sliders, and 'grab and drag' points; these are used for opening/closing, resizing, and moving windows and scrolling and paging the window's contents.

Input is usually provided by using a pointing device to manipulate the graphical object, causing the computer operations to be performed on the object or information it represents. Feedback is represented by a change in the graphic object. For example, when deleting a file, the document icon may disappear into a trash can icon.

Natural Language Dialogues – In natural language dialogues, users compose entries using a restricted subset of their natural language. The intent is to take advantage of the highly developed skills that people already have in using their own language, and to avoid the need for users to learn artificial dialogues for communicating with computer.

Query Language Dialogues – A query language is a special-purpose language designed to allow the user to direct questions to the computer, usually to interrogate a database. Query languages are artificial in the sense that they contain terms and grammar that are specifically developed for interacting with the computer. Most queries are entered as text strings via keyboards and are often constructed using keywords (e.g., Select, From and Where). Then a mapping function uses the keywords to examine

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the database and find all cases that satisfy the query's criteria. A query language may be limited in size to facilitate learning, but they are generally for experienced users.

Question and Answer Dialogues – Question and answer is a type of dialogue in which a computer presents one question at a time for a user to answer. While many computer dialogues pose questions in some form, to which the user must reply, the question and answer dialogue is distinguished by its explicit structure. At each step of the human-computer interaction, the system issues a single explicit question as a prompt, to which the user responds with a single answer. Answers are usually alphanumeric text strings entered via a keyboard. They may be terms from predefined dialogues (e.g., Yes/No, Increase/Decrease) from a limited grammar, or an arbitrary data item (e.g., a numerical value for a control setpoint). Question and answer systems may allow abbreviations in responses to reduce the number of keystrokes needed. Based upon the answer received, the system may determine which question to ask next. If the user enters an inappropriate answer, the system may issue an error message and then present the question again. This process may be repeated until the user gives an acceptable response.

Speech – A speech interface permits the user to provide spoken input, which a computer interprets as data or commands. Speech commands are interpreted by speech recognition systems, which can be either speaker dependent or independent. The latter have the advantage of allowing anyone to enter a command. The tradeoff is that they are less reliable, meaning that the percentage of utterances misunderstood or not recognized is higher. Speaker-dependent systems require individual operators to train the system on the unique characteristics of their voices; these systems are more reliable. Speech recognition systems can also perform more reliably if a limited vocabulary is used.

One limitation is that CRs are already verbally noisy environments and the operators' communication workload can be high. A potentially positive feature is that in computer-based CRs, the operator's hands are very busy with keyboards and other input devices.

2.8.2 Menus

A menu is a displayed listing of possible options from which a user can choose. Menu interfaces are widely used in many computer-based systems. Because they present the user with a set of options, the user needs to recognize rather than recall the correct one. A wide variety of menu systems exist. Some important characteristics include: type of options, menu structure, presentation format, menu panel design, and interaction method.

Types of Menus – Some display systems feature full-page menus, which appear as entire display pages that replace the currently displayed page. The pop-up window appears as a window that overlays the currently presented display page. The pull-down window offers additional options to the user. For example, some display systems have a menu bar that extends across one or more borders of the display screen and contains multiple options for selection. When one of these options is selected, a list of additional

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options appears on the screen. The expanding or pop-out menu is a variation of the pull-down menu in which further lower-level options appear after intermediate-level options are selected. For example, when the cursor is positioned over one of the options of the pop-up menu, an additional list of options appears. Individual options of the pop-out menu may have additional pop-out menus.

Menu Option Structure – Two important aspects of the menu structure are breadth and depth. Menu breadth refers to the number of options on a particular panel. Depth refers to the number of levels in the structure. When designing menu structures, breadth and depth can be traded off. As an extreme example, a very shallow structure would include all options on a single level (i.e., all options can be accessed from a single menu panel). At the other extreme, a very deep menu structure would assign each option to a different level (i.e., each option would lead to only one other option).

Menu Option Organization – Options may be organized on a menu panel in a variety of ways, including:

Categorical – grouped in conceptual relationships between the options.

Alphabetical – listed in the alphabetical order of the option names.

Frequency – listed in terms of how often each option is used.

Sequential – listed in the order in which options are used.

Mixed – grouped using more than one scheme. For example, the beginning of the menu may contain options that are used very frequently, while the rest of the menu options are arranged alphabetically. (This is not necessarily an acceptable arrangement, but it may exist in a menu structure that is under review.)

Menus may contain a combination of text and graphic forms. For example, an icon may be followed by the option name presented in text form. Menus often identify a subset of options that are relevant to the current situation.

Interaction Method – Menu selections are typically made by pointing with a cursor, by entering text (e.g., an associated option code), or by pressing a function key. A menu may have default mechanisms to aid selection.

2.8.3 Cursors

A cursor is an on-screen graphic element that is driven by the user (using a mouse, trackball, or other control device) to move and manipulate on-screen objects. Aspects of cursors that affect their use include:

Appearance – This includes the cursor's form (e.g., arrow or bar), salience characteristics (e.g., blinking), and positioning on the display screen.

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Controls – These are devices used for positioning the cursor (e.g., mouse or arrow keys) and their characteristics.

Movement – These are characteristics describing the movement and positioning capabilities of the cursor (e.g., responsiveness, pointing precision, cursor behavior at data entry fields, response adjustable features).

Multiple Cursors – A computer-based system may feature multiple cursors, such as when multiple personnel interact with a single, group-view display. Important characteristics include the appearance of the cursor (e.g., coding to aid discrimination of multiple cursors), identification of cursor states (e.g., active state), controlling multiple cursors from a single device, and compatibility among multiple cursor control devices.

Pointing Cursors – Pointing cursors are the arrows (or other symbols) that move across a display in response to movement of the pointing device. They are used to indicate functions, objects, or locations that the user wishes to select or act on.

Text Entry Cursors – Text entry cursors indicate the point at which typed or copied characters will be inserted. They typically appear as a blinking vertical line or underscore character.

Multiple Display Devices – In some systems, users may interact with multiple display devices by means of a single pointing device. It is important that the user is able to track the movement of the pointing cursor from one device to another.

2.8.4 System Response

System response refers to the computer system's behavior after receiving inputs from the user. Important characteristics include:

Prompts - These are cues the computer system gives the user that suggest the type of response that the user should provide. Prompts can support users in selecting the proper operation for an interface management task.

Feedback - This refers to the behavior of the computer system when the user enters data, which indicates whether the data is being received. Feedback can help users determine whether the computer has accepted an input and whether it is having the desired result.

System Response Time - This refers to the time between the submission of an input to a computer system and the return of results. Important characteristics include the amount of time and the variability between individual responses. The response time may be characterized according to the type of input to which the computer system responds (e.g., control activation, system activation, user requests, error feedback). System response time is important because long delays can detract from primary task performance, especially when the user must remember information while the system is responding.

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2.8.5 Display Selection and Navigation

Display navigation refers to the operation of searching for information, such as finding a desired display in a display network or finding an item of information within a large display. Display selection refers to the operation of retrieving a desired display or item of information. Subsections address important aspects (orientation features, retrieval features, and navigation features for large displays); each of these is described below.

2.8.5.1 Orientation Features

Orientation features help the user understand the relationship between currently accessed information and the rest of the information structure. These features are important because users of large information systems can have a sense of feeling lost in the information space. Orientation features minimize this problem; they may be present in both the display network and in the individual display pages. For example, the display network may contain features showing which display page is currently selected. Display pages that exceed the size of display windows may contain features identifying which portions are currently within view and out of view. A variety of features that support orientation are described below. These include overview displays, spatial references, contextual cues, text-based descriptions, and titles and identification codes.

Perhaps the simplest means of supporting the user's orientation is to include titles or other identifying information that indicates the position of a display in a larger information space. For example, if a group of display pages is functionally related, their titles may be designed to reflect this relationship. Some process control display systems assign a unique numerical or alphanumerical code to each display page. The coding scheme may include prefixes and suffixes to indicate relationships between displays. The prefix identifies the major branch of the menu system (e.g., a major plant system), while the suffix indicates the level in the branch. For example, if a four-digit numerical coding scheme is used, the first digit might indicate major branches (e.g., 1000, 2000, 3000), and the second digit the next lower level of branch (i.e., the second level of branches within the 2000 branch would be 2100, 2200, 2300); this pattern would continue for the remaining digits of the coding scheme.

Overview displays (sometimes called 'long-shot views' or system 'maps') support the user in understanding the overall organization of information, visualizing portions of the organization that are not currently in view, and understanding the relationships between current and target positions relative to each other and the overall organization. For example, such a display might depict the arrangement of a display network and important display pages within the network. Overview displays, as used in this context, should not be confused with displays that summarize important plant status information.

Some important characteristics of overview displays are described below:

Format – Overview displays may be presented in many formats, such as a separate page, a window within a display screen, and as stand-alone reference material.

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Parallel presentation – Display systems may vary in the availability of the overview display. The display may be retrievable upon demand or continuously presented.

Indication of current location – Overview displays may indicate of the user's current location within the information structure.

Amount of information structure shown and degree of resolution – overview displays may show the entire structure of the display network or page, or portions of it. The amount of the structure presented and the size of the presentation will affect the users' ability to resolve details. Viewing techniques such as pan and zoom allow selected portions of a display to be viewed. Window resizing may be used to adjust the size of the presentation.

Spatial references are visual features that convey information about the relationship of currently viewed information to the rest of the information structure. When the entire structure cannot be viewed at once, spatial references may help the user identify the current location and to understand where adjacent items may be found. Some techniques include:

Scales, axes, and grids – Scales, axes, and grids are sometimes used to provide spatial references for graphically displays. Axes are the graphical representation of orthogonal dimensions in the form of lines (e.g., horizontal and vertical axes). A scale is a graduated series of demarcations indicating the divisions of an axis. A grid is a network of uniformly spaced horizontal and vertical lines for locating points by means of coordinates. Grids may be applied to large displays to divide them into discrete sections, such as those used in geographical maps. If the grid uses a sequential coordinate system such as numbers or letters, then the user may use the coordinates of the current position to determine how much of the display structure lies in each direction around it. Grids are especially compatible with spatially organized information such as maps and mimic displays.

Perceptual landmarks – These are easily discernable display features that can support the user's understanding of the arrangement of information within a display. Once a landmark is recognized, patterns are quickly activated to guide subsequent searches in its vicinity. When they appear in successive displays, landmarks can provide a frame of reference for establishing relationships between the displays. In graphical displays, major pieces of equipment, such as the reactor vessel or turbine, may serve as landmarks. Labels and headings provide important landmarks for aiding navigation in displays of tabular data or text (e.g., computer-based procedures).

Display overlap – A single display that is too large to be shown as a single view on a display device may be divided into sections in which some portions repeat (overlap) across successive views. These repeated features establish across-display relationships (e.g., interfacing piping systems may be depicted on another display) and may call attention to other display frames (e.g., the edge of one display may identify the beginning of an adjacent display containing related information). The overlap may present physical or functional relationships between successive views.

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Orientation coding, such as different background colors and patterns, may be applied to some display pages to differentiate them from displays in other parts of the display network. These cues may be used to overcome the homogeneity of displays and convey a sense of location.

2.8.5.2 Retrieval Features

Retrieval features are features of the user interface that support the user in retrieving items from the display system. These features address questions such as, "How did I get here?" and "Where can I go, and how do I get there?" They also relate to aspects of the navigation task, specifically, selecting a navigation path and executing it. Both the display network and the individual display pages contain retrieval features. The features described in this section are applicable to selecting individual display pages from a display network. In addition, many of these features also pertain to large display pages. Many may be used by operators to bring into view areas of display pages that are too large to be viewed all at once on a single screen.

2.8.5.3 Navigation Features for Large Display Pages

Display pages are sometimes too large to be viewed all at once from a single display screen with a level of resolution adequate for users' tasks. For example, if the display page were reduced in size to fit the available space of the display device, the text and other visual details would be too small for the user to read. In NPPs, large displays with graphical information may include mimic displays (e.g., representations of plant systems), flowcharts (e.g., representations of procedure steps), overviews of the display network, and maps (e.g., a representation of the physical arrangement of equipment in the containment building). Large displays with non-graphical data may include text displays, such as tables of data with many columns and rows. These displays can be navigated by the following means:

Scrolling – Scrolling is a display framing technique that allows the user to view a display as moving behind a fixed frame. The scrolling action typically causes the data displayed at one end of the screen to move across it, toward the opposite end. When the data reach the opposite edge to the screen they are removed (i.e., scroll off of the screen). Thus, old data are removed from one end while new data are added at the other. This creates the impression of the display page being on an unwinding scroll, with only a limited portion being visible at any time from the screen; i.e., the display screen is perceived as being stationary while the displayed material moves (scrolls) behind it. Displays may be scrolled in the top-bottom direction, the left-right direction, or both.

Paging – Paging is a display framing technique that allows the user to view a display as a set of display-size pages that are accessed in discrete steps. Thus, rather than being presented as a scroll, the display page is presented as a set of discrete pages. These pages are often accessed sequentially.

Hierarchical Paging – With this approach, the large display page is divided into a set of smaller pages organized in a hierarchy. The pages vary in the amount of material

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included from the large display page and the degree of magnification. As the user moves down the hierarchy, more detailed information is accessed from smaller areas of the large display page.

Panning – Panning is movement in the left to right dimension across a display screen or from top to bottom; the latter movement is sometimes referred to as "tilt". The distinction from scrolling is one of perspective; panning is the opposite of scrolling. When panning, the viewer perceives the displayed material as being stationary while the viewing area of the display screen moves across it.

Zooming – Zooming is also based on a camera analogy; the action is analogous to changing the focal length of a camera lens. Zooming-in is similar to moving closer to an object while zooming-out is similar to moving further away from it. Because the size of the display screen is fixed, the effect of zooming-in is to show a smaller area of the display page at a higher magnification; the effect of zooming-out is to show a larger area at lower magnification. Panning capabilities are often provided in conjunction with zooming capabilities.

Distortion-Oriented Techniques – These techniques allow a user to view details of an area of a large display page while keeping the rest of the page in view. This is accomplished by presenting the focus area at a higher magnification than the rest of the display page. The result is a distorted view of the large display page because different parts of it give the user contextual information. Key features of the unmagnified global structure inform the user of the existence and location of other parts of the information structure and support the interpretation of local details.

2.8.5.4 Windows

A window is a dedicated geometric area on a display screen within which the system presents information or receives input from the user. Windows may be manipulated as follows to adjust the presentation of information in a display screen:

Closing/Opening – Windows that are not in use may be closed to reduce clutter in the display screen or opened to allow the user to view and interact with the display contained in the window.

Sizing – The size of the windows on the display screen may be increased (e.g., to make them easier to view) or decreased (e.g., to reduce clutter).

Positioning – The windows on the screen may be positioned to improve the user's view or to locate related windows adjacent to one another.

Layering – Layering refers to moving one window so it appears to be positioned on top of another one. The overlapping may be partial, such that the top window covers all but a portion of the other window, or total, such that it entirely covers the other window. The degree of overlap of one window relative to the others may be changed to improve the user's view of or increase the ease of interaction with its contents.

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Tiling – Tiling refers to a configuration in which windows are positioned beside one another like floor tiles. Windows may be arranged in a tiled format so that they can be viewed without overlaps, and related windows are adjacent to each other.

The degree of automation of window management tasks may vary. For some systems, all window management tasks are performed manually; in others, they are performed automatically by the information system. Still other window management systems present windows automatically but allow the operator to make manual adjustments. For example, when an information system opens a window (e.g., in response to a change in the plant or information system or the operator's input), it automatically determines the size and position of the window on the display screen. The operator may then close, move, or resize the window.

2.8.5.5 Display Control

Display controls allow users to select the information that is presented and the format in which it is displayed.

Display Update/Freeze Features – The update capability of a display system refreshes the data in a display with current values. A display freeze capability prevents a data display from being refreshed with current data values. The freeze capability may be used to provide a view of the status for a specified time or to allow the user to read a rapidly changing display. Display update capabilities are typically initiated automatically; in some cases, the user may be able to adjust the rate of updating. Display freeze capabilities may be initiated automatically or manually. Important characteristics of these capabilities include the degree of user control, the rate of automatic updates, and the designation of the freeze state.

Display Suppression Features – Display suppression features temporarily remove information that is less important, irrelevant, or otherwise unnecessary, and then redisplay it when needed. The intent is to reduce visual clutter. Important characteristics include the user's degree control over the display suppression capabilities, dedicated keys for this capability, and the designation of the suppressed state.

Scrolling and Paging – When the area needed to display information exceeds the space provided by the display device or window, users are able to bring selected portions into view by scrolling or paging.

Automated Actions – Guidelines for reviewing features that automatically perform window management functions are given in Section 3.1.

2.8.6 User Assistance

Systems typically include various features intended to assist the user. Guidance/help may be provided online and in hardcopy. Computer-based guidance/help may be presented automatically (e.g., after an incorrect entry has been detected) or at the user's request.

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Online help may be provided in a variety of computer-based formats ranging from online manuals to brief messages. In some systems, the guidance information appears in a display page that completely replaces the existing task display. Window-based systems can present guidance information within the same display screen as the task display, allowing the task and the guidance to be viewed simultaneously. The presentation of this guidance may be initiated by the user or the system. The user may actively access guidance (e.g., by entering a help command or opening an online guidance document). The guidance system may retrieve a help document, issue a message, or prompt the user to take a particular action.

Advisory Messages – These are messages from the computer system indicating conditions that may require the user's attention.

Error Messages – These are messages from the computer system to the user indicating that an error or potential error has been made.

User Input Validation – These are capabilities that check the user's inputs, according to defined software logic, and indicate that it is acceptable to the computer system. For example, a validating capability may inform the user that a command or query is improperly formatted.

Entry Confirmation – These are features that require users to carry out additional operations to confirm their intent of a particular entry. The system may prompt the user when an entry may have a destructive effect, such as exiting a mode, deleting or changing a file, or shutting down equipment.

Data Protection – These are automatic capabilities for minimizing the loss of data that may occur as the result of a computer failure or the user's actions. They remind personnel to take necessary action to protect data. Capabilities for protecting against computer failures include periodic automatic archiving of data files, maintenance of transaction logs for reconstructing recent data changes, offsite storage of copies of important software, and the provision of backup computing facilities. Capabilities for protecting against user errors include protection from interrupts and data changes, and safe defaults.

Correction of Information and Command Entries – These are capabilities that, after checking data or command inputs entered by the user, either automatically put them in the correct form or supply corrections that the user can either accept or reject.

2.8.7 System Security

A computer-based system may contain the following features that restrict personnel access to aspects of the computer system to prevent accidental or deliberate damage:

User Identification – These are capabilities for establishing the identities of authorized users. Important characteristics include password protection, tests to authenticate user

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identity, and notifications of potential threats to data security, such as from unauthorized personnel.

Information Access – These are capabilities that reduce the likelihood of files being accessed and changed. Examples include encryption of sensitive data, indication of the data's security classification, administrative controls regarding access to printed data, automatic records of data access, and the use of read-only files.

In the course of developing the guidance for user-interface interaction and management, several considerations were identified that are important to crew performance and safety, but for which the technical basis was insufficient to develop specific HFE guidelines.

2.8.8 Interface Flexibility

Flexibility is built into most interfaces to enable users to tailor their HSIs to meet current task demands and to adjust them to their personal preferences.

2.8.9 Display Format Selection

Table 2-1 provides some formats and conditions for their appropriate use in the context of five representative user tasks. Display formats should be task dependent. While the table identifies several classical display formats, novel formats can be acceptable if their support for the users' tasks can be demonstrated. Since tasks can vary, advanced HSIs should provide the user with the flexibility to display information in alternate formats that reflect changes in task requirements.

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Table 2-1. Display formats for representative user tasks (Reference 1.5.1)

Representative Task	Format	Condition for Appropriate Use
Comprehending Instructions or General Descriptions	Continuous Text	General
	Lists	Series of related items
	Speech Displays	User's attention not directed toward text display
	Flowcharts	Sequential decision process with no tradeoffs
Examining and Comparing Individual Numerical Values or Text	Tables	Detailed comparisons of ordered sets of data
	Data Forms	Detailed comparisons of related sets of data items from separately labeled fields
Examining Functional Relationships of Components of a System	Mimics and Diagrams	General
Examining Spatial Relationships of Objects or Places	Diagrams	General
	Maps	Geographical Data
Examining and Interpreting Patterns in Numerical Data	Bar Charts	Single variable viewed over several discrete entities or at discrete intervals
	Histograms	Frequency of occurrence viewed at discrete intervals of a single variable
	Pie Charts	Relative distribution of a single variable over several categories
	Graphs	Two or more continuous variables
	Graphs: Scatterplot	Spatial distribution of data within a coordinate system

2.9 Appropriate Use of HSI Flexibility Features

Uses of HSI flexibility – User performance may be impaired by an excessive number of flexibility features or inadequately designed flexibility features that create demands that compete with primary tasks. Inadequately designed flexibility features can also expose the user to HSI configurations that violate human factors engineering principles and may increase the likelihood of errors and poorer task performance. Some uses of HSI flexibility that may enhance performance are listed below.

Reduce the Cost of Accessing Information – Flexible HSI capabilities can reduce the attention and effort required for accessing information. The flexibility of computer-based technologies can enhance operator performance by allowing the HSI to provide the right information for the operator's current work methods and work objectives, while removing unneeded information that may become a nuisance. Examples include: automated information retrieval features; programmable function keys for accessing particular displays; capabilities for organizing information (i.e., display window management, spatial arrangement of icons); and capabilities for introducing labels, markers, or landmarks to support operators in locating information in displays that require visual scanning.

Reduce the Cost of Processing and Integrating Information – Flexible HSI capabilities can support operators in mentally processing and integrating information presented by the HSI. Examples of HSI features for arranging the spatial proximity of information to aid mental integration include: the physical movement of display devices, the movement of display pages to particular display devices, and the movement of

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display pages within display windows. Examples of HSI features for supporting users interpreting information include reconfigurable displays, such as graphical plots in which an operator may plot one variable as a function of another or as a function of time, and features that perform calculations requested by the operator.

Reduce the Cost of Executing Control Actions – Flexible HSI capabilities can reduce the effort and attention required for executing control actions. Examples include HSI features that allow particular control actions to be executed automatically. Other examples include: "escape mechanisms" features, which allow to the operator to promptly terminate and exist complicated human-system interactions, and "workarounds," which allow the user to override automatic responses that may not be beneficial for a particular task.

Enhance Signals – This capability increases the salience of an indication or piece of information to support detection by operators. These changes in salience effectively increase the signal-to-noise ratio for specific information.

Reduce Noise – This capability reduces or removes "noise" from the information environment to support the operator in detecting relevant information. This removal or reduction of noise effectively increases the signal-to-noise ratio for other information that may be more important. Noise may include indications of plant or system changes that do not provide information that is useful to the operator's current tasks.

Document a Baseline or Trend – This capability allows the operator to create a referent for monitoring so that changes can be easily identified without relying upon the operator's memory of the previous state. Examples include capabilities for documenting initial conditions or for establishing a trend over a period of time for comparison at some later time.

Create External Reminders – This capability allows the operator to create reminders for activities involved in monitoring or control execution. Reminders for monitoring activities may identify particular variables requiring close attention. Reminders for control actions may remind operators of special conditions important when carrying-out control actions. For example, operators may create reminders regarding unusual control configurations that should not be changed or to draw attention to unusual indications that are already being addressed in other ways. These reminders may be created through manipulations of the appearance of the HSI component or through the creation of messages.

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3.0 Volume II

3.1 General HSI Information

Information is at the center of human performance in complex systems. This section addresses the way in which information is presented to the user of the display system developed by NuScale Power.

The presentation of information to the operator is built around information requirements; i.e., the information operators need to monitor and control the plant. The determination of what information is needed and how to best present it is referred to as information requirements analysis.

While the HFE Functional Requirements Analysis and Function Allocation (FRA/FA) efforts identify what information is needed by the users of the plant, the way in which that information is presented is called information representation, and is composed of the following considerations: Formats, elements, display pages, networks, data quality and update rates, and display devices (see Figure 3-1).

Display formats are the types of information presentations that designers select to convey information to operators. Examples are trend displays and piping and instrumentation displays. Formats are made up of display elements, such as alphanumeric characters, icons, arrows, and axes. An important consideration when using information is its quality (how valid the information is) and update rate (how current the information is). Designers will frequently group several formats together to form display pages, i.e., the information contained on one display screen.

NuScale may have hundreds or thousands of such pages within the plant information network and operators choose the pages they want to view on the available display devices. Each of these specific aspects of information display is described below. General guidance for reviewing information displays is given in Section 3.1.2.

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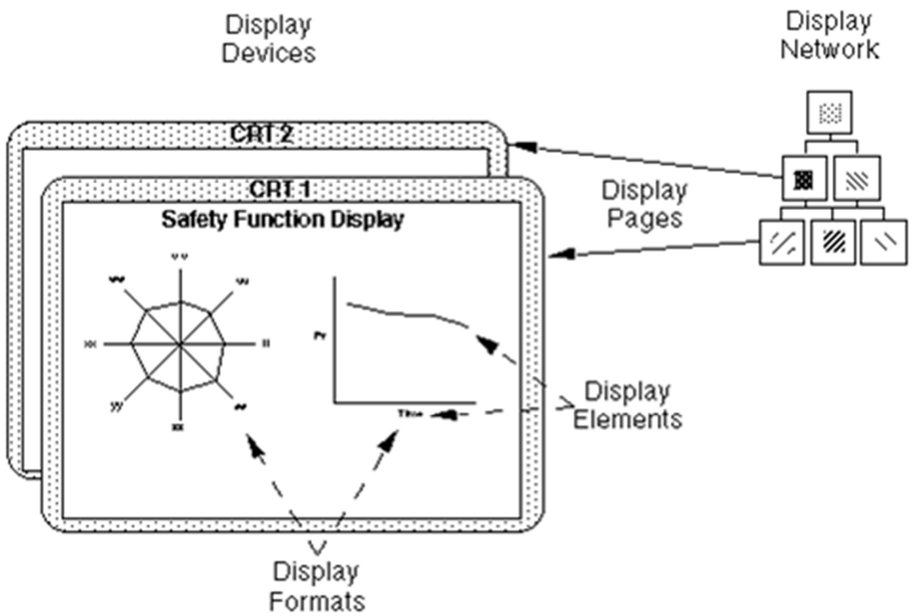

Figure 3-1. Information display characterization

3.1.1 Definitions

Display Formats – Display format refers to methods of information presentation consisting of an organized arrangement of smaller display elements. They are the most significant "unit of analysis" of the information system because the selection of format greatly influences the ability of operators to easily and correctly understand the information presented. Display formats range in complexity from simple, such as data fields and tables, to more complicated forms, such as configural and mimic displays. The ability of computer graphics to portray an essentially limitless set of novel graphic forms has offered great possibilities to provide operators with enhanced representations of the plant. The formats addressed in the design review guidelines are:

Continuous text displays – This format consists of alphanumeric character strings (e.g., words and numbers) arranged in uninterrupted linear arrays, such as sentences and paragraphs. Examples include a text-based description of a plant system and an instructional step in a computer-based procedure display.

Tables and lists – A table is a display containing alphanumeric characters arranged by rows and columns. A list is a display containing alphanumeric strings arranged in a single column by rows.

Data forms and fields – A data field is a space in a display containing information (e.g., the current value of a variable). Some data fields may accept input entered by the user. A data form is a display containing one or more data fields.

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Bar charts and histograms – A bar chart is graphic figure in which numeric quantities are represented by the linear extent of parallel lines (or bars), either horizontally or vertically. A histogram is a type of bar chart used to depict the frequency distribution for a continuous variable. The variable may be grouped into classes.

Graphs – A graph is a display that represents the variation of a variable in comparison with that of one or more other variables. For example, pressure may be plotted as a function of temperature.

Certain types of graphs (see Integral and Configural Displays, below) use emergent features to portray higher-level information.

Pie charts – A pie chart is a circular chart divided into sections (as pieces of a pie) to represent graphically the relative proportions of different parts of a whole. The segments may represent magnitudes or frequencies.

Flowcharts – A flowchart is a diagram that illustrates sequential relations among elements or events. Flowcharts are often shown as boxes connected by arrows.

Mimics and diagrams – A mimic is a display format combining graphics and alphanumerics used to integrate system components into functionally oriented diagrams that reflect component relationships. For example, a mimic display may be used to provide a schematic representation of a system. A diagram is a special form of a picture in which details are only shown if they are necessary for a task. For example, an electrical wiring diagram for a facility would show wiring but not necessarily furniture or plumbing.

Maps – A map is a graphical representation of an area or a space, such as the layout of a room or a facility.

Integral and Configural Displays – The quantity of data presented in the control room can, at times, overload the operator. To lower the workload associated with extracting meaningful information from data, displays may be designed to help integrate data into more meaningful units of information. These displays map low-level data, process constraints, and relevant performance goals into the appearance and dynamic behavior of a graphical element so that this information is readily available. There are two types of these displays, integral and configural, which differ in how the relationships among data are represented.

Integral displays show information in such a way that the individual parameters used to generate the display are not represented in it. For example, a display might provide information on overall system status by the appearance of an icon. The icon may change appearance based on computations involving lower-level parameters, but the parameter values themselves are not presented.

In configural displays, the relationships among parameters are represented as emergent features of a graphical element. (An *emergent feature* is a global perceptual feature that

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is produced by the interactions among individual lines, contours, and shapes). In contrast to integral displays, information about the individual parameters is also available in the display. Configural displays often use simple graphic forms, such as a polygon. Information that could be presented by separate display formats is integrated into a single format in which each of the separate pieces of information is represented, for example, by the distance of a polygon's vertex from its center. In addition, the geometric shape of the polygon provides a high-level summary (the emergent feature).

Graphic instrument panels – These are formats in which graphical objects are arranged to resemble instruments in a control panel. For example, an individual indicator may appear as a circular meter containing a numerical scale and an indicating needle.

Speech displays – These are displays that provide information in the form of human speech (either computer-generated or a recorded human voice). Messages are conveyed to the user through audio devices, such as speakers and headsets.

3.1.1.1 Display Elements

Display elements are the building blocks of the display formats. The following display elements are commonly used in computer-based systems:

Alphanumeric characters – These are symbols consisting of letters, digits, and usually other symbols, such as punctuation marks.

Abbreviations and acronyms – An abbreviation is a shortened form of a word or phrase used for brevity (e.g., the word “pressure” might be abbreviated as “press”). An acronym is a word formed from the initial letter(s) of each of the successive or major parts of a compound term. For example, the acronym SART is sometimes used to represent the alarm system control operations: silence, acknowledge, reset, and test.

Labels – A label in a descriptor containing one or more character strings that is intended to support users in identifying structures or components on a display page.

Icons and symbols – An icon is a pictorial, pictographic, or other nonverbal representation of objects or actions. A symbol is a representation of something by reason of relationship, association, or convention. Symbols used in information displays may be alphanumerical characters or abstract shapes.

Numeric data – These are data represented in numerical form (as opposed to text form). Examples include numerical representations of plant variables or control setpoints.

Scales, axes, and grids – Scales, axes, and grids are used to graphically represent data. Axes are the graphical representation of orthogonal dimensions in the form of lines (e.g., the horizontal and vertical axes of a plot may be the X and Y dimensions, respectively). A scale is a graduated series of demarcations indicating the divisions of an

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axis. A grid is a network of uniformly spaced horizontal and vertical lines for locating points by means of coordinates.

Borders, lines, and arrows – Borders, lines, and arrows are basic elements used to present information graphically. Lines are used to connect objects or to provide a demarcation between objects. A border is a set of demarcation lines that frame an object or group of objects. Arrows are lines that indicate direction.

Color – Color is an aspect of objects or light sources that may be described in terms of hue, lightness (or brightness), and saturation. Coding based on the use of color is an important means for representing information in displays.

Size, shape, and pattern coding – These are three methods for coding information in graphical displays. Size coding allows objects to be compared and contrasted based on relative size. Shape coding allows objects to be compared and contrasted based on similarities and differences in their outlines (shape). Pattern coding supports comparisons and contrasts of objects based on similarities in such characteristics as size, color, position, and orientation.

Highlighting by brightness and flashing – Highlighting is a means of directing the user's attention to a feature of the display. Highlighting that is based on brightness attempts to increase an object's salience by making it appear brighter than other objects. Flashing increases salience by increasing and decreasing in alteration the brightness of an object or its background.

Auditory coding – This is a type of information coding that conveys meaning through the use of sounds, such as auditory tones.

3.1.1.2 Data Quality and Update Rate

The ability of personnel to use information depends to a great degree upon the quality of the data presented, including the frequency with which it is updated. Data quality considerations include the ways in which data from plant sensors are processed and checked for accuracy (e.g., analytical redundancy and data verification). It also includes the ways in which data quality (i.e., accuracy) is communicated to the user. Data update rate refers to the frequency with which data sensors are sampled and the contents of a display are refreshed.

3.1.1.3 Display Pages

Display pages are defined sets of information intended to be presented as a single unit. Typical display pages may combine several different formats on a single video display unit (VDU) screen, such as combining bar charts and digital displays within a representation of a piping and instrumentation diagram. The content of a display page, i.e., the integration of formats that make up the page, is usually intended to provide an organized view of some aspect of the process. For example, a page may provide a high-level status overview of the primary system. Display pages typically have a label and

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designation within the computer system so they can be accessed by operators as a single "display."

3.1.1.4 Display Devices

Display devices are the media used to present information to personnel. They include computer-based and conventional devices and have characteristics important to personnel performance, such as resolution, viewing angle, number, and placement within the HSI. The following are devices commonly used to present information in HSIs:

Video display units – A VDU is an electronic device for the display of visual information in the form of text and/or graphics.

Large-screen or Group View Displays – A large-screen display is a device, which due to its large size, can be simultaneously viewed from multiple workstations and locations in a control room.

Printers, recorders, and plotters – These are devices that present information in a hardcopy (e.g., paper or other media) form. A printer is a device that writes output data from a system. Recorders and plotters are used to write trend data in graphical form.

Meters – A meter is an indicator that typically features a numerical scale and a needle. Two types of meters are fixed-scale (i.e., the needle moves across the scale) and moving-scale (i.e., the scale moves behind the needle).

Light indicators – These are display devices containing lamps that indicate status or states through the presence or absence of illumination. For example, an illuminated light indicator may be used to show that a breaker is closed.

Numeric readouts – A numeric readout is a display device that presents data as a string of numerals (digits).

3.1.1.5 Display Networks

Display network refers to an entire set of display pages within an information system. Complex systems, such as nuclear plants, are usually represented by many graphic displays. In fact, for new plants the numbers of display pages is more typically in the hundreds and thousands. To perform their functions and tasks, operators must access these pages. When the number of pages is large, knowing where information is located can become difficult. Therefore, the organizational structure of the display network is an important consideration for personnel performance because users must have a good understanding of this structure to engage in display navigation tasks.

Three commonly used display network structures are hierarchical, relational, and sequential. Each is briefly described below.

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Hierarchical Structure – In a hierarchical structure, information is organized like an inverted tree in which the lower branches provide increasingly specific categories related to the more general categories contained in the higher branches and trunk. Typically, each point or node of the structure has one entry point from a higher-level branch, and one or more exit points to lower branches. Hierarchical structure may be described in terms of depth (number of levels in the hierarchy) and breadth (number of options per node). Hierarchical structures may represent functional or physical relationships. For example, one type of hierarchical structure commonly used in process control is based on the physical organization of plant systems. In this structure, a plant system, such as the reactor coolant system, is represented by a set of display pages that provide increasingly detailed views of specific subsystems or components. Another common type of hierarchical structure is based on plant functions, in which a high-level function, such as core heat removal, is represented by a series of display pages presenting lower-level (i.e., supporting) functions.

Relational Structure – Relational display network structures have multiple links between nodes, which are based on a variety of relationships. Unlike the hierarchical structure, each node of a relational network may have one or more entry points as well as one or more exit points.

Sequential Structure – A sequential display network structure organizes display pages in a series, often representing dependent relationships. One example is the flowchart format, which may be based on the flow of physical or organizational processes.

A specific display network may contain one or more of these structures. For example, a hierarchically structured network may also contain relational links. As another example, individual branches having sequential structures may be contained in a network that has a different structure.

3.1.2 Requirements and Guidelines

The guidelines and requirements in this section will be incorporated into the NuScale HSI design by applying proven HSI display page design practices to the individual system development cycle. The process used will include but is not limited to; applying lessons learned from similar control room design efforts, review of the individual systems FRA/FA, review of the systems P&ID and the systems alarm needs to help determine the best methods of providing the operators with the information they need to perform their specific job assignments. This effort will include the determination of when to use text, graphs, icons, etc. to provide information to the operator.

Once several individual system development cycles have matured the design team will finalize the location of the information on the display page.

The outcome of the individual efforts will generate common user guidance documents which will be part of the Appendices of Volume II. The appendices will provide the distillation of the guidance and requirements found in Volume II for various areas of the NuScale design.

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The purpose of these guidance appendices will be to provide NuScale engineers and designers the tools they would need to design any new systems or perform upgrades to already developed design without needing to fully understand HFE design techniques or search through the entire document to quickly answer a display page implementation questions.

3.1.2.1 User Inputs

3.1.2.1.1 Consistent Data Entry Interface

ES-0304-1381-8927

Guideline: Techniques for entering commands or information should be simple and consistent in form and consequences.

All terms employed in the user-system interface, and their abbreviations, should be consistent in meaning from one transaction to another, and from one task to another.

The wording and required format of information should be consistently reflected in the wording of user guidance, including all operating procedures, labels, messages, and training material.

User input actions should be simple, particularly for real-time tasks requiring fast user response.

The selection of interface types should be based on anticipated task requirements.

A user should not be required to re-enter information already available to the system.

Information necessary to accomplish a specific entry (e.g., labels, annotations, prompts, or options lists) should be available to the user when that transaction action is appropriate.

An information entry sequence should be designed so that its organization reflects the user's view of the task, and should provide all control options that may be required.

Users should be allowed to control the processing of information or commands by explicit action.

The computer should acknowledge every entry.

When system functioning requires the user to stand-by, periodic feedback should be provided to indicate normal system operation.

In situations where control lockout does occur, an auxiliary means of control entry should be provided, such as a special function key, to abort a transaction causing extended lockout.

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The same explicit ENTER action should be required for entry of corrections as used for the original entry.

Users should be able to perform simple editing during text entry without having to invoke a separate edit mode.

If entries are made by keying onto the display, such as by keyed menu selections or commands, they should be distinguishable from displayed text.

Optional versus required data entries within fields on input forms should be distinct.

Annotations added by users to displayed text should be distinguishable from the text itself.

When information or command entry requirements may change, some means for the user (or a system administrator) to make necessary changes to available functions should be provided.

Users should be able to request guidance information regarding requirements for information of command entry (e.g., syntax, parameters, and options).

HSI Design Criteria

Terms used in data entry will follow the list of terms listed in Appendix A.

Push Button interfaces will be used in place of data entry where speed of entry is necessary.

Once information has been entered and confirmed it should not have to be reentered unless it was deleted by the operator. The system shall not delete entered data.

System prompts to information or actions needed from the user will be clearly labeled, provided in a familiar form (ex. steps) and use familiar terms found in Appendix A.

Termination of an entry will only cancel that entry not a series of entries.

Positive feedback will be provided to the user based on the type of command given.

Example: The changing of the setpoint will be displayed on the HSI and a confirmation of the change will be asked for.

Users will have the ability to UNDO a command made in error by going back into the process of task.

The "ENTER" key will be one method used to enter data into the system.

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For large text entries the ability to edit will be provided via a standard word editing type set of functions.

Required data entry points will be clearly displayed to the operator by either a flashing area for the current location to edit or "WHITE" boxed areas that the operator can "TAB" or mouse click on for entry.

User shall not be allowed to change data entry formats or information types.

Guidance or “HELP” on any elements on the HSI will be provided via the mouse roll-over feature that will provide a pop-up window populated with additional information pertaining to that particular element.

Reference: NUREG-0700-2.1

3.1.2.1.2 Stacked Entries

ES-0304-1381-8982

Guideline: Users should be allowed to key a sequence of commands or option codes as a single 'stacked' entry in any order, style or punctuation needed to complete the task.

HSI Design Criteria

NuScale stacked entries will be separated by the "/" symbol.

Reference: NUREG-0700-2.1

3.1.2.1.3 Distinctive and Consistent Display of Control Information

ES-0304-1381-8992

Guideline: All displays should be designed so that features relevant to user entries are distinctive in position and/or format and provide some continuous indication of current context.

Information displayed to provide context for user entries should be distinctive in location and format, and consistently displayed from one transaction to the next.

HSI Design Criteria

All controllable icons shall provide constant feedback to the operator via color for status or highlighted for selected per the icon library.

All data entry fields will provide feedback via highlighted text or blank areas with a blinking cursor per the icon library.

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The current step in an automated process shall be highlighted.

Reference: NUREG-0700-2.1

3.1.2.1.4 Record of Prior Entries

ES-0304-1381-8998

Guideline: Users should be permitted to request a summary of prior entries to help determine present status, and should be allowed to review the parameters currently in effect.

HSI Design Criteria

The data historian shall provide the sorting of data for each module and each process that is currently being followed whether that process is manual or automatic.

Reference: NUREG-0700-2.1

3.1.2.1.5 Standard Display Area for Command Entry

ES-0304-1381-9000

Guideline: A command entry area in a consistent location should be provided on every display.

HSI Design Criteria

All controllable icons will have pop up control windows that will have consistent commands for that component located in a consistent location on a consistently presented interface window.

All data entry locations such as setpoints or notes will be provided as shown in the icon library.

Unavailable options shall be dithered to show that they cannot be selected.

Menus shall always be provided in the same locations.

Reference: NUREG-0700-2.1

3.1.2.1.6 General List of Menu Options

ES-0304-1381-9002

Guideline: A general list of menu options should always be available and provide a 'home base' or consistent starting point for the user.

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The options list should be grouped, labeled, and ordered in terms of their logical function, frequency, and criticality of use, following the general guidelines for menu design in section 3.1.2.20.

HSI Design Criteria

All menus will be presented to the user in a format that provides an easy familiar method of starting back at a home position.

The types of menus will be the windows based address and tool bars as well as 3D type push buttons that drive the user to specific locations within the HSI library but allow for a quick return to the original location.

Automated process windows will use a scroll bar to scan the entire process much like windows uses the scroll bar in the navigation pane to allow for easily navigating anywhere in the process.

Reference: NUREG-0700-2.1

3.1.2.1.7 Control by Simultaneous Users

ES-0304-1381-9016

Guideline: When several users must interact with the system simultaneously, control entries by one user should not interfere with those of another.

HSI Design Criteria

Components on system pages will not be able to be controlled unless a plant operator takes control of that system.

Taking control of a particular system on a particular module DOES NOT lock out other operators from viewing the pages.

Taking control of a system DOES NOT mean that operator has control of all the systems for that module.

Reference: NUREG-0700-2.1

3.1.2.1.8 User Control of Processing

ES-0304-1381-9020

Guideline: Users should be allowed to control processing of a command or request.

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HSI Design Criteria

Where appropriate processes will have options that allow operators to start, stop, pause, cancel or end a process that is under way.

The current status of the control process shall be highlighted to indicate what step of the process the system is in.

Reference: NUREG-0700-2.1

3.1.2.1.9 User Control of Entry

ES-0304-1381-9028

Guideline: Users should be allowed to control the pace and sequence of their entry of information or commands.

HSI Design Criteria

Operator control entries shall always ask for confirmation of the command before the command is allowed to begin processing.

Reference: NUREG-0700-2.1

3.1.2.1.10 Data Manipulation

ES-0304-1381-9038

Guideline: The user should be able to manipulate information without concern for internal storage and retrieval mechanisms of the system.

Default values for the information to be entered in a particular task should be offered and displayed in the appropriate data field to speed entry.

Users should be permitted to define, change, or remove default values for any input field.

HSI Design Criteria

The control system will provide sufficient memory for plant control.

Default values will be provided to the operators in data entry fields.

Operators will be able to "TAB" from data entry locations for speed of entry.

The current entry being manipulated will be highlighted.

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The data entry interface will be a standard windows based entry icon that will be consistent throughout the entire HSI design.

Reference: NUREG-0700-2.1

3.1.2.1.11 Automatic Behavior of Data Entries

ES-0304-1381-9056

Guideline: Automatic justification of tabular data entries should be provided.

Numeric values should be displayed to the level of significance required of the data, regardless of the value of individual input data.

HSI Design Criteria

All data entry will be justified according to the task.

Numerical data will be right justified.

Text will be left justified.

Leading zeros will be truncated.

Example: 023.8 will be replaced with 23.8

Where applicable numbers after two decimal places will be rounded up and truncated. Example 3.456 will be displayed as 3.46. Exceptions: radiation monitoring may need to be more precise.

Reference: NUREG-0700-2.1

3.1.2.1.12 Overwriting Characters

ES-0304-1381-9062

Guideline: Data entry by overwriting a set of characters within a field should be avoided.

HSI Design Criteria

When a user chooses to alter the contents of a field, the existing entry (e.g., a default value or label) will be cleared from the input field.

Reference: NUREG-0700-2.1

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3.1.2.1.13 Set-Up of Computer-Based Automated Features

ES-0304-1381-9068

Guideline: Preset and automated set-up features should be used to ensure that users do not have to perform these functions while operating the plant.

HSI Design Criteria

NuScale automatic process system will provide all set-up features needed to perform the primary tasks.

Reference: NUREG-0700-2.1

3.1.2.1.14 Reminders for Interrupted Tasks

ES-0304-1381-9070

Guideline: The HSI should provide visual and/or auditory reminders for interrupted tasks.

HSI Design Criteria

Plant notifications will notify the operator of interrupted tasks or if user action has taken too long.

Notifications will be prioritized and raised to the level of notification needed to prompt operator response.

Reference: NUREG-0700-2.1

3.1.2.1.15 Access to Suspended Tasks

ES-0304-1381-9072

Guideline: The HSI should provide simple mechanisms for retrieving displays and controls for tasks that have been suspended.

HSI Design Criteria

HSI displays will provide easy access to previous tasks via the same touch field that opened the task to begin with.

Example: The selection of a component or process will always provide the operator with the controls pop-up window or process procedure regardless of the state of that component or process.

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Reference: NUREG-0700-2.1

3.1.2.1.16 Entry of Measurement Units

ES-0304-1381-9076

Guideline: The user should not be required to enter units of measure.

Additional Information: The entry of dimensional units (e.g., 'gpm') can be time consuming and error prone.

HSI Design Criteria

Data entry blocks will not ask the operators to enter the units.

Units will be predefined for all parameters for speed of entry.

Units will be predefined for all parameters to limit user error.

Reference: NUREG-0700-2.1

3.1.2.1.17 Minimize Cursor Travel

ES-0304-1381-9078

Guideline: Travel distance for cursors across and between display pages and windows on a display screen should be minimized.

HSI Design Criteria

Cursor movement within a display will be minimized but constraining that movement to the pop up window where the cursor resides.

Reference: NUREG-0700-2.1

3.1.2.1.18 Default Configuration for Decluttering

ES-0304-1381-9080

Guideline: Displays that can provide decluttering capabilities should also provide a means for the user to rapidly return the display to its original configuration.

HSI Design Criteria

HSI displays will not have customizing features that will clutter the displays.

Areas for customized work will be provided such as graphs and a notes area.

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All customized items will be reset to defaults when the user logs off of the system.

Reference: NUREG-0700-2.1

3.1.2.2 General Display Formatting

3.1.2.2.1 Operator Information Consistency

ES-0304-1381-7921

Requirement: All information provided to the operators shall be displayed consistently throughout the plant according to standards and conventions familiar to users.

HSI Design Criteria

The wording of displayed data (word choice, format and basic style) labels, and other information should incorporate the task-oriented terminology of the users, and avoid unfamiliar terms used by designers and programmers.

Appendices are being developed for the style guide that will direct the display page designers on how to develop common HSI interfaces.

The Appendices will include Text Size, Color and Patterns, Icons, Page templates and Navigation requirements that will ensure that all display pages developed will have a common theme.

NuScale is developing Appendices to Volume II that will direct the display page designers on how to develop common HSI interfaces.

The Appendices will include Text Size, Color, ICON, Page templates and Navigation requirements that will ensure that all display pages developed will have a common theme.

Reference: NUREG-0700-1.1

3.1.2.2.2 Operator Information Linking

ES-0304-1381-7925

Guideline: There should be an explicit linking between the characteristics and functions of the plant system to be represented and the features of the display page representation of that system at the levels of abstraction necessary to meet the operators' requirements relative to their task.

The methods by which lower-level data are analyzed to produce higher-level information and graphical elements should be understandable to users.

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Display dynamic sensitivity should be selected to minimize the display of normal random variations in equipment performance.

HSI Design Criteria

The physical form and functions of the display page shall be explicitly mapped to the plant's functions and states such that changes in the appearance of the display form should have a one-to-one relation with the plant states it represents.

The same graphic change should not be associated with more than one interpretation.

Users must be able to judge the acceptability of higher-level information and how it relates to lower-level information.

The display of HSI elements will have noticeable dynamic behavior between normal and abnormal plant conditions.

Reference: NUREG-0700-1.1

3.1.2.2.3 User Verification of Higher-Level Information

ES-0304-1381-7933

Guideline: Operators should have access to the rules or computations that link process parameters and graphical features, and to an explanation of how the information system produces higher-level information.

HSI Design Criteria

Information about any display page element will be provided via the mouse roll-over feature that will provide a pop-up window populated with additional information (meta data) pertaining to that particular element.

Reference: NUREG-0700-1.1

3.1.2.2.4 Operator Notifications to Support Tasks

ES-0304-1381-7935

Guideline: While viewing secondary (lower-level) displays, a perceptual (audible or visual) cue shall be provided by the system to alert the user to return to the primary (higher-level) display if significant information in that display requires user attention.

HSI Design Criteria

Plant notifications will provide immediate alert information to the operator via the notification icon set described in Appendix E.

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Reference: NUREG-0700-1.1

3.1.2.2.5 System/Equipment Demand and Status Indications

ES-0304-1381-7945

Guideline: Indications of the actual status of plant systems and equipment, as opposed to demand status, should be provided when required by the task.

HSI Design Criteria

Information that shows equipment has been commanded (by control settings or otherwise) to a particular state or level will be provided via the icon behavior described in the Appendix C.

Reference: NUREG-0700-1.1

3.1.2.2.6 Display of Normal Plant Information

ES-0304-1381-7949

Requirement: Displays should contain visual cues to the values of normal operating condition(s).

HSI Design Criteria

Distinct visual cues showing normal parameter operating values will be presented to the operators as discussed in Appendix A and Appendix C.

Color will be used to help the operator define the normal system operations form the abnormal as discussed in Appendix B.

Plant notifications will be used to aid the operator to abnormal plant behavior as discussed in Appendix E.

Text size used for the parameters will be presented in Appendix A, color codes will be specified in Appendix B and this element will be shown in the ICON Library of Appendix C for the purposes of showing the elements various states based on plant conditions.

Reference: NUREG-0700-1.1

3.1.2.2.7 Critical Value Reference Indicators

ES-0304-1381-7951

Guideline: A reference indicator should be included in a display when the user must compare displayed information with some critical value.

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Setpoints used to indicate a change in status should be chosen to provide users with sufficient time to respond appropriately.

HSI Design Criteria

Critical setpoints will be displayed by a solid appropriate colored line that indicates a high or low critical value.

Example: A solid red line above a tank

Reference: NUREG-0700-1.1

3.1.2.2.8 Indication of Proper System Operation

ES-0304-1381-7959

Requirement: A display feature shall be provided to indicate to the user that the system is operating properly.

The feature shall clearly indicate that a system failure has occurred.

HSI Design Criteria

Each NuScale HSI display page shall contain a “Heart Beat” indication located in the same location for rapid operator feedback that the data on the HSI has stopped operating/updating.

The heart beat icon will be located on the Main Navigation bar of every system page.

On the Post Trip page the heart beat icon will be located above the reactivity information.

On the Common System Overview page the heart beat icon will be replaced by the seconds displayed in the time parameter.

Each NuScale HSI Display page shall contain a “Heart Beat” indication located in the same location for rapid operator feedback that the data on the HSI has stopped updating.

Reference: NUREG-0700-1.1

3.1.2.2.9 Indication of Information Failure

ES-0304-1381-7961

Requirement: Information system failures (due to sensors, instruments, and components) should result in distinct display changes, which directly indicate that depicted plant conditions are invalid.

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HSI Design Criteria

NuScale will provide information failure indications as follows:

1) Disconnected Loss of indication (LOI) – When indication failures with a device occurs the HSI will turn that elements display color to "NuScale WHITE" dashes for parameters and “NuScale WHITE” fill in color for components.

2) Failure Loss of communications (LOC) – When communication failures with a device occurs the HSI will freeze the last known value/state of the device with a “NuScale WHITE” lasso around the component to indicate the frozen state of the information.

3) Out of service (OOS) - When a module is undergoing a refueling the Unit number on the GVD will have a “NuScale WHITE” lasso around it to indicate the unit is out of service. The disconnected components and indicators should behave in the LOI failure mode when being displayed on any of the HSI.

Reference: NUREG-0700-1.1

3.1.2.2.10 Annotating Displays with Time Data

ES-0304-1381-7963

Guideline: When task performance requires or implies the need to assess currency of information within a display, the information should be annotated with time information.

HSI Design Criteria

The event logger will collect all control data and will include a date and time stamp.

The historian will store all plant parameters and will include a date and a time stamp.

Trending data is available either on a multiple trending page or on a component level by clicking the component and having the trending window available through the work bench window.

All data will be retrievable from a single click from the main navigation bar.

Data can be filtered by module, system, date etc.

Reference: NUREG-0700-1.1

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3.1.2.2.11 Navigational Links

ES-0304-1381-7969

Guideline: Navigational links to and from high-level and lower-levels of information and to reference and supporting information should be provided when needed for operators' tasks.

HSI Design Criteria

HSI page navigation requirements are that any information needed by the user will be no more than 3 clicks away.

Reference: NUREG-0700-1.1

3.1.2.2.12 Grouping of Related Information

ES-0304-1381-7973

Guideline: Information that must be compared or mentally integrated should be organized into groups and presented in close spatial proximity of each other.

If information must be mentally integrated, similar color codes should be used for the information items.

Information that must be compared or mentally integrated should use similar physical dimensions to convey meaning through the use of standard icons.

Information that must be compared or mentally integrated should be presented using similar presentation formats (e.g., analog versus digital).

Information should be displayed to users in directly usable form consistent with the task requirements.

When precise reading of a graphic display is required, the display should be annotated with actual data values to supplement their graphic representation.

HSI Design Criteria

Parameters that indicate an element of a component (e.g., tank level) shall be placed within 0.5" of the component it addresses.

The usage of color shall be consistent with the information found in Appendix B.

The use of icons shall be consistent with the information found in Appendix C.

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The grouping and display of information shall follow the needs of the operators via the FRA/FA and TA.

Reference: NUREG-0700-1.1

3.1.2.2.13 Readability Conditions

ES-0304-1381-7987

Guideline: Important display elements and codes should be identifiable and readable from the maximum viewing distance and under minimal ambient lighting conditions.

HSI Design Criteria

Pictorial patterns shall follow the information found in Appendix B.

See guideline ES-0304-1381-8361 for formula on Text Readability Character Sizing.

Text sizing selection shall follow the information found in Appendix A

Lighting design shall follow the information found in Appendix G.

Reference: NUREG-0700-1.1

3.1.2.2.14 Information Display Flexibility

ES-0304-1381-7993

Guideline: Where applicable operators shall be able to control the amount and complexity of displayed data to meet task requirements.

HSI Design Criteria

Plant operators will have flexibility with the trending, event and historical archiving features.

Operators will not be able to change what is presented on the formal HSI display pages.

Reference: NUREG-0700-1.1

3.1.2.2.15 Range of Conditions Displayed

ES-0304-1381-7995

Guideline: The display system should correctly display information about the plant's safety status including severe accident symptoms.

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HSI Design Criteria

The safety system parameters are going to be displayed in the MCR on the safety display and indication (SDI) panels, the Module Control and the Plant Control Screens.

All three independent networks will provide status condition notices, warnings and alarms via plant notification HSI.

Reference: NUREG-0700-1.1

3.1.2.2.16 Salience of Data Presentation

ES-0304-1381-7999

Guideline: The salience of the HSI display page should reflect the importance of the information being displayed to the operator.

HSI Design Criteria

The most important features of the HSI display page will be presented to the operator through the use of color.

Important parameters will be displayed in GREEN.

When a parameter in in a warning state it will remain GREEN but will be lassoed with a YELLOW rectangle.

When a parameter is in alarm it will remain GREEN and be lassoed by a RED rectangle.

Active Components (Pumps, Heaters, etc.) will turn GREEN when powered and GRAY when de-energized.

Less important information (Labels, Navigation selections, etc.) will be more perceptually salient.

Reference: NUREG-0700-1.1

3.1.2.2.17 On-Line Dictionary of Display Element Definitions

ES-0304-1381-8015

Guideline: The user should have access to a dictionary that contains definitions for all display element conventions through the display or an online help system.

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HSI Design Criteria

Operators will be provided access to written documents via some form of electronic format.

Operators will have access to procedures, training material, libraries, etc.

Reference: NUREG-0700-1.1

3.1.2.2.18 Overlays and Pop Up windows

ES-0304-1381-8017

Guideline: Pop-up windows should not distract or interfere with the observation or interpretation of displayed information.

Mechanical overlays on VDUs should be avoided.

HSI Design Criteria

Component control pop-up windows will be strategically placed next to the component being controlled and will not cover any information needed to perform the task at hand.

If a pop-up window covers information needed by the operator then that information shall appear in the window.

No mechanical overlays shall be used.

Reference: NUREG-0700-1.1

3.1.2.2.19 Hardcopy of HSI Display Pages

ES-0304-1381-8019

Guideline: Users should be able to obtain an accurate and complete hardcopy of any HSI display page.

HSI Design Criteria

Hardcopies of the entire HSI library will be available to the operators in the MCR.

Users shall have the ability to print any active display page at any time for turn over or archiving purposes.

Reference: NUREG-0700-1.1

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3.1.2.2.20 Display Area

ES-0304-1381-8021

Guideline: Sufficient viewing area should be provided to display all important information so that repetitive transitions between displays are not required. This should be accomplished through the use of predefined information groupings that support the user in identifying displays and indicators that should be monitored during normal and abnormal conditions.

HSI Design Criteria

HSI display pages will be developed using the system FRA/FA to ensure accurate capture of the information needed by the operator.

The system TA will be used to ensure needed information is available to the operators with minimal need to page through a set of display screen.

Each system display page will mimic the system P&ID.

Adequate space will be provided to the display page designers to mimic the systems and not clutter the display.

Reference: NUREG-0700-1.1

3.1.2.3 Text

3.1.2.3.1 Standard Text Format

ES-0304-1381-8027

Guideline: A standard text display format should be used from one display to another and the display of textual data, messages, or instructions should generally follow design conventions for printed text.

Printed text should follow a standard format from one document to another.

HSI Design Criteria

Any Computer Based Manuals or duplications of written test on the screen shall follow the format of the written text with the additional guidelines listed below.

Font sizing will follow Appendix A information.

Graphics displays will follow proper English writing rules where applicable.

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Distinct words rather than contractions or combined forms should be used, especially in phrases involving negation. For example, 'will not' should be used rather than 'won't.'

When a sentence describes a sequence of events, it should be phrased with a corresponding word order and use affirmative statements rather than negative statements. For example, "Start the pump before opening the valve" is preferred over "Before opening the valve, start the pump."

Sentences should be composed in the active rather than the passive voice. For example, "Press RESET to clear the screen" is preferred over "The screen is cleared by pressing RESET."

Words should be kept intact, with minimal breaking by hyphenation between lines.

Conventional punctuation should be used in textual display.

Consistent spacing between the words of displayed text should be maintained, with left justification of lines and ragged right margins. A minimum of one character width (capital N for proportional spacing) should be used between words.

The main topic of each sentence should be located near the beginning of the sentence.

Text displays should be worded simply and clearly.

When words in text displays are abbreviated, each abbreviation (or acronym) should be defined in parentheses following its first appearance.

When a user must read continuous text on line, at least four lines of text should be displayed at one time.

Continuous text should be displayed in wide columns, containing at least 50 characters per line.

A minimum of two stroke widths or 15 percent of character height, whichever is greater, should be used for spacing between lines of text.

Displayed paragraphs of text should be separated by at least one blank line.

Text should be formatted in a few wide lines rather than in narrow columns of many short lines when space is limited owing to the display of graphics or other data.

When tables and/or graphics are combined with text, each figure should be placed near its first citation in the text, preferably in the same display frame.

Within a text file font size should not be used for highlighting information.

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When a special symbol, such as an asterisk, is used to draw attention to a selected item in alphanumeric displays, the symbol should be separated from the beginning of the word by a space.

When a line is placed under an item to mark or emphasize it, the line should not impair the legibility of the item, e.g., by obscuring the descenders.

Reference: NUREG-0700-1.2.1

3.1.2.3.2 Graphics Text Format

ES-0304-1381-20375

Guideline: Text used on graphic displays should be used consistently and should follow the design conventions for printed text as discussed in ES-0304-1381-8027 as well as the conventions listed below:

Text to be read (except labels) should be presented using upper and lower case characters.

A clearly legible font should be utilized that is capable of clearly distinguishing between the following characters: X and K, T and Y, I and L, I and 1, O and Q, O and 0, S and 5, and U and V.

The height of characters in displayed text or labels should be at least 16 minutes of arc and the maximum character height should be 24 minutes of arc.

Numeral and letter styles should be simple and consistent.

HSI Design Criteria

Alphanumeric Characters used on the HSI displays will follow the formats called out in Appendix A.

Text style will be given in Appendix A.

Minutes of arc can be converted into height as follows: Height = 6.283D (MA)/21600 where MA is minutes of arc, and D is the distance in inches from the user to the screen.

Reference: NUREG-0700-1.1, NUREG-0700-1.3.1

3.1.2.3.3 Abbreviation Rule

ES-0304-1381-8372

Guideline: The use of the letters O and I in a non-meaningful code should be avoided since they are easily confused with the numbers 0 (zero) and 1 (one), respectively.

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Letters should be grouped together and numbers grouped together rather than interspersing letters with numbers. For example, letter-letter-number ('HW5') will be read and remembered somewhat more accurately than letter-number-letter ('H5W').

HSI Design Criteria

Abbreviations on the HSI displays shall follow Table A-3 in Appendix A.

Reference: NUREG-0700-1.3.2

3.1.2.3.4 Highlighting Text Displays

ES-0304-1381-18129

Guideline: When critical text merits emphasis to set it apart from other text, that text should be highlighted by bolding/brightening or color coding or by some auxiliary annotation.

HSI Design Criteria

Use of capitalization as a coding technique will not be used.

Color will be used to set important parameters apart from less important parameters on an HSI page.

Reference: NUREG-0700-1.1

3.1.2.3.5 Hardcopy for Lengthy Text Displays

ES-0304-1381-8071

Guideline: When a user must read lengthy textual material, that text should be available in printed form.

HSI Design Criteria

Printed copies of all lengthy tests will be available in the MCR.

Reference: NUREG-0700-1.2.1

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3.1.2.4 Tables and Lists

3.1.2.4.1 Design and Organization

ES-0304-1381-8073

Guideline: The information display to the user in data tables or lists should be organized and presented consistently throughout the HSI library.

HSI Design Criteria

Information should be organized in a logical order to facilitate scanning and assimilation.

A table should be constructed so that row and column labels represent the information a user has prior to consulting the table.

Units of measurement should be part of row or column labels.

Each row and column should be uniquely and informatively labeled and should be visually distinct from data entries.

Consistent column and row spacing should be maintained.

In dense tables with many rows, a blank line (to aid horizontal scanning) should be inserted after a group of rows at regular intervals.

The font and size of alphanumeric characters should be consistent.

Columns of alphabetic data shall be displayed with left justification to permit rapid scanning.

Columns of numeric data should be justified with respect to a fixed decimal point; if there is no decimal point, then numbers should be right-justified.

Arabic rather than Roman numerals shall be used when listed items are numbered.

Item numbers should begin with one rather than zero.

When a list of numbered items exceeds one display page, the items should be numbered continuously in relation to the first item on the first page.

Complete numbers should be displayed for hierarchic lists with compound numbers, i.e., repeated elements should not be omitted.

Lists should be formatted so that each item starts on a new line.

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When a single item in a list continues for more than one line, items should be marked in some way so that the continuation of an item is obvious.

If a list is displayed in multiple columns, the items should be ordered vertically within each column rather than horizontally within rows and across columns.

Where lists extend over more than one display page, the last line of one page should be the first line on the succeeding page.

For a long list, extending more than one displayed page, a hierarchic structure should be used to permit its logical partitioning into related shorter lists.

When lists or tables are of variable length and may extend beyond the limits of one display page, the user should be informed when data are continued on another page and when data are concluded on the present page.

Reference: NUREG-0700-1.2.2

3.1.2.5 Data Fields

3.1.2.5.1 Data Field Formatting

ES-0304-1381-8113

Guideline: The ordering and layout of corresponding data fields across displays should be consistent from one display to another.

The format of a VDU data form should be similar to that of commonly used hardcopy source documents.

HSI Design Criteria

Data fields to be compared on a character-by-character basis should be positioned one above the other.

Forms used for data entry as well as for data display shall be compatible. Data fields to be compared on a character-by-character basis should be positioned one above the other.

Examples of consistency are time records punctuated with colons, as HH:MM:SS or HH:MM; and dates shown as MMM:DD:YYYY. The convention chosen should be familiar to the prospective users.

Forms used for data entry as well as for data display shall be compatible.

Reference: NUREG-0700-1.2.3

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3.1.2.5.2 Visually Distinct Labels and Data Entry Areas

ES-0304-1381-8121

Guideline: Clear visual definition of data fields should be provided so that the data are distinct from labels and other display features.

HSI Design Criteria

Techniques such as underlining or boxing shall be used to delineate data fields.

The label and the data entry area should be separated by at least one character space.

At least three spaces should appear between the longest data field in one column and the rightmost label in an adjacent column.

Where space constraints exist, vertical lines may be substituted for spaces for separation of columns of fields.

When label sizes are relatively equal, both labels and data fields should be left justified. One space should be left between the longest label and the data field column.

When label sizes vary greatly, labels should be right justified and the data fields should be left justified. One space should be left between each label and the data field.

Where needed, the label for each entry field should end with a special symbol, signifying that an entry may be made.

Reference: NUREG-0700-1.2.3

3.1.2.5.3 Protected Labels

ES-0304-1381-8131

Guideline: Field labels should be protected from keyed entry by having the cursor skip over them automatically when a user is spacing or tabbing.

HSI Design Criteria

When a user must change a displayed form, including changes to field labels, then that user must be able to override label protection.

Reference: NUREG-0700-1.2.3

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3.1.2.5.4 Highlight Active Data Entry Field

ES-0304-1381-8133

Guideline: The current field to be entered should be highlighted.

HSI Design Criteria

The entry field shall be highlighted to make the current data field discriminable from other data on the HSI.

Reference: NUREG-0700-1.2.3

3.1.2.5.5 Data Entry Cues

ES-0304-1381-8135

Guideline: If appropriate, labels should be used to help cue the user as to the expected data entry.

HSI Design Criteria

Visual cues shall be used to expedite user action. For example, "DATE (MM/DD/YYYY): / / ." or "Tagout Type (D) = Danger or (W) = Warning"

Reference: NUREG-0700-1.2.3

3.1.2.5.6 Data Form Entry Error

ES-0304-1381-8139

Guideline: Data entered that does not match the predefined format of the data form should be highlighted and signaled to the user.

HSI Design Criteria

The standard windows beep will be used to signal the operator they have entered something in error.

Reference: NUREG-0700-1.2.3

3.1.2.5.7 Distinguishing Blanks from Nulls

ES-0304-1381-8141

Guideline: Blanks (keyed spaces) should be distinguished from nulls (no entry at all) in the display of data forms, where it can aid task performance.

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HSI Design Criteria

Field delimiters will be displayed to guide data entry.

The delimiters will be left unchanged when no entry has been made.

Reference: NUREG-0700-1.2.3

3.1.2.5.8 Labeling Groups of Data Fields

ES-0304-1381-8143

Guideline: Scanning an inquiry screen will be aided if logical groupings of fields are identified by headings.

HSI Design Criteria

A field group heading should be centered above the labels to which it applies.

At least five spaces should appear between groups of data fields.

When headings are located on the line above related screen fields, the labels should be indented a minimum of five spaces from the start of the heading (see Figure 3-2).

When headings are placed adjacent to the related fields, they should be located to the left of the topmost row of related fields. The column of labels should be separated from the longest heading by a minimum of three blank spaces (see Figure 3-3).

Reference: NUREG-0700-1.2.3

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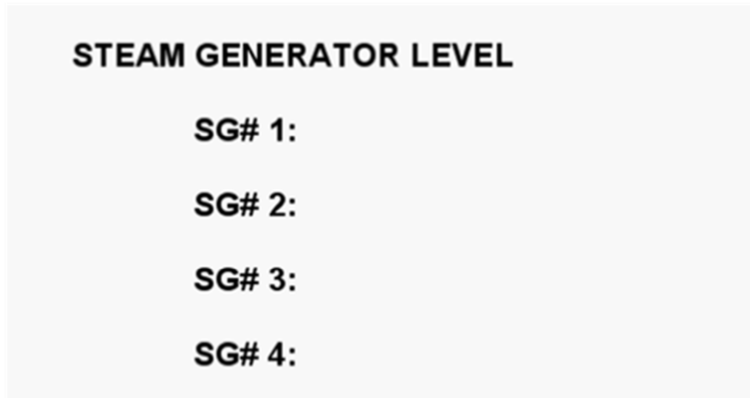

Figure 3-2. Example of placement of heading above data fields

Figure 3-3. Example of placement of heading adjacent to data fields.

3.1.2.5.9 Organization and Behavior of Data Entry Forms

ES-0304-1381-8154

Guideline: A data entry form should have a logical organization.

The number of pages in a data form required to complete a transaction should be minimized to reduce the amount of navigation.

Cursor positioning and movement between fields should be consistent.

HSI Design Criteria

Logical organizations of entry fields may include conventional order (a generally accepted or customary ordering), sequence of use, frequency of use, data comparison (entries that must be compared are grouped together), functional grouping (related functions are grouped together), importance (task-critical items are located prominently),

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and general to specific (detailed fields proceed from more general topics, as in a hierarchical organization).

The number of display pages required for the completion of a transaction should be minimized by integrating required data entry fields into fewer pages.

The cursor should be positioned at the first character location of the first data entry field upon initial presentation of a data entry form.

The user should be able to move from one entry field to the next by operating the tab key.

Reference: NUREG-0700-1.2.3

3.1.2.6 Bar Charts

3.1.2.6.1 Labeling of Bars

ES-0304-1381-8162

Guideline: Bar labels should provide positive identification of the parameter each bar represents.

A user should not have to memorize the position of each parameter on the display.

HSI Design Criteria

Each bar on the display should have a unique identification label.

When bars are displayed in pairs, they should be labeled as a unit, with individual distinguishing labels for each bar.

Reference: NUREG-0700-1.2.4

3.1.2.6.2 Bar Spacing

ES-0304-1381-8166

Guideline: When data must be compared, bars should be adjacent to one another and spaced such that a direct visual comparison can be made without eye movement.

HSI Design Criteria

A horizontal bar chart is illustrated in Figure 3-4. The spacing between bars should be less than the bar width. If many bars are displayed, then spacing may produce an alternating pattern of bright and dark bands that could prove visually disturbing. In this case, it is preferable to arrange the bars contiguously (i.e., without spaces).

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Reference: NUREG-0700-1.2.4

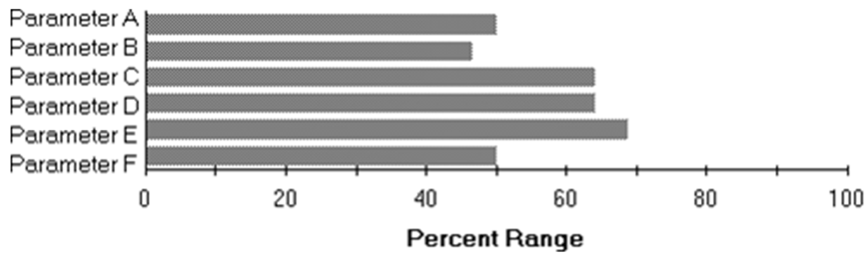

Figure 3-4. Example of a horizontal bar chart

3.1.2.6.3 Consistent Orientation of Bars

ES-0304-1381-8170

Guideline: In a related series of bar charts, a consistent orientation of the bars (vertical or horizontal) should be adopted.

HSI Design Criteria

If bar length is used to represent time duration, then it might be more appropriate to orient the bars horizontally, in accord with the general convention of plotting time on the horizontal axis of a graph. Vertical bars can be used to display frequency counts or a large variety of other measured attributes.

Reference: NUREG-0700-1.2.4

3.1.2.6.4 Highlighting

ES-0304-1381-8172

Guideline: If one bar represents data of particular significance, then that bar should be highlighted.

HSI Design Criteria

If one bar represents critical/discrepant data, then that bar might be coded differently. However, if bar coding is already used for other purposes, such as to distinguish among different sets of grouped bars, then no additional highlighting code should be superimposed on the bars themselves; some other means of highlighting (e.g., an arrow) might be adopted.

Reference: NUREG-0700-1.2.4

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3.1.2.6.5 Deviation Bar Charts

ES-0304-1381-8174

Guideline: The zero reference should be the center of the deviation bar chart.

On a deviation bar chart, the range of normal conditions for positive or negative deviations should represent no more than ten percent of the total range.

The magnitude of each variable should be displayed when a deviation bar display is used as a main display format for safety function parameters.

HSI Design Criteria

An example of a deviation bar chart appears below in Figure 3-5.

Reference: NUREG-0700-1.2.4

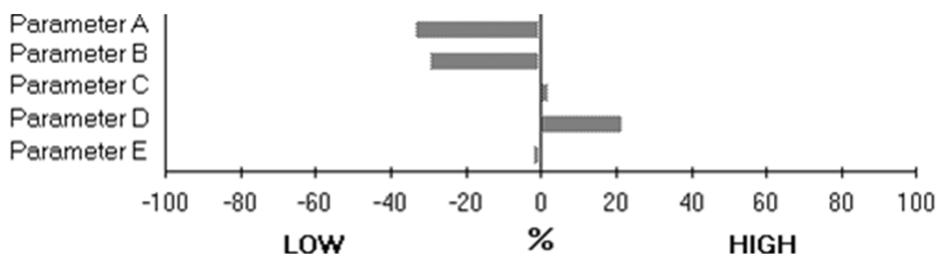

Figure 3-5. Example of a deviation bar chart

3.1.2.6.6 Coding Segmented Bar Charts

ES-0304-1381-8182

Guideline: Segmented bars, in which differently coded segments are shown cumulatively within a bar, should be used when both the total measures and the portions represented by the segments are of interest.

HSI Design Criteria

An example of a segmented bar chart appears in Figure 3-6.

Reference: NUREG-0700-1.2.4

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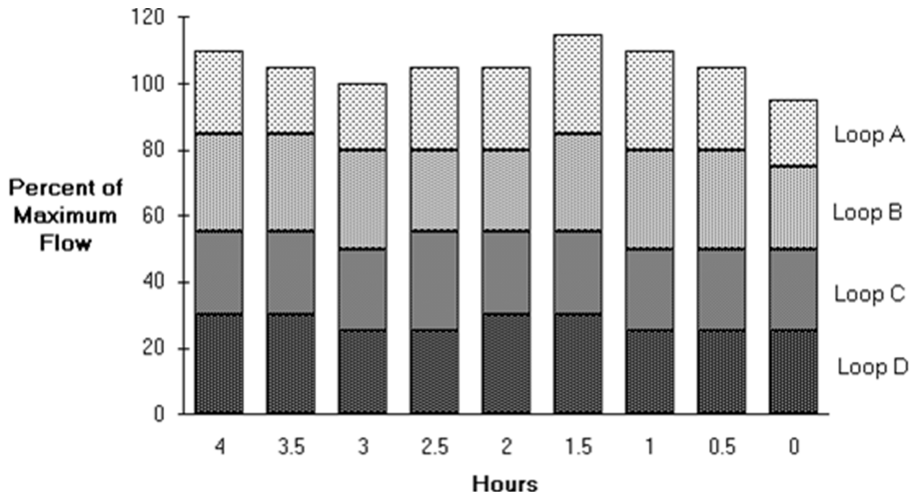

Figure 3-6. Example of a segmented bar chart

3.1.2.6.7 Ordering Data in Segmented Bars

ES-0304-1381-8186

Guideline: The data categories should be ordered within each bar in the same sequence, with the least variable categories displayed at the bottom and the most variable at the top.

HSI Design Criteria

If a segmented bar graph that is constructed on a logical basis produces confusing irregularity of segments, then it might be better to display the data in some other graphic format. Any irregularity in the bottom segment will 'propagate' throughout the segments above it, which will make it difficult for a user to examine irregularities in the upper segments.

Reference: NUREG-0700-1.2.4

3.1.2.7 Trending

3.1.2.7.1 Design of Trend Displays

ES-0304-1381-8200

Guideline: Trend displays should be capable of showing data collected during time intervals of different lengths and of multiple data points.

HSI Design Criteria

The user will be able to select the data being trended.

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Variable time length shall be available to the user.

Trend rates shall not fluctuate as a result of minor fluctuations in data or oscillatory behavior that may be superimposed on a well-defined trend.

Old data points shall be removed after some fixed period of time.

The target area, preferred combination of X- and Y-axis values, shall be graphically defined.

Reference: NUREG-0700-1.2.5

3.1.2.7.2 Repeating Display of Cyclic Data

ES-0304-1381-8212

Guideline: Where curves represent cyclic data, the graph should be extended to repeat uncompleted portions of the displayed cycle.

HSI Design Criteria

The user will be able to scan any critical portion of the displayed cycle without having to return visually to the beginning of the plot.

Reference: NUREG-0700-1.2.5

3.1.2.8 Graphs

3.1.2.8.1 Interpreting Graphs

ES-0304-1381-8188

Guideline: Graphs should convey enough information to allow the user to interpret the data without referring to additional sources.

HSI Design Criteria

Graphs should be clearly labeled and organized to reflect the needed information in a timely manner.

Reference: NUREG-0700-1.2.5

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3.1.2.8.2 Labeling Curves

ES-0304-1381-8190

Guideline: Direct labeling will permit users to assimilate information more rapidly than displaying a separate legend.

HSI Design Criteria

When multiple curves are included in a single graph, each curve should be identified directly by an adjacent label, rather than by a separate legend.

Reference: NUREG-0700-1.2.5

3.1.2.8.3 Legend Ordering

ES-0304-1381-8192

Guideline: If a legend must be displayed, the codes in the legend should be ordered to match the spatial order of their corresponding curves in the graph itself.

HSI Design Criteria

The ordering of the legend shall match the ordering of the curves.

Reference: NUREG-0700-1.2.5

3.1.2.8.4 Coding to Distinguish Curves

ES-0304-1381-8194

Guideline: Coding should be used when multiple functions are displayed in a single graph.

Additional Information: Coding should be provided particularly if curves approach and/or intersect one another. Coding is required to distinguish one curve from another.

HSI Design Criteria

Color coding of the curves will be used when multiple functions are displayed in a single graph.

Curve coding will be consistently used across the graphs.

Reference: NUREG-0700-1.2.5

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3.1.2.8.5 Highlighting Significant Curves

ES-0304-1381-8198

Guideline: If one curve represents critical/discrepant data, for example, that curve might be displayed with a noticeably thicker line stroke or in a different color. If line coding is already used to distinguish among multiple curves, then the means of highlighting any particular curve should be selected so that it will not be confused with coding for visual separation. For example, if displayed curves are distinguished by line codes (solid, dashed, or dotted), then one curve might be highlighted by displaying it in a different color.

HSI Design Criteria

In displays of multiple curves, if one curve represents data of particular significance, then that curve shall be highlighted.

Reference: NUREG-0700-1.2.5

3.1.2.9 Flow Charts

3.1.2.9.1 Decision Options

ES-0304-1381-8250

Guideline: The available decision options should be displayed in logical order and contain only a single decision at each step.

When a flowchart is designed so that a user must make decisions at various steps, the available options should be displayed in some consistent order from step to step.

HSI Design Criteria

Decisions shall not be combined to reduce flowchart size.

If options represent stages of a process, those stages should be listed in the order in which they would actually occur.

Always have the desirable path lead downward and the 'problem' paths lead out to the side.

Reference: NUREG-0700-1.2.7

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3.1.2.9.2 Availability of Supplemental Information

ES-0304-1381-8256

Guideline: While flowcharts should display only the data immediately required by the user, more detailed data should be available by means of a simple action.

HSI Design Criteria

Supplemental information will be provided by the mouse over function.

Reference: NUREG-0700-1.2.7

3.1.2.9.3 Implementation of Conventions

ES-0304-1381-8258

Guideline: Flowcharts should be designed so that the path of the logical sequence is consistent with familiar orientation conventions.

There should be a standard set of flowchart symbols.

HSI Design Criteria

Flow charts will follow the, from left to right and from top to bottom design convention.

Reference: NUREG-0700-1.2.7

3.1.2.10 Mimics and Diagrams

3.1.2.10.1 Level of Detail

ES-0304-1381-8262

Guideline: Mimics and diagrams should:

Contain the minimum amount of detail required to yield a meaningful pictorial representation.

Ensure all flow path line destination and terminal points are labeled or end at labeled components.

Ensure all plant components represented on mimic lines are identified and numerical data should be presented reflecting inputs and outputs associated with equipment.

Clearly indicate flow direction by distinctive arrowheads and avoid overlapping of flow path lines should be avoided.

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Contain computer aids for calculation and visual analysis when users must evaluate information in detail.

HSI Design Criteria

Unnecessary graphic detail (such as shadowed symbols or very detailed icons) should be avoided.

Symbols used on mimic displays should conform to the NuScale icon library found in Appendix C.

An example of a mimic display is shown in Figure 3-7**.**

Reference: NUREG-0700-1.2.8

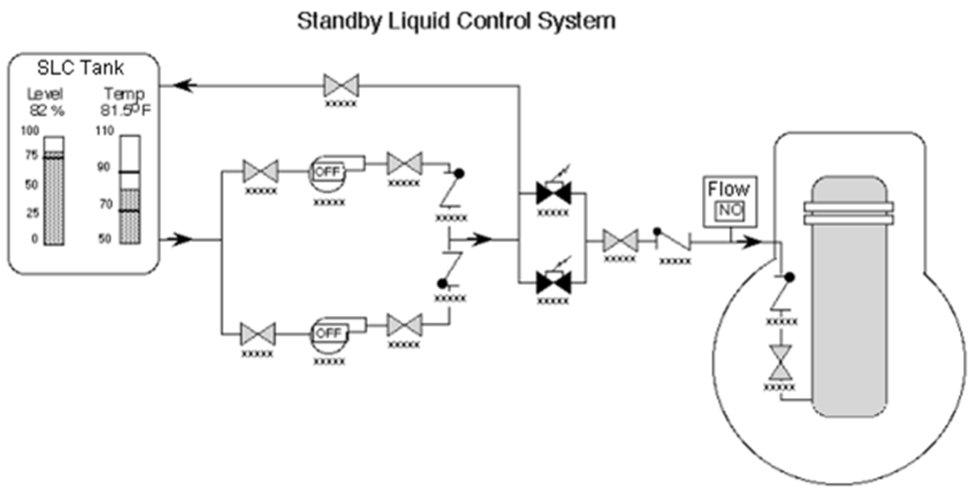

Figure 3-7. Example of a mimic display

3.1.2.11 Labels

3.1.2.11.1 Display of Labels

ES-0304-1381-8384

Guideline: Each individual aspect of a display (e.g., data group, field, or message) should contain a meaningful consistent distinct, unique, and descriptive label.

Labels should be separated from one another by at least two standard character spaces.

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When presenting a list of user options, labels should reflect the question or decision being posed to the user.

The annotation of graphic displays, including labels for the axes of graphs, should be displayed in a normal orientation for reading text.

The label for a specific graphical object (e.g., an icon) should be placed in close proximity to the object.

HSI Design Criteria

All icon and symbols shall have a label in close proximity of the element.

No labels shall obstruct any information on the display page.

If multiple component parts of the graphic object are close to the label, a line should point from the label to the associated part.

Users should be presented with horizontally displayed labels, even for the vertical axis of a graph.

Reference: NUREG-0700-1.3.3

3.1.2.12 Symbols, Icons and Patterns

3.1.2.12.1 Design Principles for Symbols, Icons, and Patterns

ES-0304-1381-8402

Guideline: The primary use of icons in graphic displays should be to represent actual objects or actions they represent.

Icons should be a single simple object and use closed figures when possible.

Abstract symbols should conform to user conventions or to common electrical and mechanical symbol conventions when user conventions do not exist.

Icons and symbols should be large enough for the user to perceive the representation and discriminate it from other icons and symbols.

If icons are used to represent control action options, a visual aid shall be provided indicating the action associated with the icon.

When the symbol size is to be proportional to the data value, the scaled parameter should be the symbol area rather than a linear dimension such as diameter.

Shapes used in coding for data groups should be clearly discriminable.

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When patterns are used to code displayed areas, simple rather than elaborate patterns should be used.

HSI Design Criteria

Symbols used on HSI displays shall not be inconsistent with those of other information sources used in the work area, such as P&IDs and logic diagrams.

To aid visual discrimination and identification color will be employed rather than complex patterns.

Size coding will not be employed on symbols or icons.

Icons and symbols should always be oriented 'upright.'

Words and symbols should not be used alternately.

Icons should be accompanied by a text label.

An icon or symbol should be highlighted when the user has selected it.

When shape coding is used, codes shall be based on established standards or conventional meanings.

Pattern density should vary with the value of the coded variable so that the least dense pattern is associated with one extreme and the densest pattern with the other extreme.

All icons and symbols will follow the icon and symbols library in Appendix C.

Reference: NUREG-0700-1.3.4, NUREG-0700-1.3.9

3.1.2.13 Numbers

3.1.2.13.1 Display of Numbers

ES-0304-1381-8426

Guideline: Numeric values should ordinarily be displayed in the decimal number system and displayed in the upright position.

Leading zeros in numeric entries for whole numbers should be suppressed.

The number of significant digits must be supported by the accuracy of the underlying sensors, instruments, and electronics and should accommodate the variable's full range.

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HSI Design Criteria

All numeric values will be upright and displayed following the decimal system format.

Maintenance, troubleshooting, or configuration tasks may use other systems (e.g., binary, octal, or hexadecimal).

The value 28 will be displayed rather than 0028.

A leading zero should be provided if the number is a decimal with no preceding integer (i.e., 0.43 rather than .43).

Reference: NUREG-0700-1.3.5

3.1.2.13.2 Rate of Display Change

ES-0304-1381-8434

Guideline: Digital displays should change slowly enough to be readable.

HSI Design Criteria

NuScale displays will change at a rate such that the data being presented is always readable.

Reference: NUREG-0700-1.3.5

3.1.2.13.3 Direction of Change in Digital Display

ES-0304-1381-8436

Guideline: If users must rapidly discern directional change, digital displays should be provided with arrows to indicate the direction of change.

HSI Design Criteria

Chevrons (arrows) will be used to indicate direction of change to the operators.

Reference: NUREG-0700-1.3.5

3.1.2.13.4 Direct Display of Differences

ES-0304-1381-8438

Guideline: If users must evaluate the difference between two sets of data, the difference should be presented on the display.

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HSI Design Criteria

All data needed to compare, evaluate and troubleshoot plant information will be available to the operator on a single page when applicable.

Information that cannot be presented on a single system overview page shall be presented to the operator in the form of the plant overview page on the GVD or the mandatory 12 Unit Overview page on the workstation.

Reference: NUREG-0700-1.3.5

3.1.2.14 Scaling

3.1.2.14.1 Orientation of Scales

ES-0304-1381-8442

Guideline: Numbers on a scale should increase clockwise, left to right, or bottom to top.

HSI Design Criteria

All numbers used for scaling on trends, bar graphs, etc. shall increase clockwise, left to right, or bottom to top.

Reference: NUREG-0700-1.3.6

3.1.2.14.2 Presentation of Scales

ES-0304-1381-8448

Guideline: Scales should have tick marks at a standard interval of 1, 2, 5, or 10 (or multiples of 10) for labeled divisions; intervening tick marks to aid visual interpolation should be consistent with the labeled scale interval.

Conventional scaling practice should be followed.

If users must compare graphic data across a series of displays, the same scale should be used for each.

The scales should be consistent with the intended functional use of the data.

HSI Design Criteria

Scaling will follow the standard 1, 2, 5, 10 intervals.

In special instances, the X-axis may be scaled a non-standard interval to show customary divisions, such as the 12 months in a year.

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The horizontal X-axis is used to plot time or the postulated cause of an event, and the vertical Y-axis is used to plot the effect.

The HSI will provide the operator with the ability to trend any values on a single plot.

Scales will be selected to (1) span the expected range of operational parameters, (2) employ appropriate scale ranging techniques, or (3) be supported by auxiliary wide-range instruments.

For example, the monitoring of neutron flux at reactor trip must have a variable scale of 0 to 100 percent of the design value and a time scale resolution of seconds. However, post-trip monitoring may have a variable scale of 0 to 10 percent with a time scale resolution of minutes.

A linear scale should be used for displayed data.

Only a single scale shall be shown on each axis.

Reference: NUREG-0700-1.3.6

3.1.2.14.3 Axis Labels

ES-0304-1381-8452

Guideline: Axes should be clearly labeled with a description of what parameter is represented by the axis.

The units of measurement represented by the scale should be included in the axis label.

HSI Design Criteria

Axis labels should be displayed in upright orientation on both the X- and Y-axis for ease of reading.

Font sizes of the axis will follow the font size chart found in Appendix A

The unit of measurement shall appear in the axis label.

Reference: NUREG-0700-1.3.6

3.1.2.14.4 Numeric Scales Start at Zero

ES-0304-1381-8466

Guideline: When users must compare aggregate quantities within a display, or within a series of displays, scaling of numeric data should begin with zero.

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HSI Design Criteria

Numerical scales should have zero at the bottom as the first number on a vertical scale or at the left as the first number on a horizontal scale.

The exceptions to this would be: (1) if the numbers are used for naming categories, (2) if zero is not a plausible number on the scale, or (3) if the scale contains negative numbers. If for any reason the zero point is omitted, the display should include a clear indication of that omission, and the scales on which quantities are to be compared should be the same.

Reference: NUREG-0700-1.3.6

3.1.2.14.5 Display of Origin

ES-0304-1381-8468

Guideline: When graphed data represent positive numbers, the graph should be displayed with the origin at the lower left, such that values on an axis increase as they move away from the origin of the graph.

HSI Design Criteria

Graphs will follow the traditional design where the origin is placed at the lower left of the XY axis.

When the data includes negative values and the axes must extend in both directions from a zero point, that origin should be displayed in the center of the graph.

Reference: NUREG-0700-1.3.6

3.1.2.14.6 Indication of Scale

ES-0304-1381-8474

Guideline: When a graphic display has been expanded from its normal coverage, some scale indicator of the expansion factor should be provided.

HSI Design Criteria

All shall be clearly marked as to whether the indicated values should be multiplied or divided, and the factor to be used (e.g., 10, 100, or 1000).

Reference: NUREG-0700-1.3.6

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3.1.2.14.7 Manual Rescaling

ES-0304-1381-8476

Guideline: Users should be able to manually change the scale to maintain an undistorted display under different operating conditions.

HSI Design Criteria

All trends will have the ability to be rescaled.

Reference: NUREG-0700-1.3.6

3.1.2.14.8 Indication of Automatic Rescaling

ES-0304-1381-8478

Guideline: If the system is designed to automatically change scale, an alert should be given to the user that the change is being made.

Additional Information: Automatic rescaling can lead to confusion if the change in scale is not recognized.

HSI Design Criteria

All trends will automatically rescale however by displaying the last five minutes of the trend with an upper and lower margin NuScale feels that no user notification is needed.

Reference: NUREG-0700-1.3.6

3.1.2.14.9 Aids for Scale Interpolation

ES-0304-1381-8480

Guideline: If interpolation must be made or where accuracy of reading graphic data is required, computer aids should be provided for exact interpolation.

HSI Design Criteria

Mouse roll over features will provide additional information to the user.

Reference: NUREG-0700-1.3.6

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3.1.2.14.10 Unobtrusive Grids

ES-0304-1381-8482

Guideline: When grid lines are displayed, they should be unobtrusive and not obscure data elements (e.g., curves and plotted points).

HSI Design Criteria

Grid lines shall be thinner than data curves, and should be invisible behind depicted objects and areas.

Grids can be displayed or suppressed by the operator.

A mouse roll over feature will provide the value of any selected point.

Reference: NUREG-0700-1.3.6

3.1.2.14.11 Restricted Use of Three-Dimensional Scaling

ES-0304-1381-8490

Guideline: Unless required, use of three-dimensional scales (i.e., where a Z-axis is added to the display) should be avoided.

HSI Design Criteria

NuScale will not use 3-D graphing.

Reference: NUREG-0700-1.3.6

3.1.2.15 Lines

3.1.2.15.1 Line Types

ES-0304-1381-8492

Guideline: Meaningful differences between lines appearing in graphic displays should be presented.

Sequential links between various elements should be presented.

A border should only be used to improve the readability of a single block of numbers or letters.

If several labels or messages are clustered in the same area, distinctive borders can be placed around the critical ones only or color and location on the screen can be used.

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HSI Design Criteria

Flow paths shall be depicted through the use of color.

Arrowheads shall be used in a conventional fashion to indicate directional relations.

Lasso boxes (borders) shall be used to improve the recognition of a tagged out component or a bar graph.

Color will help to differentiate the difference of lines in trend charts.

Line thickness will follow the criteria presented in the icon and symbols library found in Appendix C.

Reference: NUREG-0700-1.3.7

3.1.2.16 Color

3.1.2.16.1 Use of Color

ES-0304-1381-8502

Guideline: Where color is used for coding, it should be employed conservatively and consistently.

A unique color should be used to display the data in each category.

When the relative rather than the absolute values of a variable are important, gradual color changes as a tonal code should be used to show the relative values of a single variable.

Brighter and/or more saturated colors should be used when it is necessary to draw a user's attention to critical data, e.g. alarm conditions.

HSI Design Criteria

Color usage on NuScale HSI displays should follow the recommendations given in Table 3-1.

NuScale color codes will be stated in Appendix B.

Pertinent information should be available from some other cue in addition to color.

Color coding will be used for discrete categories (e.g., setpoint values (Black) and actual values (Green).

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The number of colors used for coding shall be kept to the minimum needed for providing sufficient information.

Reference: NUREG-0700-1.3.8

Table 3-1. Associations and related characteristics for colors used in panel design

Color	Associated Meanings	Attention -Getting Value	Contrasts Well With
Red	Unsafe Danger Alarm state Hot Open/flowing[1] Closed/stopped[1]	Good	White
Yellow	Hazard Caution Abnormal State Oil	Good	Black Dark Blue
Green	Safe Satisfactory Normal state Open/flowing[1] Closed/stopped[1]	Poor	White
Light blue (cyan)	Advisory Aerated water Cool	Poor	Black
Dark Blue	Advisory Untreated water	Poor	White
Magenta[2]	Alarm state	Good	White
White	Advisory Steam	Poor	Green Black Red Dark blue Magenta
Black	Background	Poor	White Light blue Yellow

[1] Meanings associated with red and green colors differ, depending on past experience. Personnel with previous fossil fuel plant experience typically associate an open/flowing state with red and a closed/stop state with green, but reverse associations typically exist for personnel with previous Navy experience.

[2] Magenta on yellow is the nuclear industry standard for radiation caution.

3.1.2.16.2 Pure Blue

ES-0304-1381-8512

Requirement: A pure blue color combination is a poor choice and will lead to readability issues for the majority of the users.

HSI Design Criteria

Pure blue on a dark background shall be avoided for text, for thin lines, or for high-resolution information.

The Color Palette (Appendix B) and the ICON Library (Appendix C) will ensure this combination does not occur.

Reference: NUREG-0700-1.3.8

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3.1.2.16.3 Easily Discriminable Colors

ES-0304-1381-8514

Guideline: When color coding is used to group or highlight displayed data, all of the colors in the set should be readily discriminable from each other.

Table 3-2 identifies the wavelengths of colors that are easily discriminable. For example, on a light background: red, dark yellow, green, blue, and black; and on a dark background: desaturated red, green and blue, plus yellow, and white.

Additional Information: When color coding is used for discriminability or conspicuity of displayed information, all colors in the set should differ from one another by E distances (CIE L*u*v*) of 40 units or more.

This approach will make available at least 7 to 10 simultaneous colors. Increasing ambient illuminance decreases color purity and, consequently, color discriminability. Accordingly, color measurements should be made under the presumed ambient lighting conditions in which the display will be used. The discriminability of pairs of colors depends on their differences in chrominance and luminance. While an entirely satisfactory metric does not exist which combines these attributes into a single assessment of total color difference, an estimate can be derived by calculating the weighted difference between the locations of the colors in the 1976 CIE Uniform Color Space (CIE UCS L*u*v). Note that this estimate should be used only to ensure discriminability of colors of relatively high luminance. Severe nonlinearities in the UCS limit the usefulness of this metric for colors having small luminance differences. In addition, the specification of small color differences should be treated with caution due to the inherent lack of color uniformity on most VDUs.

For full color displays, the reference white can be taken as the white on the display obtained with full-intensity red, D6500 K° or 9300 K°.

The difference formula is given in Equation 1 (Table 3-3).

HSI Design Criteria

If color coding is applied to symbols that subtend small visual angles, which makes color perception difficult, there will be a special need to limit the number of colors used.

If colors are used for displaying text, care should be taken to ensure that colored letters are legible as well as discriminable.

Since the perception of color depends on ambient lighting, the use of color should be evaluated in situ under all expected lighting conditions.

Color coding should not create unplanned or obvious new patterns on the screen.

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Reference: NUREG-0700-1.3.8

Table 3-2. Representative set of candidate colors for use in panel design

Color Name	Dominant Wavelength (in nanometers)	Munsell Code
Red	610	5.0R/3.9/15.4
Yellow	582	3.3Y/8.0/143
Green	515	3.2G/4.9/11.1
Light blue (cyan)	494	2.7GB/7.9/6.0
Dark Blue	476	2.9PB/4.1/10.4
Magenta	430	6.5P/4.3/9.2
White		2.5PB/9.5/0.2
Black		N/0.8

Table 3-3. Equation 1 calculation of color differences

$$\Delta E \text{ units (CIE } L^*u^*v^*) = [(L_1^* - L_2^*)^2 + (u_1^* - u_2^*)^2 + (v_1^* - v_2^*)^2]^{0.5}$$

$$\begin{aligned} \text{where} \quad L^* &= 116(Y/Y_0)^{1.3} - 16; \; 1.0 > Y/Y_0 > .01 \\ u^* &= 13L^*(u' - u'_0) \\ v^* &= 13L^*(v' - v'_0) \\ u' &= 4X / (X + 15Y + 3Z) \\ v' &= 9Y / (X + 15Y + 3Z) \end{aligned}$$

u'_0 and v'_0 are the UCS coordinates for the reference white derived from the 1976 UCS.

For reference white, 9300 K° + 27 MPCD u'0 = 0.181 and v'0 = 0.454

(MPCD = Minimum Perceptible Color Difference)

Y is luminance in cd/m2. Y0 is the luminance of the reference white.

Note: The 9300 K° + 27 MPCD (Minimum Perceptible Color Difference) located the white point at the intersection of the ISO temperature line for 9300 K° with the daylight locus. Y0 in this use of the ∆E (CIE L*u*v*) distance metric is defined differently than suggested by the CIE.

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3.1.2.16.4 Unique Assignment of Color Codes

ES-0304-1381-8520

Guideline: When color coding is used, each color should represent only one category of displayed data.

HSI Design Criteria

Where color will prove the dominant coding dimension on a display the color shall only be used for that purpose.

Where color is used to minimize color impact such as grey then that color shall be used for more than one element of the design.

Reference: NUREG-0700-1.3.8

3.1.2.16.5 Reuse of color

The specific situations in which the color is used might be very diverse. It is important to convey to the user how color is being used when it is being used inconsistently.

3.1.2.16.6 Color Contrast

ES-0304-1381-8522

Guideline: Symbols should be legible and readily discriminable against the background colors under all expected ambient lighting conditions.

Additional Information: For adequate legibility, colored symbols should differ from their color background by an E distance (CIE Yu'v') of 100 units or more. The E distances (CIE Yu'v') are derived from the 1976 CIE UCS color diagram. As with the (CIE L*u*v) distances, caution should be used in assessing legibility for characters in colors having small luminance differences.

This caution applies not only to characters in color but also to small luminance differences in background colors and for very small luminance differences between characters in color and background in color. Unusually large or small characters may lead to erroneous estimates of legibility. The elements required for the calculation are the luminance in cd/m^2 (Y) and the UCS coordinates (u',v') of the text and background.

The metric is given in Equation 2 (Table 3-4).

HSI Design Criteria

Color combinations are presented in Appendix B.

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Reference: NUREG-0700-1.3.8

Table 3-4. Equation 2 calculation of color contrast

The metric is as follows:

$$\Delta E\,(Yu'v') = [(155\,\Delta Y/Y_M)^2 + (367\,\Delta u')^2 + (167\,\Delta v')^2]^{0.5}$$

where Y_M = the maximum luminance of text or background
ΔY = difference in luminance between text and background
$\Delta u'$ = difference between u' coordinates of text and background (see 1.3.8-7)
$\Delta v'$ = difference between v' coordinates of text and background (see 1.3.8-7).

NOTE: The values 155, 367, and 167 are empirically derived weights.

3.1.2.16.7 Red-Green Combinations

ES-0304-1381-8528

Requirement: Whenever possible, red and green colors should not be used in combination.

This color combination is a poor choice and will lead to readability issues for the majority of the users.

HSI Design Criteria

Red and green colors shall not be used in combination.

The Color Palette (Appendix B) and the ICON Library (Appendix C) will ensure this combination does not occur.

Reference: NUREG-0700-1.3.8

3.1.2.16.8 Chromostereopsis

ES-0304-1381-8530

Guideline: Simultaneous presentation of both pure red and pure blue on a dark background should be avoided.

HSI Design Criteria

The presentation of both pure red and pure blue on a dark background shall not be used.

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Reference: NUREG-0700-1.3.8

3.1.2.16.9 Provide color schemes designed for people with disabilities

Software that includes color schemes should provide color schemes designed for use by people who have disabilities.

3.1.2.16.10 Pure Red

ES-0304-1381-8532

Guideline: Dominant wavelengths above 650 nanometers in displays should be avoided.

HSI Design Criteria

The Color Palette (Appendix B) and the ICON Library (Appendix C) will ensure the proper combinations are used consistently through the HSI.

The equations used to determine the correct colors are used are shown in Table 3-3 and Table 3-4.

Reference: NUREG-0700-1.3.8

3.1.2.17 Highlighting and Flashing

3.1.2.17.1 Use of Highlighting

ES-0304-1381-8556

Guideline: A rule of thumb for displays of nominal conditions is to limit the maximum amount of highlighting to 10 percent of the displayed information.

HSI Design Criteria

Highlighting should be easily recognizable and used to attract the user's attention to special conditions, items important to decision-making or action requirements, or as a means to provide feedback.

Highlighting of information should be minimized.

A particular highlighting method should be used consistently.

If highlighting is used to emphasize important display items, it should be removed when it no longer has meaning.

Reference: NUREG-0700-1.3.10

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3.1.2.17.2 Use of Brightness Coding

ES-0304-1381-8564

Guideline: Levels approximating 33 percent and 100 percent of the display luminance should be used for brightness coding.

HSI Design Criteria

Coding by differences in brightness will not be used by NuScale.

Reference: NUREG-0700-1.3.10

3.1.2.17.3 Inverse Video

ES-0304-1381-8570

Guideline: The use of inverse video should be used as an operator aid not a common method of display.

HSI Design Criteria

Inverse video should be used primarily for highlighting in dense data fields or to indicate selection of on-screen objects and information.

Reference: NUREG-0700-1.3.10

3.1.2.17.4 Use of Flash Coding

ES-0304-1381-8572

Guideline: Flashing should be used when a displayed item implies an urgent need for attention or action, but not in displays requiring attention to detail or reading of text.

Only a small area of the screen should flash at any time.

No more than two flash rates should be used.

HSI Design Criteria

The differences between the two flash rates should be at least 2 Hz. The slow flash should not be less than 0.8 Hz and the fast flash rate should not be more than 5 Hz. The percentage of time that the image is 'on' should be greater than or equal to the time that it is 'off.' A 50 percent duty cycle is preferred. When a single blink rate is used, the rate should be roughly 2-3 blinks per second with a minimum of 50 msec 'on' time between blinks.

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An 'off' condition should never be used to attract attention to a message.

Flashing should not be used as a means to highlight routine information.

Flashing should only be used as an alerting/warning code. If used sparingly, flashing symbols are effective in calling a user's attention to displayed items of unusual significance. Flash coding generally reduces search times, especially in dense displays.

When two rates are used, the higher rate should apply to the more critical information.

Reference: NUREG-0700-1.3.10

3.1.2.17.5 Flash Coding for Text

ES-0304-1381-8574

Guideline: When a user must read a displayed item that is flash coded, an extra symbol such as an asterisk or arrow to mark the item should be used, and the marker symbol should flash rather than the item itself.

Additional Information: This practice will draw attention to an item without detracting from its legibility. Flashing characters may have somewhat reduced legibility, and may cause visual fatigue.

HSI Design Criteria

NuScale will employ this technique if the flash coding of text is used.

Reference: NUREG-0700-1.3.10

3.1.2.18 Auditory

3.1.2.18.1 Use of Auditory Signals

ES-0304-1381-8586

Guideline: An auditory signal should provide users with a greater probability of detecting the triggering condition than their normal observations would provide in the absence of the auditory signal.

HSI Design Criteria

Auditory signals shall be provided to alert the operators to situations that require attention.

Reference: NUREG-0700-1.3.11

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3.1.2.18.2 Dedicated System

ES-0304-1381-8588

Guideline: Failure of auditory signal circuitry should not adversely affect plant equipment.

HSI Design Criteria

The system used to transmit non-verbal auditory signals shall not be used for any other purpose unless a redundant back-up system is available.

The audio display device and circuit should be designed to preclude warning signal failure in the event of system or equipment failure and vice versa.

Reference: NUREG-0700-1.3.11

3.1.2.18.3 Localization

ES-0304-1381-8590

Guideline: Auditory signals should provide localization cues that direct users to those control room workstations where attention is required.

HSI Design Criteria

Visual cues will be provided at the workstations in conjunction with the audio cues heard in the MCR.

Reference: NUREG-0700-1.3.11

3.1.2.18.4 Selection

ES-0304-1381-8592

Guideline: Auditory signals should be selected to avoid interference with other auditory sources, including verbal communication.

HSI Design Criteria

All audio signals shall be unique to all other auditory noise in the MCR.

Reference: NUREG-0700-1.3.11

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3.1.2.18.5 Signal Priority Distinction

ES-0304-1381-8594

Guideline: Advisory or caution signals should be readily distinguishable from warning signals and used to indicate conditions requiring awareness, but not necessarily immediate action.

HSI Design Criteria

NuScale notifications will provide unique auditory signals for clear distinction between types by the operators.

Reference: NUREG-0700-1.3.11

3.1.2.18.6 Association with Visual Warnings

ES-0304-1381-8596

Guideline: If used, auditory alerts, as well as caution and warning sounds, should accompany visual displays.

HSI Design Criteria

The audio signals in the MCR will be used in conjunction with the appropriate visual display.

Reference: NUREG-0700-1.3.11

3.1.2.18.7 Unique Signal-Event Association

ES-0304-1381-8598

Requirement: Once a particular auditory signal code is established for a given operating situation, the same signal should not be designated for some other display.

Audio warning signals that might be confused with routine signals or with other sounds in the operating environment should not be used.

Coding methods should be distinct and unambiguous, and should not conflict with other auditory signals.

Similar auditory signals must not be contradictory in meaning with one another.

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HSI Design Criteria

Auditory signals used to alert the operators in the MCR shall be unambiguous as well as different from routine signals such as bells, buzzers, and normal operating noises.

The frequency of a warning tone should be different from that of the electric power employed in the system, to preclude the possibility that a minor equipment failure may generate a spurious signal.

Plant Notifications, Appendix E, will cover the code/tone of audible signals as well as their use.

Reference: NUREG-0700-1.3.11

3.1.2.18.8 Total Number of Simple Signals

ES-0304-1381-8600

Guideline: If the audio signal varies on one dimension only (such as frequency), the number of signals to be identified should not exceed four.

HSI Design Criteria

MCR auditory signals shall vary by more than one dimension.

Reference: NUREG-0700-1.3.11

3.1.2.18.9 Use with Several Visual Displays

ES-0304-1381-8602

Requirement: One audio signal may be used in conjunction with several visual displays, provided that immediate discrimination is not critical to personnel safety or system performance.

HSI Design Criteria

A single audio signal will be used for the entire MCR.

Plant Notifications, Appendix E, will cover the number of audible signals as well as their use.

Reference: NUREG-0700-1.3.11

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3.1.2.18.10 Signal Compatible with Environment

ES-0304-1381-8606

Guideline: Audio signals should not startle listeners, add significantly to overall noise levels, or prevent communication among users.

HSI Design Criteria

The intensity, duration, and source location of the signal shall be compatible with the acoustical environment of the intended receiver as well as with the requirements of other personnel in the signal area.

Reference: NUREG-0700-1.3.11

3.1.2.18.11 Turning Off Noncritical Auditory Signals

ES-0304-1381-8608

Guideline: A simple, consistent means of acknowledging and turning off warning signals should be provided.

HSI Design Criteria

Noncritical auditory signals if used will have the capability of being turned off at the discretion of the user.

Reference: NUREG-0700-1.3.11

3.1.2.18.12 Indicating Who is Responding

ES-0304-1381-8610

Guideline: When the signal must indicate which user (of a group of users) is to respond, a simple repetition code should be used.

HSI Design Criteria

The HSI will display which operator has ownership/control of a particular system or module.

Reference: NUREG-0700-1.3.11

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3.1.2.18.13 Auditory Guides

ES-0304-1381-8612

Guideline: Auditory alert and warning signals should be audible in all parts of the control room.

HSI Design Criteria

Sound sources (speakers or buzzers) should direct sound toward the center of the main operating area.

When an audio signal must bend around major obstacles or pass through partitions, its frequency should be less than 500 Hz.

The intensity of auditory signals should be set to unmistakably alert and get a user's attention. A signal should generally yield a 20dB signal-to-noise ratio in at least one octave band between 200 and 5000 Hz. This level should apply throughout the main operating area. (A 20dB differential may not be necessary for all signals and all environments.)

Auditory signal intensity should not cause discomfort or 'ringing' in the ears. Auditory signal intensities should not exceed 90 dB(A), except for evacuation signals, which may be up to 115 dB(A).

When the noise environment is unknown or expected to be difficult to penetrate, audio signals should have a shifting frequency that passes through the entire noise spectrum and/or be combined with a visual signal.

Audio warning signals should not interfere with any other critical functions or warning signals, or mask any other critical audio signals.

Auditory alarm systems should be designed so that false alarms are avoided.

Auditory signals may be pulse coded by repetition rate. Repetition rates should be sufficiently separated to ensure discrimination.

Reference: NUREG-0700-1.3.11

3.1.2.18.14 Frequency Coding

ES-0304-1381-8636

Guideline: The signal frequency of auditory displays should be compatible with the midrange of the ear's response curve, i.e., the use of signals with frequencies to which the ear is less sensitive should be avoided. No more than four separate frequencies should be used.

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HSI Design Criteria

If modulation of the frequency (Hz) of a signal denotes information, center frequencies should be between 500 and 1000 Hz.

If discrete-frequency codes are used for audible signal coding, frequencies should be broad band and widely spaced within the 200 to 5000 Hz range (preferably between 500 and 3000 Hz).

Reference: NUREG-0700-1.3.11

3.1.2.18.15 Coding by Intensity

ES-0304-1381-8640

Requirement: Sound level notification is not reliable enough to be used as a method to determine information.

HSI Design Criteria

Using the intensity of a sound to convey information shall not be used.

Plant Notifications, Appendix E, will cover the number of audible signals as well as their use.

Reference: NUREG-0700-1.3.11

3.1.2.18.16 Testing

ES-0304-1381-8642

Requirement: If audible signals are part of the alarm system testing is required to ensure the system is operating properly.

HSI Design Criteria

It shall be possible to test the auditory alarm signal system.

Plant Notifications, Appendix E, will cover the number of audible signals as well as their use.

Reference: NUREG-0700-1.3.11

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3.1.2.19 Display Page Organization

3.1.2.19.1 Display Screen Partitioning for HSI Functions

ES-0304-1381-8666

Guideline: Consistent display screen organization will help establish and preserve user orientation.

Reserved screen areas, for example, might be used for a display title, alarms, display control options, instructions, error messages, and menus.

Display formats should be consistent with accepted usage and existing user habits.

HSI Design Criteria

A standard display screen organization should be evident for the location of various HSI functions (such as a data display zone, control zone, or message zone) from one display to another.

The HSI functional zones and display features should be visually distinctive from one another, especially for on-screen command and control elements (which should be visibly distinct from all other screen structures).

Different display areas can be separated by blank spaces, lines, or some other form of visual demarcation. Areas used to display data, control options, and instructions should be distinct from one another.

When information is grouped on a display, the groups should be made visually distinct by such means as color coding or separation using blanks or demarcation lines.

Reference: NUREG-0700-1.5

3.1.2.19.2 Display Title

ES-0304-1381-8670

Guideline: The title may be incorporated as part of the display itself, as a window title, or as a label mounted on the display device.

HSI Design Criteria

Every display should begin with a title or header at the top.

Every display page should have a unique identification to provide a reference for use in requesting the display of that page.

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There should be at least one blank line between the title and the body of the display.

The page identification should be prominently displayed in a consistent location.

Reference: NUREG-0700-1.5

3.1.2.19.3 Hierarchy of Titles

ES-0304-1381-8674

Guideline: Where displays have several levels of titles (and/or labels), the system should provide visual cues to aid users in distinguishing among the levels in the hierarchy.

HSI Design Criteria

Standard windows menu bars will be used to show hierarchy.

Reference: NUREG-0700-1.5

3.1.2.19.4 Display Simplicity

ES-0304-1381-8676

Guideline: Displayed information should be tailored to user needs, providing only necessary and immediately usable data for any user action.

HSI Design Criteria

Displays should present the simplest information consistent with their function.

Information irrelevant to the task should not be displayed, and extraneous text and graphics should not be present.

Displays should be as uncluttered as possible.

Display packing density should not exceed 50 percent.

Displays consisting largely of alphanumeric data generally should not exceed 25 percent density.

Displays composed largely of graphics may be denser.

When a display contains too much data for presentation in a single frame, the display should be partitioned into separately displayable pages (multipage displays) or displayed through frames/viewports (such as scrollable windows).

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Redundancy in the presentation of information items should be limited to cases where needed for backup or to avoid excessive movement.

Reference: NUREG-0700-1.5

3.1.2.19.5 Task-Related Partitioning of Displays

ES-0304-1381-8682

Guideline: When displays are partitioned into multiple pages, function/task-related data items should be displayed together on one page.

Users working with multipage displays should be provided with a page location reference within the display sequence.

HSI Design Criteria

Each page of a multipage display sequence should be numbered.

The phrase "page x of y" will typically be used for this purpose.

Relations among data sets should appear in an integrated display rather than partitioned into separate display pages.

Reference: NUREG-0700-1.5

3.1.2.19.6 Display Frame Location Cues

ES-0304-1381-8686

Guideline: Users viewing a portion of a larger display should be provided with an indication of the location of the visible position of a display (frame) in the overall display.

HSI Design Criteria

A graphic indication of the frame's location in the overall display will provide a visual context to help a user maintain a conceptual orientation between the visible part and the whole display.

Reference: NUREG-0700-1.5

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3.1.2.19.7 Grouping of Information in a Display

ES-0304-1381-8688

Guideline: Information on a display should be grouped according to principles obvious to the user (e.g., by task, system, function, or sequence, based upon the user's requirements in performance of the ongoing task).

HSI Design Criteria

Table 3-5 provides grouping principles and examples of their appropriate uses.

Grouping conventions should be used consistently within sets of displays of a particular type. For example, grouping by function may take precedence over other grouping methods for mimic-type plant displays.

Grouping for data comparison may take precedence over other grouping methods for displays that present only text. Since users' tasks can vary, advanced HSIs should provide the user with the flexibility to group information by alternative grouping principles to reflect changes in task requirements.

Reference: NUREG-0700-1.5

Table 3-5. Information grouping principles (Reference 1.5.1)

Grouping Method	Conditions for Appropriate Use
Task	Information necessary to support a user's task should be grouped together.
Sequence of Use	Where displayed information is used in spatial or temporal order, the information should be grouped by sequence of use to preserve that order. For example, data in a VDU display should match the order of steps in an associated paper procedure referencing the data. Information should be arranged sequentially from left to right or top to bottom.
Frequency	Where some information is used more frequently than others, the frequently used information should be grouped at the top or some other predefined location of the display.
Data Comparison	When users must analyze sets of data to discern similarities, differences, trends, and relationships, the display format should be structured so that the data are consistently grouped. Grouping similar items together in a display format improves their readability and can highlight relationships between different groups of data. Grouping can be used to provide structure in the display and aid in the recognition and identification of specific items of information.
Importance	Information that is particularly important should be grouped at the top or some other predefined location of the display.
Function	Where a set of information has strong functional relationships such as lower-level status indications that are related to a higher-level plant system (e.g., main feedwater) or function (e.g., core heat removal), the information should be grouped together to help illustrate those relationships.
Alphanumeric or Chronological Sequence	When items or data must be selected from a list or where there is no appropriate logic for grouping data according to some other principle, alphabetical or chronological grouping should be employed.

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3.1.2.19.8 Display Background Color

ES-0304-1381-8694

Guideline: A uniform non-distracting background color should be used with a hue/contrast that allows the data (foreground) to be easily visible and which does not distort or interfere with the coding aspects of the display.

Patterned backgrounds should be avoided.

HSI Design Criteria

See Appendix C for background color codes.

See Appendix D for examples of display page design.

Reference: NUREG-0700-1.5

3.1.2.19.9 Labeling Scrollable and Multipage Displays

ES-0304-1381-8696

Guideline: Display formats such as tables, lists, forms, and graphs may be scrollable.

HSI Design Criteria

General labels and row/column labels should remain along the top (or bottom) and left (or right) edges of the display.

When this capability is available, all labeling information should be preserved.

Reference: NUREG-0700-1.5

3.1.2.19.10 Data Overlays (Pop-up Boxes)

ES-0304-1381-8698

Guideline: Overlays are acceptable when they improve the user's interpretation of displayed information.

Overlay displays that are generated by the display system can allow additional information to be shown when needed and then removed to reduce visual clutter.

HSI Design Criteria

Displayed information which temporarily overlays and obscures other display data should not erase the overlaid data.

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Important or needed information covered by an overlay shall be reproduced within the overlay itself.

Reference: NUREG-0700-1.5

3.1.2.20 Menus

3.1.2.20.1 Menu Design

ES-0304-1381-9116

Guideline: When control entries for any particular transaction will be selected from a small set of options, those options should be displayed in a menu added to the working display, rather than requiring a user to remember them or to access a separate menu display.

When menus are provided in different displays, they should be designed so that option lists are consistent in wording and ordering.

Menus should be displayed in consistent screen locations for all modes, transactions, and sequences while minimizing the use of permanent menus.

When permanent menus are used, there should be one standard design for the input prompt that is used across all tasks.

Menus should be designed so that the function of the menu is evident to the user.

An explanatory title should be provided for each menu that reflects the nature of the choice to be made.

HSI Design Criteria

Several menu techniques will be provided to the operator as part of the standard display page template.

Consistency is maintained by applying all menu techniques to the HSI template.

The menu technique and the use of a standard template will apply to pop-up, pull-down, windowed menus, and to menu bars.

All menu options shall be clearly marked using terminology familiar to the operator.

Icons will be used as a means of providing quick information to the operator. An example of this is a printer icon for a print function.

A menu should be designed to display all options appropriate to any particular transaction.

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Reference: NUREG-0700-2.2.2.1

3.1.2.20.2 Pull-Down and Pop-Up Menus

ES-0304-1381-9126

Guideline: Among the types of user-requested menus, pull-down menus provide two advantages over pop-up menus: (1) the menu bar serves as a useful mnemonic aid, showing the user the command categories available in the menu; and (2) gaining visual access to the menu items within a category, selecting the item, and removing the menu can be accomplished with a minimal number of actions.

The primary advantage of a pop-up menu over a pull-down menu is that, depending on the specific implementations, the user may have immediate access to the menu at the screen location of the selection action.

HSI Design Criteria

Pull-down and pop-up menus shall not appear when the cursor has passed over the menu title.

Pull-down and pop-up menus shall only be activated by a specific user action.

When a pull-down or pop-up menu item(s) has/have been selected, the menu shall revert to its hidden state as the selected command is carried out.

Reference: NUREG-0700-2.2.2.1

3.1.2.20.3 Programmable Keys

ES-0304-1381-9132

Guideline: If menu items are selectable via activation of programmable function keys, the arrangement of the menu list should be compatible with the arrangement of the keys to the greatest degree possible.

When equivalent keyboard commands are provided, they should be displayed as part of the menu option label.

HSI Design Criteria

The function keys will be used as a quick key to open one of the 12 modules overview page.

With the use of key templates on screen reminders are not needed.

Reference: NUREG-0700-2.2.2.1

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3.1.2.20.4 Option Display Dependent on Context

ES-0304-1381-9138

Guideline: Menus should display as selectable only those options that are actually available in the current context.

HSI Design Criteria

Non available menu options will be greyed out.

Reference: NUREG-0700-2.2.2.1

3.1.2.20.5 Menus Distinct from Other Displayed Information

ES-0304-1381-9142

Guideline: If menu options are included in a display that is intended also for data review and/or data entry, the menu options should be distinct from other displayed information.

HSI Design Criteria

Menu options will be designed to be distinguishable from all other methods of input.

Reference: NUREG-0700-2.2.2.1

3.1.2.20.6 Breadth and Depth of Menu Items

ES-0304-1381-9144

Guideline: Menus should have a limited number of items in breadth and in depth.

HSI Design Criteria

Menu options shall be less than 15.

Reference: NUREG-0700-2.2.2.1

3.1.2.20.7 Number of Options

ES-0304-1381-9146

Guideline: Menus with only two options should be avoided. "Menus" with only one item should not be used.

HSI Design Criteria

Each menu option list will have 2 to 8 options.

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Reference: NUREG-0700-2.2.2.1

3.1.2.20.8 Use of Multiple Paths

ES-0304-1381-9164

Guideline: Multiple navigation paths should accommodate a range of user experience in navigating the display system. Highly experienced users should be allowed to use shortcuts, such as 'type- ahead' or 'jump-ahead' to reduce the number of interface management actions required to navigate through the display selection system.

HSI Design Criteria

Multiple navigation paths will be provided to items in the display system.

Reference: NUREG-0700-2.2.2.1

3.1.2.20.9 Representation of Menu Structure

ES-0304-1381-9166

Guideline: Where space allows, some aspects of the menu structure should be presented visually so the user is not required to remember it. That is, information should be provided in the user interface to augment or substitute for the user's knowledge of the display navigation structure.

HSI Design Criteria

A visual representation of the menu structure shall always be visible.

Reference: NUREG-0700-2.2.2.1

3.1.2.20.10 Indicating Selectable Menu Items

ES-0304-1381-9168

Guideline: Menu systems should clearly indicate which options are selectable.

HSI Design Criteria

Menus that direct the operator to the many display pages available will always show every option.

Menus that provide a control signal will have the un-selectable items greyed out.

Reference: NUREG-0700-2.2.2.1

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3.1.2.20.11 Menu Ordering

ES-0304-1381-9170

Guideline: Menu options should be ordered and grouped logically.

HSI Design Criteria

HSI menus will be grouped according to the operators need to safely operate the plant.

The scrolling option will not be used on menus.

Menus will be fixed and be presented in single column format.

Reference: NUREG-0700-2.2.2.2

3.1.2.20.12 Labeling Grouped Options

ES-0304-1381-9180

Guideline: If menu options are grouped in logical subunits, each group should have a descriptive label that is distinctive in format from the option labels themselves.

Additional Information: Although this practice might sometimes seem to waste display space, it will help provide user guidance. Moreover, careful selection of group labels may serve to reduce the number of words needed for individual option labels.

HSI Design Criteria

Menu options shall be uniquely labeled.

Reference: NUREG-0700-2.2.2.3

3.1.2.20.13 Hierarchic Menus for Sequential Selection

ES-0304-1381-9182

Guideline: When menu selection must be made from a long list, and not all options can be displayed at once, a hierarchic sequence of menu selections should be provided rather than one long multipage menu.

Additional Information: Where a long list is already structured for other purposes, such as a list of customers, a parts inventory, or a file directory, it might be reasonable for the user to be required to scan multiple display pages to find a particular item. Even in such cases, however, beginning users may learn faster and understand better a menu permitting a single choice from all available options, when those can be displayed on

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one page. However, a single long menu that extends for more than one page will hinder learning and use.

HSI Design Criteria

An imposed structure for sequential access shall be used such as but not limited to making a preliminary letter choice to access a long alphabetic list.

Reference: NUREG-0700-2.2.2.3

3.1.2.20.14 Consistent Design of Hierarchic Menus

ES-0304-1381-9184

Guideline: The display format and selection logic of hierarchic menus should be consistent organized and labeled to guide users within the hierarchic structure at every level.

*Additional Information: U*sers will learn menus more quickly if a map of the menu structure is provided as HELP.

HSI Design Criteria

All menus and header bars shall be consistent throughout the entire HSI design.

Reference: NUREG-0700-2.2.2.3

3.1.2.20.15 Visual Representation of Path

ES-0304-1381-9188

Guideline: Users should be able to access a visual representation of their paths through a hierarchy of menus and have some indication of their current position in the menu structure.

HSI Design Criteria

Push button type menus shall have highlighted indication of the selected page.

Windows type navigation techniques shall have a bread crumbing method to show the user where they are in the menus selection.

Reference: NUREG-0700-2.2.2.3

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3.1.2.20.16 Sequential Menu Selection Design

ES-0304-1381-9190

Guideline: When users must step through a sequence of menus to make a selection, the hierarchic menu structure should be designed to minimize the number of steps required.

Examples of a broad, shallow menu structure and narrow, deep menu structure are provided in Figure 3-8.

HSI Design Criteria

The number of hierarchic levels shall be minimized.

Display crowding shall be avoided.

Users should have to take only one simple key action to return to the next higher level in hierarchic menus.

Each subordinate menu should be visually distinct from each previous superordinate menu.

The number of menu choices should be minimized on menus located midway in a hierarchical menu structure.

Broad and shallow menu structures, rather than narrow and deep menu structures should be used.

Users shall be able to select a menu or submenu directly, without going through intermediate selection steps.

Reference: NUREG-0700-2.2.2.3

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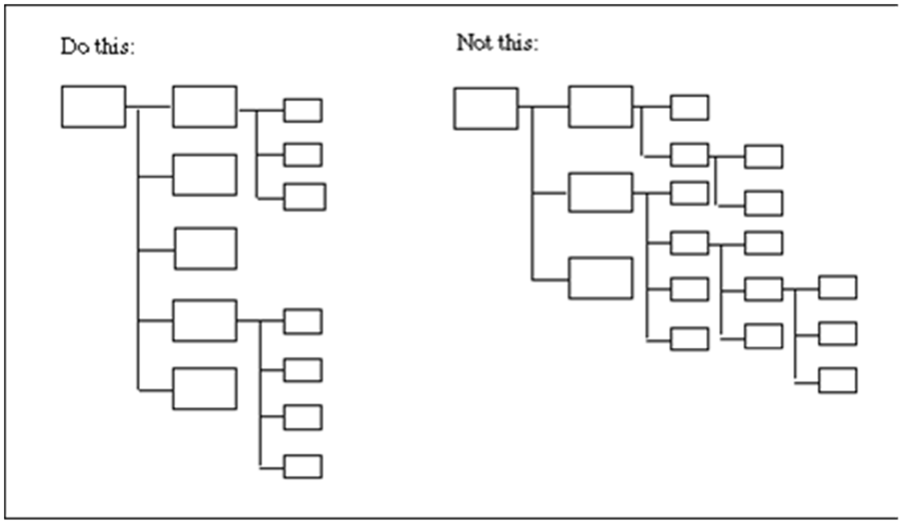

Figure 3-8. Examples of broad and shallow menu structures

3.1.2.20.17 Return to Higher-Level Menus

ES-0304-1381-9192

Guideline: Users should have to take only one simple key action to return to the next higher level in hierarchic menus.

Additional Information: This action could be considered analogous to the BACK option.

HSI Design Criteria

NuScale menu techniques will incorporate a one click away from the next level methodology to the HSI design.

Reference: NUREG-0700-2.2.2.3

3.1.2.20.18 Distinct Subordinate Menus

ES-0304-1381-9196

Guideline: If hierarchical branching is used, each subordinate menu should be visually distinct from each previous superordinate menu.

Additional Information: Examples include the display of level numbers and a graphical stacking effect. Successful user operations depend on knowledge of context. The user needs to know the levels from which the current display menu came and how far down in the hierarchy the current menu is.

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HSI Design Criteria

NuScale will not incorporate subordinate menu techniques into the HSI design.

Reference: NUREG-0700-2.2.2.3

3.1.2.20.19 Control Options Distinct from Menu Branching

ES-0304-1381-9198

Guideline: The display of hierarchic menus should be formatted so that options that actually accomplish control entries can be distinguished from options, which merely branch to other menu frames.

HSI Design Criteria

Control type selections shall be separated from menu selection.

Reference: NUREG-0700-2.2.2.3

3.1.2.20.20 Return to General Menu

ES-0304-1381-9200

Guideline: Users should have to take only one simple key action to return to the general menu at the top level in hierarchic menus.

HSI Design Criteria

Windows type menus shall be used to support this guideline.

Reference: NUREG-0700-2.2.2.3

3.1.2.20.21 Use of Broad, Shallow Menu Structures

ES-0304-1381-9202

Guideline: Broad and shallow menu structures, rather than narrow and deep menu structures should be used.

HSI Design Criteria

Examples of a broad, shallow menu structure and narrow, deep menu structure are provided in Figure 3-8.

Reference: NUREG-0700-2.2.2.3

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3.1.2.20.22 Minimizing Menu Choices In the Middle of a Menu Structure

ES-0304-1381-9204

Guideline: The number of menu choices should be minimized on menus located midway in a hierarchical menu structure.

Additional Information: Users are more likely to get lost in the middle levels of a menu structure.

HSI Design Criteria

Menu choices shall be minimized at all levels of the menu.

Reference: NUREG-0700-2.2.2.3

3.1.2.20.23 Direct Selection of Submenus

ES-0304-1381-9206

Guideline: Users should be able to select a menu or submenu directly, without going through intermediate selection steps.

Additional Information: One method for avoiding intermediate selection steps is to allow users to select nodes directly from a representation of the menu structure.

HSI Design Criteria

Windows type menus shall be used to support this guideline.

Reference: NUREG-0700-2.2.2.3

3.1.2.20.24 Menu Bar Design

ES-0304-1381-9210

Guideline: Conventions should be established for the organization of the menu bar. For example, the categories on the left side of the menu bar might be system functions that apply across all (or most) applications. The categories on the right side of the menu bar might be those that are specific to the currently active application. Within this general spatial layout, both the system-wide and specific categories would be ordered from left (the category containing the most frequently used actions) to right (the category containing the least frequently used).

One standard character width would be required to separate adjacent words in a multiword category. To indicate separate categories, more than one width would be needed.

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The effective target area should be to provide easier pointing action and provide less risk of error in selecting a wrong option.

HSI Design Criteria

The categories listed across the menu bar shall be organized systematically.

Category labels on menu bars shall be centered in the vertical dimension.

Horizontally, category labels on the menu bar should be separated by enough space to be distinguishable as separate items, i.e., by at least two standard character widths.

The height of a menu bar should be sufficient to contain standard text characters that serve as menu category labels, as well as space above and below the text characters.

If touch screens are used then follow the 0.5-inch x 0.5-inch minimum space requirement.

If menu selection is accomplished by pointing, the acceptable area for pointing should be as large as consistently possible, including at least the area of the displayed option label plus a half-character distance around that label.

Reference: NUREG-0700-2.2.2.4

3.2 Plant Notifications

Traditional alarm systems can be described both in terms of their physical and functional characteristics. Each is discussed below. The physical characterization illustrates the relationship between the alarm system and the rest of the plant, including both equipment and operators. The functional characterization is a way of describing how the alarm system is used in the operation of the plant.

Figure 3-9 shows a block diagram of a conventional alarm system. Various plant parameters (such as temperatures and pressures) are monitored by sensors (such as resistance temperature detectors and bellows pressure detectors). The output of the sensors is processed electronically to send the signals to various circuits that serve as controls, displays, and alarms. The figure shows the inputs to a parameter display and to an alarm bistable. Each alarm circuit for a parameter has a setpoint value at which the alarm is triggered. The bistable senses when the parameter exceeds the alarm setpoint; this in turn actuates the alarm display. The control room operators can then make judgments about the plant's state and what actions to take, based upon the alarm and parameter displays and the procedures. The operators would, as necessary, adjust the plant systems and components through the plant controls. Such adjustments would in turn be reflected by the sensors back into the alarms and displays.

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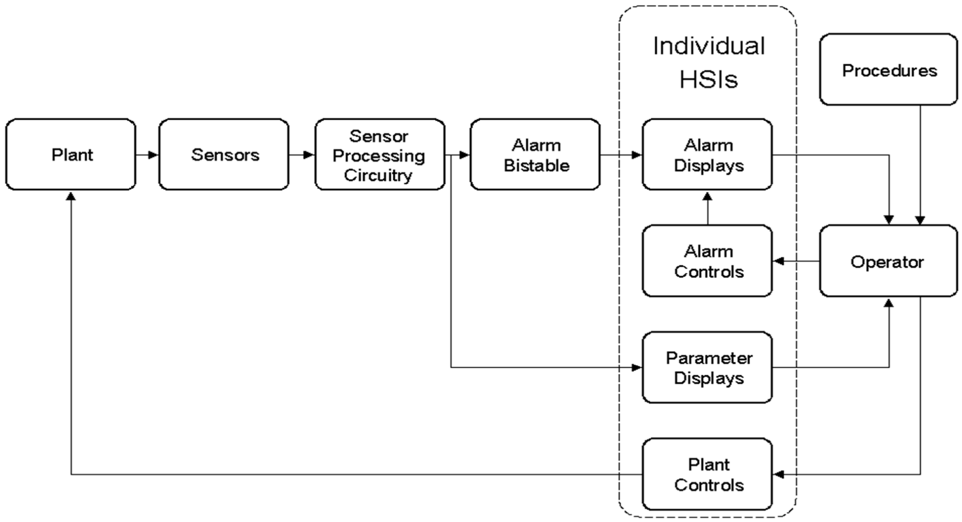

Figure 3-9. Conventional alarm system

Figure 3-10 presents a similar block diagram for one version of an advanced alarm system. In this version the plant, the sensors, and the sensor signal processing circuitry are similar to that for a conventional alarm system (Figure 3-9). However, the advanced alarm system (depicted in the dotted box) is typically integrated and contains a significant capability for information processing. The functioning of this circuitry is discussed later. The outputs from the advanced alarm system are typically input to some integrated HSI network that may employ VDUs or other versatile display devices. The individual parameter displays and the controls may also be included within the same integrated HSI. The operators would then use their procedures and the HSI to assess the situation, plan responses, and take any necessary actions to control the plant. Again, these actions would be reflected in a feedback loop to the plant, the sensors, and back to the HSI.

The alarm system depicted in Figure 3-10 is representative of an original analog alarm system that has had digital post-processing back-fitted to it in order to improve the alarm system's functionality. The safety parameter display system is one example of such a digital post-processor. Other more modern alarm systems that are designed digitally from the beginning may include alarm processing at the sensor processing level.

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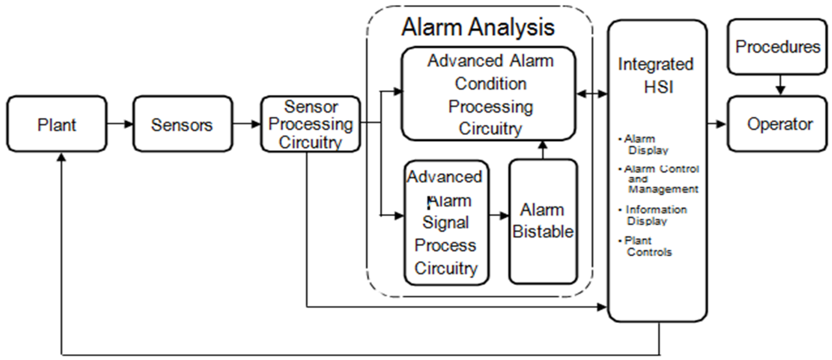

Figure 3-10. Advanced alarm system

The characterization of an alarm system by the major functional and physical topics addressed in the guidance is shown in Figure 3-11. This shows the five main functions of an alarm system: Alarm definition, alarm processing, alarm prioritization, alarm display, and alarm control and management. Alarm Response Procedures (ARPs) provide more detailed information concerning the nature of the alarm condition than is typically provided in the alarm message. This characterization is useful for an HFE design reviewer, and therefore it forms the basis for organizing the alarm system guidelines. For each sub-section below, three types of information are given: an introduction to the functional area, an identification of the types of information a reviewer should address, and a reference to the appropriate section, which contains the guidelines for reviewing the topic. These alarm characteristics are discussed below.

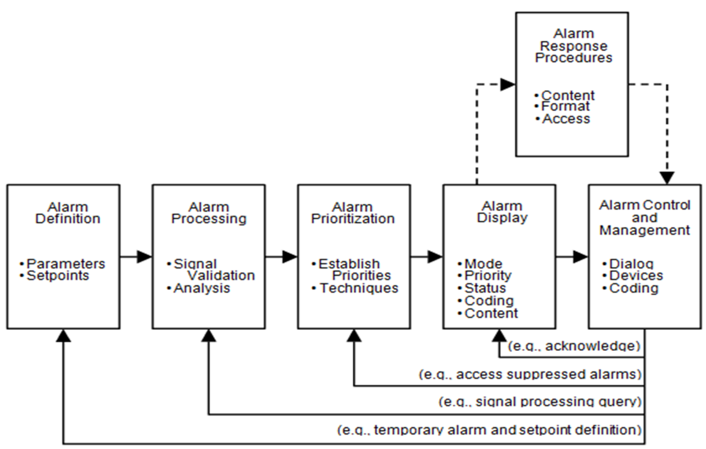

Figure 3-11. Alarm system functional elements

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3.2.1 Definitions

Alarm System Functions

The characterization and description presented here should assist the reviewer in understanding the alarm system from a functional standpoint and guide the reviewer to appropriate guideline sections. This characterization addresses both traditional analog alarm systems and more modern systems that have significantly more capability. However, one must recognize that as alarm system designs evolve, changes in functionality may occur that affect the characterization. As an example, one trend for new advanced systems is to more completely integrate the alarm system functions into the main part of the control room interfaces, blurring the distinction between the alarms and the other displays.

The general characteristics include the basic alarm functions associated with alerting the operator, guiding the operator's actions, helping the operator monitor plant events, and facilitating the operator's interaction with the plant.

Alarm Definitions

Alarm definition is the specification of the types of process parameters to be monitored and displayed by the alarm system and the setpoints to be used to represent those parameters. The following are important considerations in alarm definition:

- Alarm categories (the events and states from which alarms are selected)
- The criteria used to select alarm parameters to represent the categories
- The criteria for determining the setpoints
- The verification process (for task appropriateness):
    - process by which alarm inclusion was checked
    - process for assuring that non-alarms are not presented in the alarm system
- Alarm states (unacknowledged, acknowledged, cleared, and reset)

The systems engineering basis for the alarm definition specification should be established to ensure that it is appropriate from a safety standpoint.

Alarm Processing

Alarms in conventional plants tend to be stand-alone systems that alert operators to off-normal conditions and to the status of systems and components, and, by inference, the functions they support. After being alerted, the operators consult other indicators for specific information (e.g., they may determine the actual value of a parameter for which an alarm for low level had just activated). Such systems tended to overwhelm operators during transients because of the many nearly simultaneous annunciator activations with varying degrees of relevance to the operators' tasks. Thus, alarm processing techniques

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were developed to support operators in coping with the volume of alarms, to identify which are significant, and to reduce the need for operators to infer plant conditions. Alarm processing addresses a fundamental aspect of system design, namely, which alarms are presented to the operating crew.

Alarm signal processing refers to the process by which signals from sensors are automatically evaluated to determine whether any of the monitored parameters have exceeded their setpoints and to determine whether any of these deviations represent true alarm conditions. Alarm signal processing includes techniques for analyzing normal signal drift and noise signals and signal validation. Normal signal drift and noise are analyzed to eliminate signals from parameters that momentarily exceed the setpoint limits but do not represent a true alarm condition. Figure 3-10 illustrates the incorporation of signal processing into the circuitry for an advanced alarm system.

Signal validation is a group of techniques for comparing and analyzing redundant or functionally related sensors to identify and eliminate false signals resulting from malfunctioning instrumentation, such as a failed sensor. Alarm conditions that are not eliminated by the alarm signal processing may be evaluated further by alarm condition processing and other analyses before alarm messages are presented to the operator.

Alarm condition processing refers to the rules or algorithms used to determine the operational importance and relevance of alarm conditions; this process determines whether the alarm messages that are associated with these conditions should be presented to the operator. Figure 3-10 illustrates alarm condition processing. Note that alarms screened by the alarm condition processing circuitry may or may not have already been screened by the alarm signal processing/validation circuitry. Also, the alarm condition processing circuitry receives inputs directly from the sensor processing circuitry to set the various values of logic that automatically determine how alarms are screened.

A wide variety of processing techniques have been developed; combinations of them are often employed in advanced alarm processing systems. Additionally, the processing may be occurring at various portions of the alarm systems depending on the advanced system design. The reviewer should be alert to the fact to ensure that all pertinent processing has been identified and reviewed. Each technique changes the resulting information provided to operators. For this discussion, four classes of processing techniques are defined: Nuisance Alarm Processing, Redundant Alarm Processing, Significance Processing, and Alarm Generation Processing. The classes of processing techniques are described below, and examples of each are given in Table 3-6.

Nuisance Alarm Processing – This class of processing includes techniques that eliminate alarms with no operational safety importance. For example, mode dependent processing eliminates alarms that are irrelevant to the current mode of the plant (e.g., the signal for a low pressure condition may be eliminated during modes when this condition is expected such as startup and cold shutdown, but be maintained when it is not expected, such as during normal operations).

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Redundant Alarm Processing – This class of processing includes techniques that analyze for alarm conditions that are true/valid but are considered to be less important because they provide redundant information and theoretically offer no new/unique information. For example, in causal relationship processing only causes are alarmed and consequence alarms are eliminated or their priority is lowered. However, such techniques may minimize information that is used by the operator to confirm that the situation represented by the "true" alarm has occurred, for situation assessment, and for decision-making. Thus, in addition to quantitatively reducing alarms, processing methods may qualitatively affect the information given to the operating crew.

Table 3-6. Alarm processing approaches

Category	Approach	Functional Description[1,2]
Nuisance	Status-alarm Separation	Separating status annunciators from alarms that require operator action.
Nuisance	Plant Mode Relationship	Alarms that are irrelevant to the current operational mode, such as start-up, are suppressed.
Redundant	Multi-setpoint Relationship	The relationship between multi-setpoints of a process variable is used to suppress lower priority alarms, e.g., when the level in the steam generator exceeds the high-high level setpoint, the high-level alarm is suppressed.
Redundant	State Relationship	Alarms associated with a well-defined situation, e.g., pump trip, are suppressed.
Redundant	Causal Relationship	The cause-effect relationship is used to identify alarms associated with causes while suppressing alarms associated with effects.
Significance	Relative Significance	Alarms associated with relatively minor disturbances during more significant events are suppressed.
Generation	Hierarchical Relationship	Using an alarm's relationship with components, trains, systems, and functions, hierarchical alarms are generated to provide operators with higher-level information.
Generation	Event Relationship	The unique pattern of alarms typically activated following the occurrence of an event is recognized and the potential initiating event is identified.
Generation	Alarm Generation	Alarms are generated when (1) conditions or events are expected to occur but do not (for example, when all control rods do not reach their fully inserted limits within a prescribed time after a scram) or (2) an alarm is expected but does not occur.

[1] For illustration purposes, the descriptions refer to alarm suppression, but filtering and prioritization can be also used.

[2] Functional descriptions are not intended to imply how the processing is accomplished in software.

Significance Processing – This class of processing includes techniques that analyze for alarm conditions that are true/valid but are considered to have less importance in comparison to other alarm conditions. For example, in an anticipated transient without scram event, alarms associated with minor disturbances on the secondary side of the plant could be eliminated or lowered in priority.

Alarm Generation Processing – This class of processing includes techniques that evaluate the existing alarm conditions and generate alarm messages which (1) give the operator higher level or aggregate information, (2) notify the operator when 'unexpected' alarm conditions occur, and (3) notify the operator when 'expected' alarm conditions do not occur. In effect, these processing techniques generate new (e.g., higher-level) alarm conditions. These new alarm conditions and their resulting alarm messages present an interesting paradox. Alarm systems should function to reduce errors, which often reflect

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the overloaded operator's incomplete processing of information. Alarm generation features may mitigate these problems by calling the operator's attention to conditions that are likely to be missed. However, the single most significant problem with alarm systems, as reported in the literature, is the large number of alarm messages presented to the operator at once. Since alarm generation creates additional messages, it may potentially exacerbate the problem.

Guidelines for reviewing alarm processing at NuScale are provided in Appendix E.

Alarm Prioritization

Alarm prioritization (or condition priority) refers to the determination of the relative importance to the operating crew of all current alarm conditions. This also includes consideration of alarm message availability. This assessment is accomplished in an advanced alarm system by applying alarm condition processing or in some cases processing at the sensor output level. The dimensions for evaluating the priority of an alarm condition should include the required immediacy of operator action and the significance of the condition to plant safety.

Alarm message availability refers to the process by which alarm messages are selected for presentation to the operators based on the priority of their alarm conditions. Thus, although two alarm messages may be valid for current plant conditions, one may be very important to the operator's role and should be emphasized, while the other may be of little importance and should be de-emphasized. Alarm message availability techniques emphasize important messages and de-emphasize less important ones, thereby focusing the operator's attention on the messages with the greatest operational significance.

The following techniques will be employed by NuScale in the categorizing and handling of notifications.

Screening – An evaluation by the Operations & HFE group to determine the category of a NuScale notification (i.e., alarm, caution, or notice).

Filtering – An HSI tool used to selectively view notifications based on various parameters such as Unit, notification type, or system.

Suppression – NuScale will have three tiers of suppression used to reduce the number of alarms presented to operators when those alarms provide no additional situational awareness value:

1) Mode Based – Notifications suppressed by the system based on the Modes of the plant.

2) Condition Based – Notifications suppressed by the system based on the condition of the plant or status of a component (tagged out) or a system of components.

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3) Shelving – Notifications that are temporarily suppressed manually by the operator using a method administratively controlled so that the shelved status is known and tracked.

The following considerations are important in prioritizing alarms:

Specific dimensions used to prioritize the alarm's importance, e.g.:

- Need for operator action
- Challenges to the safety system
- Threat to critical safety function
- Others should be specified.

Alarm priority characteristic

- Number of levels for each prioritization dimension
- Method for assigning priority (for static prioritization) or computing priority (for dynamic prioritization)
- The treatment of alarms that have been removed through filtering (complete removal) or suppression (available to operators upon request).

Guidelines for reviewing alarm prioritization and availability are provided in Appendix E.

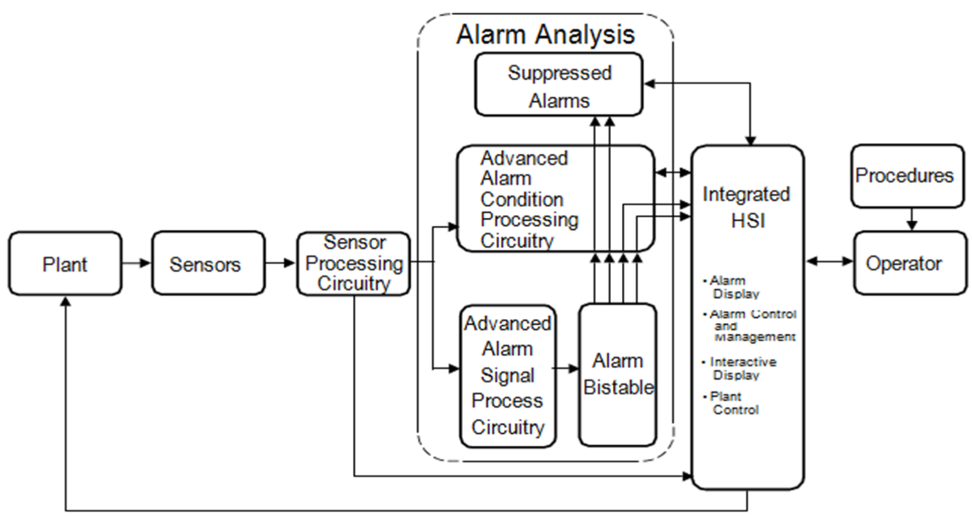

Figure 3-12. Alarm suppression

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Alarm Display

The information display aspects on alarms include both auditory and visual components. The auditory components are designed to capture the operator's attention to a change in the plant, while the visual components guide attention to the appropriate alarm (by using techniques such as flashing) and provide detailed alarm information (such as an alarm message).

To support the different functions of the alarm system, multiple visual display formats may be required, e.g., a combination of separate displays (such as alarm tiles) and integrated displays (such as alarms integrated into process displays). Thus, the display format of alarm information and the degree to which that information is presented separately or in an integrated fashion with other process information are important safety considerations.

Alarm display approaches can first be characterized into three basic types:

- Spatially dedicated, continuously visible (SDCV) alarm displays (e.g., tiles).
- Alarm message lists (e.g., temporary alarm displays).
- Alarms integrated into process displays.

Other displays are possible, combining features of more than one type. For each of the alarm display types, the following characteristics are important:

- General characteristics
- Display functions (e.g., the operators' monitoring and decision-making capabilities to be supported)
- Degree of independence of alerting and informing functions
- Degree of independence of priority and detailed information
- Principles and criteria for allocating alarms to major display types
- Alarm graphics

Consistency of alarm coding

- Display of high-priority alarms
- Display of alarm status
- Display of shared alarm
- Alarm messages
- Coding methods
- Detailed arrangement of alarm information

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- SDCV alarm displays
- Alarm message lists

Guidelines for reviewing alarm displays are provided in Appendix E. Guidelines for the review of general display characteristics are given in Section 3.1.

Alarm Control and Management

The alarm control and management (or user-system interaction) aspects of the interface should be considered along two dimensions: functional requirements (what control functions are needed by operators) and implementation (how the functions are accomplished with the HSIs provided).

The typical functions used in alarm systems in the nuclear industry are silence, acknowledge, reset, and test (SART). In conventional plants, these functions are supported by dedicated controls such as pushbuttons. The SART philosophy also applies to advanced alarm systems, where interaction with the control functions may be more sophisticated and require greater flexibility than conventional alarm systems.

In addition to the basic SART controls, newer alarm systems provide many and varied alarm management functions. For example, the operator may be able to define temporary alarms, adjust setpoints, control filtering options, and sort alarms according to many separated dimensions, such as time, priority, and system. These dynamic aspects of the interface should be reviewed to ensure that excessive workload demands are avoided, while the overall functional characteristics of the alarm system are preserved. The dynamic aspects of the alarm system should not be disruptive or confusing to operators, especially when the alarm system changes modes of operation.

Some of these capabilities may require more sophisticated methods of communicating with the system than traditional dedicated switches or pushbuttons allow. The general method of communication between the operator and the alarm system, also called the dialog format, can include methods such as menu selection, command language, and special function keys. In advanced control rooms, this aspect of operator communication with the system is likely to be integrated with other control room interfaces. Therefore, the alarm system may use the same input/control interfaces as the other HSI resources, such as the entry of temporary setpoints through a general-purpose keyboard.

In certain situations, such as during major process disturbances, it may be desirable to reduce workload by automating some alarm system functions, such as by silencing lower priority alarms or by temporarily stopping the flashing of an unacknowledged alarm. Similarly, automated controls may be implemented to trigger appropriate displays, such as alarm graphics, data windows, or display pages. These dynamic aspects of the alarm system should not be disruptive or confusing to operators, especially when the alarm system changes modes of operation.

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Important characterization considerations for each type of user-system interaction function include the following:

- Control availability
- Modes of user interaction
  - Dialogue types (e.g., menus)
  - Verification indications
  - Navigation and access of additional information
  - Additional parameter information and process displays
- Devices (design implementation)
  - Types (push buttons, switches, and touch screen)
  - Coding
  - Organization/layout (of control devices)
  - Location with respect to alarm displays and panels
- Alarm management features
  - Administrative controls
  - Operator-defined features
- Automatic features

Guidelines for reviewing alarm user-system interaction are provided in Section 3.2.2.11. Guidelines on general user-system characteristics are given in Section 3.1.

Reliability, Test, Maintenance, and Failure Indication

The alarm system must reliably provide alarm information to the operator. Important considerations include the reliability of the alarm system's hardware and software, the manner in which the alarm system conveys information to the operator about its failures or malfunctions, and the ease with it can be tested and maintained with minimal interruption to the operators. Each of these points is discussed below.

First, the hardware and software components of the alarm system should have sufficient reliability that the failure of a single component does not cause significant loss of functions or information. For example, the redundancy and diversity of the alarm system design should protect against alarm indications being lost or spurious alarm messages being generated as the result of sensor or signal processing malfunctions. In addition, the alarm system should allow the operators to obtain information from an alternate display if the primary display device fails.

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Second, when alarm system malfunctions do occur, the alarm system should make them apparent to the operators. NPP events emphasize the importance of verifying the status of the alarm system (see, for example, Information Notice 93-47, U.S. NRC, 1993). Test controls in conventional control rooms have traditionally allowed operators to check the operation of the alarm display (e.g., detect burnt-out annunciator lamps), but not other portions of the alarm system, such as signal processing components. In addition, these controls only tested the alarm system upon demand; they did not provide continuous monitoring for anomalies. Since operators rely on the alarm system as the first indication of a process disturbance, it is important that advanced systems notify the operator of any loss of functioning. The ability of the alarm system to promptly indicate its malfunctions is an important review consideration.

Third, test and maintenance features of the alarm system should be designed so that these activities can be performed with minimal interference with the activities of the operators. Desirable design features may include built-in test capabilities, modular components that can be rapidly removed and replaced, and rear access panels which prevent maintenance activities from obstructing the operator's view of controls and displays.

Alarm Response Procedures

Alarm Response Procedures (ARPs) provide more detailed information concerning the nature of the alarm condition than is typically provided in the alarm message. Typically, the information provided is alarm source (sensor), setpoint, causes, automatic actions, and operator actions. This information is especially important to operators when an unfamiliar alarm is activated or when an alarm seems inconsistent with the operator's understanding of the state of the plant. ARPs may be hardcopy or computer-based documents.

The following characteristics of ARPs are important:

- ARP information content
- ARP format
- ARP location
- Methods of user access to, and interaction with, ARPs (especially computer-based ARPs) Guidelines for reviewing ARPs are provided in Section 3.2.2.13.4.

Control-Display Integration and Layout

Control-display relationships and general layout significantly impact the operator's performance with alarm systems, as they do for other aspects of the HSI. The following considerations are important:

- Control console layout of alarm display devices and controls
- Alarm display layouts for VDUs

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- Relationship between alarm controls and displays and the associated process indicators and controls
- Physical relationship between the operators and the alarm controls and displays and the associated process indicators and controls

Guidelines for reviewing control-display integration are provided in Section 3.2.2.14.2.

Integration with other HSI Elements

The consistency and compatibility of the alarm system with the rest of the HSI can affect the operator's performance and, therefore, should be addressed.

3.2.2 Requirements and Guidelines

3.2.2.1 Alarm Definition

3.2.2.1.1 Alarm Selection

ES-0304-1381-10640

Guideline: The following criteria should be included in the basis for selecting alarm conditions:

- Monitoring critical safety functions and key parameters,
- Preventing personnel hazards,
- Avoiding significant damage to equipment having a safety function,
- Assuring that technical specifications are met,
- Monitoring emergency procedure decision points, and
- Monitoring plant conditions appropriate to plant modes ranging from full power to shutdown.

Additional Information: One of the key aspects of an alarm system is to help ensure that the plant remains within the safe operating envelope as defined by the Safety Analysis Report (SAR) and technical specifications. This includes ensuring that automatic systems can still perform their intended functions to protect the plant and personnel. This assurance can be provided in a number of ways by the alarm system with the monitoring of critical safety functions and key parameters being a typical choice. Selection of alarms should consider all operational modes including shutdown.

HSI Design Criteria

The scheme for the screening and suppressing of notifications will be applied as discussed in Appendix E. The plant notifications will be reviewed during HSI testing to verify that important aspects of all of the above categories are addressed.

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Reference: NUREG-0700-4.1.1

3.2.2.1.2 Timely Warning

ES-0304-1381-10642

Guideline: Notifications are established to help ensure that the plant remains within SAR and technical specification limits. In order to achieve this, the setpoints may be specified at conservative levels that are well within the actual limits to allow sufficient response time for operators and plant systems. Thus, where practical, alarm setpoints should be determined such that the operator is alerted before a major system or component problem results in a condition which causes a loss of availability (e.g., plant trip), equipment damage, violation of SAR and technical specification requirements, or other serious consequences. Other criteria are acceptable if they do not compromise these factors.

HSI Design Criteria

Notification set points will be determined to ensure that the operating crew can monitor and take appropriate action for each category of notifications, e.g., respond to out-of-tolerance conditions, in a timely manner.

Reference: NUREG-0700-4.1.1

3.2.2.1.3 Setpoint Determination and Nuisance Notification Avoidance

ES-0304-1381-10644

Guideline: The determination of notification setpoints should consider the trade-off between the timely alerting of an operator to off-normal conditions and the creation of nuisance notifications caused by establishing setpoints so close to the "normal" operating values that occasional excursions of no real consequence are to be expected.

HSI Design Criteria

When determining setpoints, consideration should be given to the performance of the overall human-machine system (i.e., operator and notifications acting together to detect process disturbances).

Processing techniques (see Guideline ES-0304-1381-10653) are applied to prevent normal variation from producing alarms.

Alarms and setpoints should be designed so that only parameters and conditions that fall outside of the normal and expected range and that require operator attention or action are in the alarm state.

Reference: NUREG-0700-4.1.1

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3.2.2.2 Alarm Processing

3.2.2.2.1 Assured Functionality Under High Alarm Conditions

ES-0304-1381-10648

Guideline: Notification processing should be provided to ensure that alarm functional criteria are not lost under any operational or accident conditions. The alarm system should provide the capability to reduce the number of concurrent alarm messages so that during off-normal conditions, the alarm system does not overload of the operator's cognitive processes. Special attention should be given to the problem of detecting subsequent malfunctions following the presentation of alarms related to an initial disturbance.

HSI Design Criteria

The NuScale HSI will ensure that notifications that require immediate action or indicate a threat to plant critical safety functions are presented in a manner that supports rapid detection and understanding under all notification loading conditions.

Reference: NUREG-0700-4.1.2

3.2.2.2.2 Alarm Reduction

ES-0304-1381-10650

Guideline: Since there is no specific guidance on the degree of alarm reduction required to support operator performance, the designer should evaluate the system with operators to assess the effectiveness of the alarm reduction process. This assessment should include evaluations that simulate the operation of the alarm system under situations that activate multiple alarm conditions and/or generate increased operator workload. The use of dynamic mockups and prototypes of the alarm system and dynamic control room simulators should be considered when developing these assessments.

HSI Design Criteria

The number of alarm messages presented to the crew during off-normal conditions should be reduced by alarm processing techniques (from a no-processing baseline) to support the crew's ability to detect, understand, and act upon all alarms that are important to the plant condition within the necessary time

Reference: NUREG-0700-4.1.2

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3.2.2.2.3 Alarm Signal Validation

ES-0304-1381-10652

Guideline: Sensor and other input signals should be validated to ensure that spurious alarms are not presented to plant personnel, due to sensor or processing system failure.

HSI Design Criteria

When such failures occur such as a failed sensor, biased or false signals are generated. The use of these signals by the alarm system may result in the presentation of either false or nuisance alarm messages. Such alarm messages are misleading and may interfere with the crew's situation assessment or reduce the crew's confidence in future alarm messages. Signal validation is a set of alarm processing techniques by which signals from redundant or functionally related sensors are compared and analyzed to determine whether a true alarm condition exists. The purpose of these techniques is to prevent the presentation of false alarms to the operator due to malfunctioning plant instrumentation. Hence, signal validation will be included in the plant notifications. .

Reference: NUREG-0700-4.1.2

3.2.2.2.4 Parameter Stability Processing

ES-0304-1381-10654

Guideline: The alarm system should incorporate the capability to apply time filtering, time delay, or deadbanding to the alarm inputs to allow filtering of noise signals and to eliminate unneeded momentary alarms.

Additional Information: Noise from plant instrumentation may result in signals that momentarily exceed the limit for alarm message activation for a plant parameter. Time delay processing prevents this signal from generating a spurious alarm message to the crew. In some cases, applying these techniques may reduce the timeliness of the information provided to operators. When this tradeoff is not acceptable, other processing methods can be used.

HSI Design Criteria

NuScale will employee standard signal conditioning practices to cover this concern.

Reference: NUREG-0700-4.1.2

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3.2.2.2.5 Segregation of Status Indications

ES-0304-1381-10656

Guideline: Status indications, messages that indicate the status of plant systems but are not intended to alert the user to the need to take action, generally should not be presented via the alarm system display because they increase the demands on the users for reading and evaluating alarm system messages.

HSI Design Criteria

Status information is important to operators; status indications are not alarms and shall be presented to operators via the standard HSI system displays.

Reference: NUREG-0700-4.1.2

3.2.2.2.6 First-Out Processing

ES-0304-1381-10658

Guideline: As an aid to diagnostic procedures and root cause analysis, provision should be made for identifying the initiating event associated with automatic plant trips through the use of first-out alarms.

Additional Information: In most conventional alarm systems used in nuclear power plants, first-out alarms, which identified the parameter within an interrelated group that first exceeded its setpoint, were provided to support operators in determining the initiating cause of a reactor or turbine trip. Advanced alarm systems should include this first-out capability along with the results of any additional processing that could improve the identification of the initiating event. First-out alarms work well where all signals respond equally quickly (e.g. electrical 'sequence of events' monitoring), but are not necessarily as useful to operators where response characteristics can be time-variable. This situation arises in process systems because of differential lags in some measurements (e.g., temperature, level) compared to others (e.g., pressure, electrical parameters).

HSI Design Criteria

The HSI will display the alarms warnings and notifications in a sequential order via a single touch, in addition plant personnel will have the ability to filter notification information in anyway useful to their needs.

Reference: NUREG-0700-4.1.2

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3.2.2.2.7 Mode Dependence Processing

ES-0304-1381-10660

Guideline: If a component's status or parameter value represents a fault in some plant modes and not others, it should be alarmed only in the appropriate modes.

Additional Information: The following is an example of mode dependent processing. The fact that a particular pump has shutdown may only have operational significance to the crew when the plant is operating in the power range. Mode dependent processing would allow this alarm message to be presented when the plant is in the power range but not when it is in other modes (e.g., hot standby). Strategies have also been described in which different alarm setpoints are in effect for some parameters depending on plant mode. When there may be mode-dependent changes in the alarm system's responses the cautions contained in this guideline should be considered.

HSI Design Criteria

The plant notifications will have automatic acknowledgment of casual alarms based on plant conditions to avoid needlessly notifying plant personnel of predictable alarms based on plant behaviors.

Reference: NUREG-0700-4.1.2

3.2.2.2.8 System Configuration Processing

ES-0304-1381-10662

Guideline: If a component's status or parameter value represents a fault in some system configurations and not others, it should be alarmed only in the appropriate configurations.

Additional Information: The following is an example of system configuration processing. The fact that a particular pump has a low discharge pressure may indicate that the pump is not running or it might only indicate a fault when the associated fluid system is configured to perform a particular function. Other discharge pressures may be appropriate when the fluid system is configured to perform a different function. In addition, a low pump discharge pressure may not be relevant when the fluid system is taken out of service. System configuration processing would allow the alarm message for pump discharge pressure to be presented when the fluid system is in the proper configuration and prevent its presentation when the system is in an alternate configuration.

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HSI Design Criteria

The plant notification suppression schema will allow the notifications to be presented when the proper configuration or plant condition is present and prevent its presentation when the system is in an alternate configuration.

Reference: NUREG-0700-4.1.2

3.2.2.2.9 Logical Consequences Processing

ES-0304-1381-10664

Guideline: If a single event invariably leads to subsequent alarmed events that are the direct consequence of this event, only the alarm message associated with the main event may be presented and the other alarm messages suppressed, so long as this does not interfere with the use of alarm information.

HSI Design Criteria

Logical consequences will be used to suppress notifications that follow as a logical consequence of trip or isolation conditions. When implementing logical consequences processing, the plant notification schema will ensure that messages associated with the "consequence" alarm conditions are not needed for other operational tasks, and that operators are aware that the associated "consequence" alarm conditions were generated but not presented.

Reference: NUREG-0700-4.1.2

3.2.2.2.10 Exceptions to Expected Alarm Patterns

ES-0304-1381-10666

Guideline: The system should notify the user when 'unexpected' alarms occur, if the alarm processing logic can support such an analysis.

Additional Information: A related feature that may also be considered is to annunciate the absence of expected alarm patterns; i.e., the system can notify the operator when 'expected' alarms do not occur, if the alarm processing logic can support such an analysis.

HSI Design Criteria

Analyses may apply, for example, during certain transients (e.g., reactor scram) where the expected alarm pattern is well known.

Reference: NUREG-0700-4.1.2

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3.2.2.2.11 Intelligibility of Processed Alarm Information

ES-0304-1381-10668

Guideline: The alarm system should provide functions that enable users to evaluate the meaning or validity of the alarm messages resulting from alarm processing; for example, it should be possible to view the inputs to the alarm processing system.

HSI Design Criteria

Complexity of the processing impacts the operator's ability, as the system supervisor, to understand the results of alarm processing and its constraints and limitations. Since the alarm system is the operator's first indication of process disturbances and operators will confirm the validity of alarm signals prior to taking action, it is essential that operators easily comprehend the meaning of alarm data, how they are processed, and the bounds and limitations of the system. An alarm system that combines multiple processing methods should not be so complex that it cannot be readily understood and interpreted by the operators who must rely on the system's outputs. If operators are unaware of the relationships among displayed alarms and how those relationships might depend on the processing being applied, they may draw incorrect conclusions about the state of the system or the reliability of the alarms. For example, operators may need to view sensor data and values that result from alarm system processing under certain circumstances, such as if the pattern of alarm messages appears to be contradictory, or if operators suspect that there is a problem with the processing system such that the results of alarm processing are incorrect.

Reference: NUREG-0700-4.1.2

3.2.2.3 Alarm Prioritization

3.2.2.3.1 Prioritization Criteria

ES-0304-1381-10670

Guideline: Alarm messages should be presented in prioritized form to indicate urgency (immediacy of required action) and challenges to plant safety.

Additional Information: Additional alarm priority dimensions, such as challenges to plant productivity or investment protection, may also be implemented.

HSI Design Criteria

The selected prioritization scheme should be logical such that those alarms of the highest safety significance receive the highest priority and such that the prioritization appears reasonable to operators.

Reference: NUREG-0700-4.1.3

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3.2.2.3.2 Access to Suppressed Alarms

ES-0304-1381-10672

Guideline: When alarm suppression is used, the user should be able to access the alarm information that is not displayed.

HSI Design Criteria

Suppressed alarms are not presented to the operators, but they can be accessed by operators upon request. The method for accessing suppressed alarms and the scheme for their presentation to the operators should not be excessively complex.

Reference: NUREG-0700-4.1.3

3.2.2.3.3 Filtered Alarms

ES-0304-1381-10674

Guideline: Alarm filtering should only be employed where alarm messages have no current operational significance to the crew's monitoring, diagnosis, decision making, procedure execution, and alarm response activities.

HSI Design Criteria

As the term is used here, filtered (as contrasted with suppressed) alarm messages are eliminated and are not available to the operators. Research has indicated that operators prefer to have information available to them to support verification and decision-making activities. Thus, only alarms that can be demonstrated to have no operational significance to operators should be filtered. This includes alarm messages that are irrelevant within the context of the current plant mode or the configuration of the associated plant system. For example, alarm messages that indicate that a pump discharge pressure is low after the fluid system has been removed from service should be filtered. Alarms that are considered redundant or lower priority should be suppressed (where operators can retrieve them) rather than filtered.

Reference: NUREG-0700-4.1.3

3.2.2.4 Alarm Display

3.2.2.4.1 Display Functions

ES-0304-1381-10676

Guideline: The alarm display should support the user's ability to rapidly discern:

- Priority (e.g., urgency for action and importance to plant safety);

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- Distinct alarm states: new, acknowledged, and cleared;
- The first-out alarms for reactor trip;
- The need to access other displays to verify or clarify the alarm state; and
- The difference between alarms which can be cleared through ongoing corrective actions (i.e., by operations personnel) and alarms that require significant maintenance intervention.

HSI Design Criteria

Multiple alarm display formats, such as dedicated tile-like display and message lists, may be necessary to satisfy all alarm information needs.

Reference: NUREG-0700-4.2.1

3.2.2.4.2 Coordination of Alarm Alerting and Informing Functions

ES-0304-1381-10678

Guideline: When alarm alerts are displayed separately from detailed alarm information, the design should support rapid transitions between alerts and detailed information.

HSI Design Criteria

In conventional annunciator tile-based alarm systems, the annunciator tile performs both the alerting function (i.e., providing a salient indication of the presence of an alarm condition) and the informing function (i.e., providing information that describes the nature of the alarm condition). In advanced alarm systems, the alerting and informing functions may be separated. For example, an alarm tile display may alert the operator to the presence of an alarm condition while an alarm message list display may provide detailed information such as the alarm parameter name and setpoint value. The presentation of the alerting and informing information should be coordinated so the operator can rapidly access detailed alarm information associated with the alarm condition alerts.

Reference: NUREG-0700-4.2.1

3.2.2.4.3 Presentation of Alarm Priority with Detailed Alarm Information

ES-0304-1381-10680

Guideline: When alarm alerts are displayed separately from detailed alarm information, the detailed alarm information display should provide an indication of the priority and status of the alarm condition.

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HSI Design Criteria

The operational significance of the detailed alarm information, such as the parameter name and the exceeded setpoint value, may be more readily apparent to the operator when accompanied by an indication of alarm's priority and its status (e.g., whether it is acknowledged or unacknowledged).

Reference: NUREG-0700-4.2.1

3.2.2.4.4 Use of Spatially Dedicated, Continuously Visible Displays

ES-0304-1381-10682

Requirement: Spatially dedicated, continuously visible (SDCV) alarm displays should be considered for:

- Regulatory Guide 1.97 Category 1 parameters,
- Alarms that require short-term response,
- The most important alarms used in diagnosing and responding to plant upsets, and
- The most important alarms used to maintain an overview of plant and system status.

Additional Information: Spatial dedication means that the alarm messages always appear in the same position. Continuously visible means a parallel presentation method is used, i.e., the alarm information is always available to the operator, as opposed to serial presentation methods in which the operator must select the information to be seen. A SDCV alarm display (such as is provided by conventional tiles) generally has been found during high-density alarm conditions to be superior to other forms of alarm presentation, such as message lists.

HSI Design Criteria

The HSI will incorporate a SDCV display technique that will provide the perceptual advantages of rapid detection and enhanced pattern recognition.

Reference: NUREG-0700-4.2.1

3.2.2.4.5 Alarm Coding Consistency

ES-0304-1381-10684

Guideline: Coding (e.g., flash-rate, intensity, and color coding) conventions should be consistently applied throughout alarm displays (e.g., on tiles and on VDUs).

HSI Design Criteria

Flashing usage will be used in the plant notification schema as discussed in Appendix E.

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Reference: NUREG-0700-4.2.1

3.2.2.4.6 Multi-Unit Alarms

ES-0304-1381-10686

Guideline: Alarms for any shared systems in multiple-unit plants should be duplicated in all locations they are displayed.

HSI Design Criteria

The status of any notification will be provides at all locations where the NuScale HSI is provided as discussed in Appendix E.

Reference: NUREG-0700-4.2.1

3.2.2.4.7 Precedence for Important Information

ES-0304-1381-10688

Guideline: Alarms that have higher importance or greater safety significance should be given greater priority in their presentation than less important or significant alarms.

HSI Design Criteria

The priority of presentation should be part of an overall process for notification management, which may include coding for the level of importance or priority, and alarm processing, filtering, and suppression.

Reference: NUREG-0700-4.2.2

3.2.2.4.8 Simultaneous Display of High-Priority Alarms

ES-0304-1381-10690

Guideline: For non-spatially dedicated alarm presentations such as VDU message lists, sufficient display area should be provided for the simultaneous viewing of all high-priority alarms.

HSI Design Criteria

Non-spatially dedicated alarm displays, such as message lists, should generally not be used as the primary method of presenting high-priority alarm messages. If non-spatially dedicated alarm displays are used, they should have sufficient display space available for simultaneous presentation of all high-priority alarms under the worst credible conditions. Operators should never have to page or scroll a display to view high-priority alarms.

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Reference: NUREG-0700-4.2.2

3.2.2.4.9 Coding of Alarm Priority

ES-0304-1381-10692

Guideline: A method of coding the visual signals for priority should be employed.

An alarm message should indicate its priority.

HSI Design Criteria

Acceptable methods for priority coding include color, position, shape, and special symbols. Color and position (top to bottom) are especially effective visual coding methods.

Reference: NUREG-0700-4.2.2, NUREG-0700-4.2.5

3.2.2.4.10 Indication of Alarm Status

ES-0304-1381-10694

Guideline: Unacknowledged, acknowledged, and cleared notification states should have unique presentations to support the users' ability to rapidly distinguish them.

HSI Design Criteria

The NuScale HSI will provide clear presentation of notification status as discussed in Appendix E.

Reference: NUREG-0700-4.2.3

3.2.2.4.11 Unacknowledged Alarm Indication

ES-0304-1381-10696

Guideline: Unacknowledged alarms should be indicated both by visual (e.g., flashing) and audible means.

HSI Design Criteria

The NuScale HSI will provide clear presentation of notification status as discussed in Appendix E.

Reference: NUREG-0700-4.2.3

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3.2.2.4.12 Notice of Undisplayed Unacknowledged Alarms

ES-0304-1381-10698

Guideline: If the user is not currently viewing the VDU display where unacknowledged alarm messages appear, the alarm system should notify the user that an alarm message is available, the priority of the alarm message, and the location where the alarm message can be found.

HSI Design Criteria

The NuScale HSI will provide clear presentation of notification status as discussed in Appendix E.

Reference: NUREG-0700-4.2.3

3.2.2.4.13 Acknowledged Alarm Indication

ES-0304-1381-10700

Guideline: After the user has acknowledged an alarm (e.g., pressed the acknowledge button), the alarm display should change to a visually distinct acknowledged state.

HSI Design Criteria

The NuScale HSI will provide clear presentation of notification status as discussed in Appendix E.

Reference: NUREG-0700-4.2.3

3.2.2.4.14 Clearing Alarm Ringback

ES-0304-1381-10702

Guideline: When an alarm clears (i.e., the parameter returns to the normal range from an abnormal range), the return to normal conditions should be indicated by visual and audible means.

Additional Information: Ringback, alerting the operator when a parameter returns to normal, should not be required for all alarms but should be required when it is important that the operator know immediately when the deviation has cleared, or when the deviation is not expected to clear for some time. Such cleared alarms should provide a positive indication by initiating audible and visual signals. Techniques that may be employed include: a special flash rate (one-half the normal flash rate is preferred, to allow discrimination); reduced brightness; or a special color. Cleared alarms should have a dedicated, distinctive audible signal, which should be of finite and relatively short duration.

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HSI Design Criteria

The NuScale HSI will provide clear presentation of notification status as discussed in Appendix E.

Reference: NUREG-0700-4.2.3

3.2.2.4.15 Cleared Alarms That Re-Enter the Abnormal Range

ES-0304-1381-10704

Guideline: If an alarm has cleared but was not reset and the variable re-enters the abnormal range, then the condition should be presented as a new alarm.

Additional Information: When an alarm clears, the operator is informed via the ringback feature that the value is now in its normal range. Since the operator might expect the parameter to remain in the normal range, the alarm system should alert the operator when the parameter deviates from the normal range. If the variable again enters the abnormal range, the alarm system should behave as it does for new alarms, by producing visual and auditory signals to alert the operator. For cases in which a variable might move (e.g., oscillate) in and out of the normal range, alarm processing should be used to prevent the frequent reoccurrence of the alarm from becoming distracting to the operator. One technique might be to require the parameter to move further into the normal range before the alarm clears. Another technique might be to require the parameter to remain within the normal range for a particular amount of time before allowing the alarm to clear.

HSI Design Criteria

The NuScale HSI will provide clear presentation of notification status as discussed in Appendix E.

Reference: NUREG-0700-4.2.3

3.2.2.4.16 Minimize Shared Alarms

ES-0304-1381-10706

Guideline: Alarms that are triggered by any one of an aggregate of individual alarms (e.g., 'Pump Trouble') and which require the operators to perform additional actions to determine the cause should be limited.

Additional Information: This guideline does not apply to the use of alarm processing through which individual alarms are logically processed to provide more operationally meaningful, higher-level alarm messages. By contrast, shared alarms are defined by the activation of one or more of a set of different process deviations. For example, a "trouble" message may combine several potential problems associated with a single

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plant system or component, or it may address the same problem for a group of similar components (e.g., a bearing temperature alarm may address bearings from more than one component). When shared alarms are used, an inquiry capability should be provided to allow the operator to obtain specific information about which of the ganged parameters exceeded its setpoint. In traditional (i.e., tile-based annunciator) alarm systems, shared alarms imposed additional workload on the operator compared to single alarms because the operator had to identify the deviant parameter(s). This type of shared alarm should be minimized in advanced alarm systems. Some advanced alarm systems automatically present information related to the deviant parameter when the shared alarm is initiated. This reduces the operator workload associated with retrieving alarm information and minimizes the negative effects of shared alarms.

HSI Design Criteria

The NuScale HSI will provide clear presentation of notification status as discussed in Appendix E.

Reference: NUREG-0700-4.2.4

Table 3-7. Shared alarm considerations (Reference 1.5.1)

TYPES OF ALARMS THAT MAY BE CONSIDERED FOR COMBINATION
(SUBJECT TO THE RESTRICTIONS LISTED BELOW)

- Alarms for the same condition on redundant components, or logic trains, when each has a separate indicator and the indicators are placed in close proximity on the console (e.g., pump A or B trip, logic train A or B actuation)
- Alarms for several conditions relating to one component or several redundant components, which require the operator to obtain further diagnostic information either by sending an auxiliary operator out to the component(s) or checking the computer (e.g., pump A or B trouble)
- Alarms for several conditions that call for the same corrective action
- Alarms that summarize single-input alarms elsewhere in the control room

CONDITIONS UNDER WHICH ALARMS SHOULD NOT BE COMBINED

- Different actions are to be taken depending on which alarm condition exists and information is not readily available to the operator to identify which constituent is alarming
- Information or protection for other alarm constituents is not available to the operator after any one alarm constituent has activated the combined alarm (reflash can provide such protection as discussed in Guideline 4.2.4-3)
- The constituent conditions are not of the same importance

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3.2.2.4.17 Access to Roll-Up Alarm Information

ES-0304-1381-10711

Guideline: The system should allow users to access the individual alarm information when a shared alarm activates.

Additional Information: The information could be provided by means of alarm messages on a VDU, an alarm list on an alarm printer, or by other means. This information may be provided automatically or by operator action.

HSI Design Criteria

The NuScale HSI will provide clear messaging of notifications as discussed in Appendix E.

Reference: NUREG-0700-4.2.4

3.2.2.4.18 Roll-Up Alarm Reflash

ES-0304-1381-10713

Guideline: If a new parameter deviation has occurred before a preceding alarm has cleared, the Roll-Up alarm should return to the new alarm state (e.g., flashing).

Additional Information: The alarm logic system should provide the capability to "reflash" (i.e., reactivate the visual and audible alert indications for the alarm) when subsequent alarm conditions occur after the initial alarm condition has been acknowledged.

HSI Design Criteria

The NuScale HSI will provide clear presentation of notification status as discussed in Appendix E.

Reference: NUREG-0700-4.2.4

3.2.2.5 Alarm Content

3.2.2.5.1 Alarm Titles/Legends

ES-0304-1381-10715

Guideline: Titles/legends should be clearly understandable, use standard terminology, and address conditions specifically.

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HSI Design Criteria

The NuScale plant notification schema will identify the parameter and state (e.g., HIGH PRESSURE) instead of using one legend for multiple parameters or multiple states (e.g., TEMPERATURE-PRESSURE or HIGH-LOW).

Reference: NUREG-0700-4.2.5

3.2.2.5.2 Alarm Messages – SDCV Tile Format

ES-0304-1381-10717

Guideline: The format of messages on alarm tiles or tile-like displays should be consistent for all alarms.

Additional Information: Information on a tile might be organized as follows: top line, name of alarmed parameter; middle line, alarm setpoint value; bottom line, indication of severity.

HSI Design Criteria

The NuScale HSI will provide clear presentation of notification messaging as discussed in Appendix E.

Reference: NUREG-0700-4.2.5

3.2.2.5.3 Alarm Messages – List or Printer Format

ES-0304-1381-10719

Guideline: The format of printed alarm lists should be consistent with that of VDU and SDCV displays.

HSI Design Criteria

The NuScale HSI will provide clear formatting of notifications as discussed in Appendix E.

Reference: NUREG-0700-4.2.5

3.2.2.5.4 Alarm Source

ES-0304-1381-10721

Guideline: The content of each message should provide information that identifies the alarm source.

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HSI Design Criteria

Information will be available as to which specific sensor (or group of sensors) supplied the alarm signal.

Reference: NUREG-0700-4.2.5

3.2.2.5.5 Setpoint Values

ES-0304-1381-10725

Guideline: If an alarm condition requires verification before action is taken, the relevant setpoint limits should be included in the alarm message when alarm information is presented on a VDU or is printed.

HSI Design Criteria

The NuScale HSI will provide all relevant information of notifications as discussed in Appendix E.

Reference: NUREG-0700-4.2.5

3.2.2.5.6 Parameter Values

ES-0304-1381-10727

Guideline: Deviant parameter values should be included in the alarm message when alarm information is presented on VDU or printer displays.

HSI Design Criteria

The NuScale HSI will provide all relevant information of notifications as discussed in Appendix E.

Reference: NUREG-0700-4.2.5

3.2.2.5.7 Required Immediate Actions

ES-0304-1381-10729

Guideline: Immediate actions should be presented or made available directly upon request when alarm information is presented on VDU or printer displays.

HSI Design Criteria

To support the general alarm system function of guiding the operator's response to an alarm, the immediate actions will be provided to the operator.

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Reference: NUREG-0700-4.2.5

3.2.2.5.8 Reference to Procedures

ES-0304-1381-10731

Guideline: When alarm information is presented on VDU or printer displays, references to alarm response procedures should be provided.

HSI Design Criteria

The document title, major section, and page number will be included in NuScale notifications.

Reference: NUREG-0700-4.2.5

3.2.2.5.9 Reference to Other Panels

ES-0304-1381-10733

Guideline: Alarms which refer the user to another, more detailed display located outside the main operating area should be minimized.

HSI Design Criteria

Plant notifications will be designed such that required information is readily accessible from within the main operating area.

Reference: NUREG-0700-4.2.5

3.2.2.6 Coding

3.2.2.6.1 Coding Effectiveness

ES-0304-1381-10735

Guideline: The coding scheme used by the alarm system should assure rapid detection and interpretation by the users under all control room operating conditions.

HSI Design Criteria

NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.1

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3.2.2.6.2 Coding Dimension Discriminability

ES-0304-1381-10737

Guideline: Each level of a coding dimension should be easily and readily distinguishable from the other levels.

Additional Information: For example, if color is used, the different colors should be easily discriminated. Each color should have a single, precise meaning that is consistent with applicable population stereotypes. A formal coding scheme that encompasses all coding methods (e.g., color, shape, brightness, textures/pattern, and flash rates) and specifies a hierarchical order should be established and formally documented. Alarms should be organized into categories according to priority. Coding should be systematically applied such that alarm information with the highest priority is also most prominent.

HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.1

3.2.2.6.3 Single Coding Dimensions

ES-0304-1381-10739

Guideline: Each technique used to code alarms should represent only one dimension of the alarm classification.

Additional Information: If flash rate is being used to indicate alarm state (e.g., unacknowledged, acknowledged, or cleared), it should not also be used to indicate need for user action (e.g., immediate action required, action required within 15 minutes, or no near- term action needed).

HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.1

3.2.2.6.4 Coding Complexity

ES-0304-1381-10741

Guideline: The number of different coding techniques should be kept to a minimum, so that the coding system does not become too difficult to use or understand.

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HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.1

3.2.2.6.5 Visual Coding for Importance

ES-0304-1381-10743

Guideline: A visual coding method should be used to indicate alarm importance and should be consistently applied throughout the alarm system.

Additional Information: To be effective, an alarm system should attract attention and help the operator focus attention on more-important rather than less-important alarms. A flashing visual signal is a preferred means for directing attention and indicating alarm status (e.g., unacknowledged, acknowledged, and cleared-not reset) on SDCV and computer-based displays.

HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.2

3.2.2.6.6 Redundant Priority Coding

ES-0304-1381-10745

Guideline: Redundant codes (e.g., color and location) should be used for alarms that require rapid action.

HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.2

3.2.2.6.7 Flash Rate

ES-0304-1381-10747

Guideline: Flash rates should be from three to five flashes per second with approximately equal on and off times.

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HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.2

3.2.2.6.8 Brightness Levels for Transilluminated Displays

ES-0304-1381-10749

Guideline: For transilluminated displays, such as lighted alarm tiles, the luminance of the dim state (if used) should be at least 10 percent greater than the inactivated state; the brightest state should not be more than 300 percent of the surrounding luminance.

HSI Design Criteria

Transilluminated displays should have no more than three levels. Brightness of 'on' alarms should not be annoying or distracting.

Reference: NUREG-0700-4.2.6.2

3.2.2.6.9 Brightness Levels for VDU Displays

ES-0304-1381-10751

Guideline: For VDU displays, the bright state should be at least 100 percent brighter than the normal state.

HSI Design Criteria

VDU displays should be limited to only two levels.

Reference: NUREG-0700-4.2.6.2

3.2.2.6.10 Color Detectability

ES-0304-1381-10753

Guideline: Low-intensity indications (e.g., dark red) in the periphery of the visual field should be avoided where color coding is used, since they may not be readily detected.

HSI Design Criteria

If the display system has an area that is a specific focus of attention, then displays located in adjacent areas may be frequently in the periphery of the operator's field of vision.

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Reference: NUREG-0700-4.2.6.2

3.2.2.6.11 Spatial Coding

ES-0304-1381-10755

Requirement: Spatial coding may be used to indicate alarm importance.

HSI Design Criteria

Appendix E, will cover the coding of the alarm signals as well as their use.

Reference: NUREG-0700-4.2.6.2

3.2.2.6.12 Suppressed Visual Codes

ES-0304-1381-10757

Guideline: If the visual codes indicating alarm status are automatically suppressed or delayed during high alarm volume conditions or the presence of more important alarms, they should be automatically presented after the more important alarms have been addressed.

HSI Design Criteria

Under high alarm volume conditions the HSI may suppress or delay the alerting indications (e.g., visual flashing) for those alarm conditions that: (1) do not require immediate response, and (2) do not indicate a challenge to plant safety and technical specifications. This will assist operators in detecting the more significant alarm messages and reduce distraction from less important ones. Plant personnel should not be required to remember to request alarms that have been automatically suppressed.

Reference: NUREG-0700-4.2.6.2

3.2.2.6.13 Audio Signals for Alarms

ES-0304-1381-10759

Guideline: An auditory signal should be used to alert the user to the existence of a new alarm, or any other condition of which the user must be made immediately aware.

HSI Design Criteria

Auditory cues should be provided for all new alarms under normal operating conditions. However, under off-normal conditions where high alarm density exists, the HSI should consider suppressing the auditory signal for those alarmed conditions that: (1) do not require immediate response, and (2) do not indicate a challenge to plant safety and

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technical specifications. For example, audio signals associated with clearing alarms might be omitted under certain circumstances. This will prevent operators from being distracted by less important alarms while attending to more significant ones. Some designs may have a timed audible signal rather than one that is continuous until acknowledged. In this case, see the guideline for reminder audible signals, below.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.14 Auditory Coding of Remote Alarms

ES-0304-1381-10761

Guideline: Auditory coding techniques should be used when the workstation associated with the alarm is not in the main operating area.

HSI Design Criteria

During off-normal conditions, the HSI should consider the suppression of the auditory code for those alarms that: (1) do not require immediate response, and (2) do not indicate a challenge to plant safety and technical specifications. This will prevent operators from being distracted by less important alarms while attending to more significant ones.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.15 Distinguishable Auditory Signals

ES-0304-1381-10763

Guideline: The auditory signal associated with a SDCV alarm should be easily distinguishable from the auditory signal associated with an alarm message displayed by other means (e.g., on a VDU message display).

HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.16 Audible Signals for Alarm States

ES-0304-1381-10765

Guideline: The tones used for incoming alarms should be separate and distinct from tones used to signify "clearing" alarms.

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HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.17 Reminder Audible Signals

ES-0304-1381-10767

Guideline: If the tone associated with an unacknowledged alarm automatically turns off after an interval of time, a reminder tone should be presented to alert the user to the continued presence of an unacknowledged alarm.

Additional Information: The same principle holds for alarms that may have had the auditory code suppressed because of high alarm conditions or the presence of more important alarms. When the more important alarms have been addressed, the alarm system should remind the operator, via visual or auditory signals, of the presence of the unacknowledged alarms.

HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.18 Reset of Auditory Alert

ES-0304-1381-10769

Guideline: The auditory alert mechanism should automatically reset when it has been silenced.

HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.19 Interference Among Signals

ES-0304-1381-10771

Guideline: Audio alarm signals should not conflict with other auditory codes or signals.

Additional Information: If continuous, relatively loud signals are used, they may render other codes and signals less audible. Thus, it may be necessary to consider the

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audibility of a signal not just in the presence of ambient control room noise, but also in combination with other signals that might plausibly occur at the same time. To avoid mutual masking, the frequencies of tonal signals associated with alarms that may be active at the same time should be separated by at least 20 percent of the center frequency. Interference among alarm signals is less of a concern if the signals consist of a number of widely separated frequency components or of brief groups of pulses presented at intervals. Techniques are available that allow the audibility of signals in noise to be predicted.

HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.20 Readily Identifiable Source

ES-0304-1381-10773

Guideline: The user should be able to quickly determine where to direct attention (e.g., which functional area of the plant or which station) from the characteristics of the auditory alert and/or the source from which the auditory alert originated.

Additional Information: This guideline pertains to the use of auditory tones to direct the operator to the location of a spatially fixed alarm display device in order to expedite the operator's response to the alarm condition. The use of sound to indicate the location of the alarm display may be of less value if the advanced alarm system allows the same alarm message to be retrieved from multiple locations (e.g., from redundant VDUs) in the control room. It should also be noted that in advanced control rooms that feature compact control consoles, the alarm display devices may not be physically separated enough to use sound localization as a cue. In this case, coded audio signals (possibly from a single source) would be used to direct the operators' attention. Thus, this guideline is most appropriate for advanced alarm systems that feature spatially fixed alarm display devices. It has been recommended that coded signals from a single audio source should not be used to identify individual workstations within the main operating area, and that each major console should be equipped with a separate sound generator capable of producing a distinctive sound. If the direction of a source sound is to be used as a cue, the signal should not be a high- frequency pure tone, since such signals can be difficult to localize.

HSI Design Criteria

The NuScale HSI will provide a useful notification schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.3

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3.2.2.6.21 Signal Level

ES-0304-1381-10775

Guideline: The signal intensity should be such that users can reliably discern the signal above the ambient control room noise.

HSI Design Criteria

The intensity of an audio signal should be such that users are alerted aurally to an alarm occurrence under the most adverse anticipated background noise conditions. A signal level 10 dB(A) above average ambient noise is generally considered adequate. It has also been recommended that sound intensity should be limited to a maximum of 95 dB(A), but that signal levels of 115 dB(A) may be used if considered absolutely necessary to achieve required attention-getting reliability for alarms indicating extreme danger.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.22 Design of Audio Signals

ES-0304-1381-10777

Guideline: Audio signals should be designed to minimize irritation and startle.

HSI Design Criteria

Signals should reliably capture the user's attention but should not be unpleasant. Considerations include the selection of signal frequency and intensity, and the overall design of the audible alarm scheme.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.23 Manual Disable/Adjustment of Signal Intensity

ES-0304-1381-10779

Guideline: Manual disable or adjustment of auditory signal intensity (loudness) should be avoided.

HSI Design Criteria

The need to adjust auditory signal level can be alleviated by improved signal design and level selection. If signal level is adjustable, it should be controlled by administrative procedure. Under no circumstances should users be able to disable audio alarm signals or reduce their level so as to render them inaudible.

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Reference: NUREG-0700-4.2.6.3

3.2.2.6.24 Sound Sources

ES-0304-1381-10781

Guideline: The number and placement of loudspeakers should be such that auditory signals are free of distortion and are equally audible at any workstation in the control room.

HSI Design Criteria

Speakers should be oriented away from surfaces that could scatter or diffuse the acoustic wave. Speakers should not be located behind structures that could cause distortion, echoes, or sound shadows. When sound localization is used to direct the operator to particular alarm display devices, the loudspeakers should be oriented such that their location can be quickly discerned and corresponds to the location of the intended alarm display device. Loudspeakers for adjacent alarm display devices should have adequate separation to allow their individual locations to be discerned.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.25 Auditory Signal Discriminability

ES-0304-1381-10783

Guideline: Each audio signal should be unambiguous and easily distinguishable from every other tone in the control room.

HSI Design Criteria

Current sound generation technology allows the design of alarm signals that make better use of the operator's ability to process audio information. It is possible to design signals that are not only more discriminable from one another than are conventional signals, but also have the potential to carry more information. Signals should be composed of unique combinations of tone pattern and frequency.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.26 Number of Tonal Signals

ES-0304-1381-10785

Guideline: When information is coded by the pitch of narrow-band signals (i.e., tones), no more than three frequencies should be used.

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HSI Design Criteria

The frequencies should not be in a ratio of 2:1 with one another, since it can be difficult to identify pitches an octave apart. Although some sources recommend that no more than five separate frequencies should be used, operators may not reliably distinguish among more than three pitch codes. For critical alarms with differing response requirements, the more conservative guidance should be followed. If more than three critical alarms are to be coded, it is preferable to combine pitch with another dimension to create more distinctive signals.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.27 Frequency of Tonal Signals

ES-0304-1381-10787

Guideline: Center frequencies should be widely spaced within a range of from 500 to 3,000 Hz, although a wider range of from 200 to 5,000 Hz may be acceptable.

HSI Design Criteria

NuScale notification tonal signals will provide broad band and widely spaced tonal signals within the 200 to 5000 Hz range.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.28 Pulse Codes

ES-0304-1381-10789

Guideline: No more than three pulse repetition rates should be used for coding purposes.

HSI Design Criteria

Repetition rates should be between 1 and 8 pulses per second, since faster rates may not be perceived as pulses. Repetition rates should be sufficiently separated (e.g., differ by a factor of 2) to ensure operator discrimination. Sounds with the same temporal pattern, including signals with similar duty cycles (on-off times), may be confused, despite having very different pulse speeds (i.e., periods). Such signals are therefore more appropriate for coding the level of urgency of a condition than for indicating different types of conditions.

Reference: NUREG-0700-4.2.6.3

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3.2.2.6.29 Number of Frequency Modulated Signals

ES-0304-1381-10791

Guideline: No more than three modulated frequency codes for audible alarms should be used.

HSI Design Criteria

Warbling sounds, with frequencies modulating from 1 to 3 times per second, are attention-getting as well as easily recognized, whereas slower modulation rates do not develop distinguishable characteristics rapidly enough to be appropriate for alerting applications.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.30 Center Frequency of Frequency Modulated Signals

ES-0304-1381-10793

Guideline: If modulation of frequency (Hz) of a signal is used to denote information, the center frequencies should be between 500 and 1000 Hz.

HSI Design Criteria

The NuScale HSI will provide a useful notification signal schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.31 Audio Pattern Codes

ES-0304-1381-10795

Guideline: If sequences of tones are used to represent information, the patterns should be easily recognizable.

HSI Design Criteria

Warning sounds consisting of "bursts" composed of five or more brief pulses (about 0.1 second in duration) with inter-pulse intervals of 0.15 to 0.3 seconds have been recommended. The pulses may be designed to be distinctive with respect to their onset and offset shaping, fundamental frequency, and harmonic structure. The bursts may vary as to the number of pulses, the tempo at which they are presented, and the rhythmic and pitch contours.

Reference: NUREG-0700-4.2.6.3

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3.2.2.6.32 Compound Codes

ES-0304-1381-10797

Guideline: A maximum of nine auditory signals should be used when coded in two or more dimensions.

HSI Design Criteria

When signals differ in two or more dimensions (e.g., pitch and temporal pattern), a greater number of signals can be reliably distinguished. This maximum includes auditory signals used outside of the control room (e.g., fire alarm or site emergency alarm).

Reference: NUREG-0700-4.2.6.3

3.2.2.6.33 Intensity Coding

ES-0304-1381-10799

Guideline: Coding of auditory signals by intensity (loudness) should not be used.

HSI Design Criteria

The range of intensities between the level required to ensure audibility and the level at which signals become aversive can be relatively narrow; the usefulness of this dimension for coding is therefore limited. If such coding must be used, no more than two levels should be defined. The signals should differ from each other by a minimum of 6 dB(A). The lower intensity should be about 10 dB(A) above the ambient noise level, and the maximum signal-to-noise ratio should be 10 dB(A) for most applications of sound intensity coding. It is recommended that sound intensity should be limited to a maximum of 95 dB(A), but that signal levels of 115 dB(A) may be used if considered absolutely necessary to achieve required attention-getting reliability for alarms indicating extreme danger. Whether this coding would be effective would depend on the frequency spectrum of the ambient control room noise and the frequency of the signal.

Reference: NUREG-0700-4.2.6.3

3.2.2.6.34 Speech Presentation of Alarm Information

ES-0304-1381-10801

Guideline: Using speech alone for presenting alarm information is not recommended.

HSI Design Criteria

Speech is an acceptable medium for presenting interface-related information and there may be advantages associated with using speech for presenting alarm information as

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well. However, its appropriateness has been questioned for tasks where there is a memory component, there is likely to be some delay before the fault is attended to, there is likely to be more than one alarm presented at a time, and the operator is required to assimilate information from a variety of sources using spatial reference. Therefore, it has not yet been shown that it is an appropriate method for presenting alarm information in process control contexts. Speech should only be used in conjunction with other methods of presenting alarm information.

Reference: NUREG-0700-4.2.6.3

3.2.2.7 Distinctive Coding of Critical Information

ES-0304-1381-7997

Guideline: Distinctive means of coding/highlighting should be used when a user's attention must be directed to changes in the state of the system, critical or off-normal data, and hazardous conditions.

HSI Design Criteria

Significant changes might include discrepant data exceeding acceptable limits or data failing to meet some other defined criteria. 'Highlight' is used here in its general sense, meaning to emphasize or make prominent, and is not restricted to any particular method of display coding such as brightening or inverse video. Highlighting is most effective when used sparingly, adding emphasis to a display that is relatively uniform in appearance except for just a few highlighted items. For some purposes, location coding (i.e., displaying important items consistently in a particular location) might be a sufficient means of highlighting, as when an error message appears in a space otherwise left blank. However, auxiliary codes may still be needed to highlight important items, even if they are positioned consistently. For example, line coding by color or bolding might be used to highlight displayed paths, and/or the boxes or other graphic elements representing displayed states. (Color coding may be particularly appropriate in flowcharts, because of the effective primacy of color for guiding the visual scanning required to trace paths.)

Reference: NUREG-0700-1.1

3.2.2.8 Grouping

3.2.2.8.1 Functional Grouping of Alarms

ES-0304-1381-10803

Guideline: Alarms within a display should be grouped by function, system, or other logical organization.

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HSI Design Criteria

Alarm elements should be grouped so that system functional relationships are readily apparent. For example, area radiation alarms should be grouped on one display not spread throughout the control room. As much as possible, the alarms should be grouped with controls and displays of the same system.

Reference: NUREG-0700-4.2.7.1

3.2.2.8.2 Visual Distinctness of Functional Groups

ES-0304-1381-10805

Guideline: Alarm functional groups should be visually distinct from one another.

HSI Design Criteria

Although the concept of functional grouping is typically applied in the context of spatially dedicated, continuously visible displays, it can be applied to alarm lists as well. Segregating alarm messages by plant system may allow operators to direct their attention more effectively, especially when individual members of a crew are assigned principal responsibility for different plant systems.

Reference: NUREG-0700-4.2.7.1

3.2.2.8.3 Group Labels

ES-0304-1381-10807

Guideline: System/functional groups should be clearly delineated and labeled such that the operating crew can easily determine which systems have alarms that have not yet cleared and which system is affected by a particular incoming alarm.

HSI Design Criteria

The NuScale HSI will provide a useful notification grouping schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.7.1

3.2.2.8.4 Coordinate Designation Identifiers

ES-0304-1381-10809

Guideline: If alarm displays are organized in matrices, the vertical and horizontal axes of the displays should be labeled with alphanumeric labels for ready coordinate designation of a particular visual element.

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HSI Design Criteria

The NuScale HSI will provide a useful notification grouping schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.7.1

3.2.2.8.5 Density of Alarm Elements

ES-0304-1381-10811

Guideline: An alarm tile display matrix should contain a maximum of 50 alarms.

Additional Information: Matrices smaller than 50 alarms are preferred.

HSI Design Criteria

The NuScale HSI will provide a useful notification grouping schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.7.1

3.2.2.8.6 Logical Arrangement of Alarms

ES-0304-1381-10813

Guideline: Alarms should be ordered to depict naturally occurring relationships.

HSI Design Criteria

Naturally occurring relationships (e.g., those derived from the physical process) include the following:

- pressure, flow, level, and temperature alarms in fluid systems;
- alarms for a given thermodynamic parameter at different points within the system that indicate a progression (e.g., within a fluid system, a series of pressure alarms starting with the source tank and ending with the system discharge);
- several alarms for the same variable indicating levels of severity (e.g., tank level low and tank level low-low); and
- alarms related by cause and effect.

For example, pressure, flow, level, and temperature could be arranged left-to-right.

Reference: NUREG-0700-4.2.7.1

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3.2.2.8.7 Consistent Ordering

ES-0304-1381-10815

Guideline: Alarm parameters (e.g., pressure, flow, level, and temperature) arranged in one order on one panel should be arranged in the same order on other panels.

HSI Design Criteria

Circumstances may dictate different orderings for systems with very different functions. However, once an arrangement has been chosen, the arrangement should be used consistently within similar systems or alarm groups.

Reference: NUREG-0700-4.2.7.1

3.2.2.8.8 Alarm Display Identification Label

ES-0304-1381-10817

Guideline: Each group of alarm displays should be identified by a label above the display.

Additional Information: A group of displays could be a panel of tiles or a group of tile-format VDU displays.

HSI Design Criteria

The NuScale HSI will provide a useful notification grouping schema as discussed in Appendix E

Reference: NUREG-0700-4.2.7.1

3.2.2.9 Alarm Message Lists

3.2.2.9.1 Listing by Priority

ES-0304-1381-10820

Guideline: Lists of alarm messages should be segregated by alarm priority with highest priority alarms being listed first.

HSI Design Criteria

The NuScale HSI will provide a useful notification messaging schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.7.2

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3.2.2.9.2 Message Listing Options

ES-0304-1381-10822

Guideline: In addition to priority grouping, users should have the capability to group alarm messages according to operationally relevant categories, such as function, chronological order, and status (unacknowledged, acknowledged/active, cleared).

HSI Design Criteria

It should be possible to list alarm messages in chronological order with the most recent messages placed at the top of the stack (i.e., alarm messages entered in a pushdown stack mode). Grouping alternatives should not interfere with the detection of high-priority alarms. The grouping should be easy to implement.

Reference: NUREG-0700-4.2.7.2

3.2.2.9.3 Blank Lines

ES-0304-1381-10824

Guideline: Alphanumeric alarm lists should have a separation (blank row) between every four or five alphanumeric messages.

HSI Design Criteria

The NuScale HSI will provide a useful notification messaging schema as discussed in Appendix E.

Reference: NUREG-0700-4.2.7.2

3.2.2.9.4 Scrolling of Message List

ES-0304-1381-10826

Guideline: The method of adding alarm messages to the list should preclude message scrolling.

Additional Information: Scrolling makes it difficult to read alarm messages, especially when many alarms are coming in. An alternative method of viewing alarm lists, such as paging, is preferred.

HSI Design Criteria

The NuScale HSI will provide a useful notification messaging schema as discussed in Appendix E.

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Reference: NUREG-0700-4.2.7.2

3.2.2.9.5 Message Overflow

ES-0304-1381-10828

Guideline: Alphanumeric alarm messages that overflow the first page of alarm messages should be kept on subsequent alarm pages.

HSI Design Criteria

Important alarm information should not be truncated solely because the immediate display space is exceeded. In addition, the alarm system should clearly indicate that additional information is available in subsequent pages.

Reference: NUREG-0700-4.2.7.2

3.2.2.10 Acknowledge

3.2.2.10.1 Access to Undisplayed Unacknowledged Alarms

ES-0304-1381-10830

Guideline: A VDU-based alarm system should provide rapid access to any unacknowledged alarm messages that are not shown on the current display.

HSI Design Criteria

When an alarm has been indicated, e.g., by an auditory signal, plant personnel should have rapid access to the alarm information that describes the nature of the alarm condition.

Reference: NUREG-0700-4.3.1

3.2.2.10.2 Global Silence Capability

ES-0304-1381-10832

Guideline: It should be possible to silence an auditory alert signal from any set of alarm system controls in the main operating area.

HSI Design Criteria

A global silence capability together with separate silence and acknowledge capabilities can be useful during high alarm situations. It can allow the operator to silence many distracting alarms and then acknowledge these alarms at their respective panels. It is not necessary that silence capability be provided only where the specific alarm can be

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read, so long as the operator is made aware of all alarms that are being silenced. That is, the operator should not be able to silence alarms that cannot be visually detected from the global silence control. The primary purpose of the auditory signal is to alert the operator to a new alarm. Once alerted, the operator refers to visual indications of the specific alarm and its message. The auditory signal can rapidly become distracting and irritating to the operators. It should be possible to silence an audible cue from either a VDU or a tile panel control station (also see guideline ES-0304-1381-10854).

Reference: NUREG-0700-4.3.2

3.2.2.10.3 Manual Silencing

ES-0304-1381-10834

Guideline: Auditory signals should be silenced manually unless this interferes with other more critical actions.

HSI Design Criteria

While manual silence is a generally desirable feature to get the operator's attention, it may become distracting to manually silence all alarms under high-alarm conditions. NuScale will address alarm system configuration changes made either automatically or by operator-selection, such as automatic silence of auditory alerts for lower priority alarms under high- alarm conditions.

Reference: NUREG-0700-4.3.2

3.2.2.10.4 Effect of Acknowledge Function

ES-0304-1381-10836

Guideline: An alarm acknowledgment function should cause the alarm's visual coding to change from that indicating an unacknowledged alarm to a visually distinct ' not cleared' state.

HSI Design Criteria

The acknowledge function might cause an alarm to change from flashing to steady. (also see Guideline ES-0304-1381-10700).

Reference: NUREG-0700-4.3.3

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3.2.2.10.5 Acknowledgment Locations

ES-0304-1381-10838

Guideline: Acknowledgment should be possible only from locations where the alarm message can be read.

HSI Design Criteria

If alarm information is available at multiple VDUs, then operators should be capable of acknowledging the alarm from the VDU at which they are working. If alarm information is presented on a large control room overview display, operators should be able to acknowledge it from alarm control locations where it can be seen. This flexibility will minimize disruption caused by the alarm system interactions. It should not be possible to acknowledge alarms from locations where they cannot be read. If alarms can be acknowledged from multiple locations, then a means should be provided for ensuring that all operators for whom the alarm is important are aware that the alarm occurred. These means may include spoken, telephone, or computer-based communications between personnel.

Reference: NUREG-0700-4.3.3

3.2.2.10.6 Acknowledgment of Alarm Messages

ES-0304-1381-10840

Guideline: Non-SDCV alarms should only be acknowledged when the alarm message is on the screen.

HSI Design Criteria

Alternatively, the acknowledgment action may display the alarm message.

Reference: NUREG-0700-4.3.3

3.2.2.10.7 Effect of Reset Function

ES-0304-1381-10842

Guideline: The reset function should place an alarm in an unalarmed state after the condition has cleared.

HSI Design Criteria

The reset function should silence any audible signal indicating clearance and should extinguish the light and return the alarm to an inactive state. Note that some alarms may

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have automatic reset, when it is not necessary that the operators specifically know the reset condition.

Reference: NUREG-0700-4.3.4

3.2.2.10.8 Appropriate Use of Manual Reset

ES-0304-1381-10844

Guideline: A manual reset sequence should be used where it is important to explicitly inform users of a cleared condition that had once been deviant.

Additional Information: An automatic reset sequence should not be used in this situation.

HSI Design Criteria

The NuScale HSI will provide a useful notification reset schema as discussed in Appendix E.

Reference: NUREG-0700-4.3.4

3.2.2.10.9 Appropriate Use of Automatic Reset

ES-0304-1381-10846

Guideline: An automatic reset sequence should be available where users have to respond to numerous alarms or where it is essential to quickly reset the system.

HSI Design Criteria

A manual reset sequence should not be used in high-workload situations in which the time and attention required to reset the alarms may detract from other, more-critical tasks.

Reference: NUREG-0700-4.3.4

3.2.2.10.10 Reset Function Location

ES-0304-1381-10848

Guideline: The reset function should be effective only from locations at which plant personnel know which alarm they are resetting.

HSI Design Criteria

The NuScale HSI will provide a useful notification reset schema as discussed in Appendix E.

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Reference: NUREG-0700-4.3.4

3.2.2.11 Configuration

3.2.2.11.1 User-Selectable Alarm System Configuration

ES-0304-1381-10850

Guideline: If the alarm system provides user-selectable operational configurations, then these configuration changes should be coupled with an indication of the present configuration.

HSI Design Criteria

NuScale will allow users to select alternative functional configurations of the alarm system under some alarm situations, such as automatic silence of auditory alerts for lower priority alarms under high-alarm conditions. Another example may be operator selection of an alarm message suppression mode in which low priority messages are not presented via the alarm displays but may be accessed through operator action. It is important that the alarm system informs the operators that a requested change in system configuration has been successfully achieved. In addition, a prominent display of the present configuration should be available.

Reference: NUREG-0700-4.3.5

3.2.2.11.2 Acknowledgment of Alarm System Configuration Changes

ES-0304-1381-10852

Guideline: Acknowledgment (or confirmation) should be required if a significant alarm system configuration change is to be made by user selection.

HSI Design Criteria

NuScale will allow users to select alternative functional configurations of the alarm system under some alarm situations. An example may be operator selection of an alarm message suppression mode in which low priority messages are not presented via the alarm displays but may be accessed through operator action. It is important that the alarm system informs the operators that a requested change in system configuration has been successfully achieved. In addition, a prominent display of the present configuration should be available.

Reference: NUREG-0700-4.3.5

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3.2.2.11.3 User-Defined Alarms/Setpoints

ES-0304-1381-10854

Requirement: The alarm system may provide temporary, user-defined alarms and user-defined set points for specific conditions where such alarms are determined to be of assistance in selected evolutions (e.g., temporary alarms to support increased monitoring of a problem component, or at other times when the user wants to know of a parameter trend that is approaching a limit).

HSI Design Criteria

Appendix E, will cover the alarm set point schema to be used by all NuScale HSI.

Reference: NUREG-0700-4.3.5

3.2.2.11.4 Interference of User-Defined Alarms/Setpoints with Existing Alarms

ES-0304-1381-10856

Guideline: User-defined alarms and setpoints should not override or interfere with the existing alarms and setpoints.

HSI Design Criteria

The NuScale HSI will provide a useful notification setpoint schema as discussed in Appendix E.

Reference: NUREG-0700-4.3.5

3.2.2.11.5 Indication of User-Defined Alarms/Setpoints

ES-0304-1381-10858

Guideline: The alarm system should provide clear indication of user-defined alarms and setpoints as distinct from the alarm/setpoints designed into the system.

HSI Design Criteria

The NuScale HSI will provide a useful notification setpoint schema as discussed in Appendix E.

Reference: NUREG-0700-4.3.5

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3.2.2.11.6 Control of User-Defined Alarms/Setpoints

ES-0304-1381-10860

Guideline: The definition and removal of operator-defined system characteristics should be under administrative controls.

HSI Design Criteria

The NuScale HSI will provide a useful notification setpoint schema as discussed in Appendix E.

Reference: NUREG-0700-4.3.5

3.2.2.11.7 Automated Alarm System Configuration

ES-0304-1381-10862

Guideline: If the alarm system automatically changes operational configurations under some alarm situations, then these configuration changes should be coupled with an alert to the user and an indication that the configuration has changed.

Additional Information: Alarm systems may provide automated functions under some alarm situations, such as automatic silence of auditory alerts for lower priority alarms under high-alarm conditions. It is important that operators be notified of the change in system functioning. In addition, a prominent display of the present configuration should be available to remind operators of the current configuration of the system.

HSI Design Criteria

The NuScale HSI will provide a useful notification configuration schema as discussed in Appendix E.

Reference: NUREG-0700-4.3.6

3.2.2.11.8 Acknowledgment of Automatic Alarm System Configuration Changes

ES-0304-1381-10864

Guideline: Acknowledgment (or confirmation) should be required if a significant alarm system configuration change is to be made automatically.

Additional Information: Alarm systems may allow users to select alternative functional configurations of the alarm system under some alarm situations, such as automatic silence of auditory alerts for lower priority alarms under high-alarm conditions. It is important that the alarm system informs the users that a requested change in system

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configuration has been successfully achieved. In addition, a prominent display of the present configuration should be available.

HSI Design Criteria

The NuScale HSI will provide a useful notification configuration schema as discussed in Appendix E.

Reference: NUREG-0700-4.3.6

3.2.2.11.9 Automatic Mode-Defined Setpoints

ES-0304-1381-10866

Guideline: The need for operator acknowledgment of system-generated setpoint changes based on plant mode should be evaluated on a case-by-case basis.

Additional Information: Alarm systems may alter setpoints in an effort to minimize nuisance alarms. While such changes may be associated with well-understood, easily recognizable plant conditions, others may be less familiar and not readily understood by plant personnel. In the latter situation, plant personnel may misunderstand the alarm information because they do not realize the setpoints have changed. When this situation is of concern, confirmation of the change should be considered.

HSI Design Criteria

The NuScale HSI will provide a useful notification configuration schema as discussed in Appendix E.

Reference: NUREG-0700-4.3.6

3.2.2.12 Controls

3.2.2.12.1 Separate Controls for Alarm Functions

ES-0304-1381-10868

Guideline: Separate controls should be provided for silence, acknowledgment, reset (acknowledging an alarm that has cleared and returning it to normal), and testing.

HSI Design Criteria

A global silence capability together with separate silence and acknowledge capabilities can be useful during high alarm situations by allowing the user to silence many distracting alarms and then acknowledge these alarms at their respective panels. A variety of controls is possible, such as pushbuttons, function keys, and on-screen controls.

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Reference: NUREG-0700-4.3.7

3.2.2.12.2 Distinct Coding of Control Functions

ES-0304-1381-10870

Guideline: Alarm system controls should be distinctively coded for easy recognition.

HSI Design Criteria

The controls should be distinguishable from each other, by touch and sight, to prevent accidental operation of the wrong control. Such techniques as color coding, color shading the group of alarm controls, demarcating the group of alarm controls, or shape coding should be used.

Reference: NUREG-0700-4.3.7

3.2.2.12.3 Consistent Layout of Control Group

ES-0304-1381-10872

Guideline: Each set of alarm system controls should have the functions in the same relative locations.

HSI Design Criteria

Consistent locations will be established for silence, acknowledge, reset, and test operating sequence controls.

Reference: NUREG-0700-4.3.7

3.2.2.12.4 Separate Controls for Tile and VDU Alarms

ES-0304-1381-10874

Guideline: If the alarm system contains both alarm tiles and VDU alarm displays, each should have its own set of controls.

Additional Information: If alarm information is presented redundantly on tile and VDU displays, then alarm acknowledgment via one device (i.e., either the VDU or tile panel control station) should cause the redundant alarm to be automatically acknowledged on the other device. All other control actions (acknowledge, reset and test) should be specific to the workstation associated with the alarm. (also see Guideline ES-0304-1381-10831).

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HSI Design Criteria

The NuScale HSI will be presented on a VDU display only.

Reference: NUREG-0700-4.3.7

3.2.2.12.5 Defeating Controls

ES-0304-1381-10876

Guideline: Alarm system control designs should not allow the controls to be altered or defeated.

Additional Information: For example, some pushbuttons used for alarm silencing and acknowledgement can be held down by inserting an object in the ring around the pushbutton. While the controls should be designed to prevent their being defeated, the system should be designed to minimize the desire to do so.

HSI Design Criteria

The NuScale HSI will provide a useful notification controls schema as discussed in Appendix E.

Reference: NUREG-0700-4.3.7

3.2.2.13 Reliability and Testing

3.2.2.13.1 Design for Reliability

ES-0304-1381-10878

Guideline: The alarm system should be designed so that no single failure will result in the loss of a large number of alarms.

HSI Design Criteria

The NuScale HSI will be designed such that the failure of a single alarm system component will result in the loss of an individual alarm important to plant safety.

Reference: NUREG-0700-4.4.1

3.2.2.13.2 VDU Reliability

ES-0304-1381-10880

Guideline: Where alarms are presented on a VDU as the primary display, users should be able to access the alarms from more than one VDU.

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HSI Design Criteria

Failure of a single VDU will not prevent access to VDU-based alarm presentations at any workstation.

Reference: NUREG-0700-4.4.1

3.2.2.13.3 Dual Light Bulbs

ES-0304-1381-10882

Guideline: Annunciator tile-type displays should be designed with dual light bulbs so that a single bulb failure will not interfere with detection of the alarm condition.

Additional Information: Alarm system displays should be designed with a high level of reliability. In the case of annunciator tile displays, each tile should be illuminated by two or more lights to protect against loss of indication due to failure of one.

HSI Design Criteria

NuScale plant notifications will not incorporate tile-type indicators at this time.

Reference: NUREG-0700-4.4.1

3.2.2.13.4 Flasher Failure Mode

ES-0304-1381-10884

Guideline: In case of flasher failure, an unacknowledged alarm should assume a highly conspicuous state such as a steady on (e.g., illuminated) state rather than a less conspicuous state such as off.

Additional Information: While it is preferable in the case of a flasher failure for the associated alarm element to remain on (e.g., illuminated) rather than off, a unique and highly conspicuous code is best. The code should be unique to prevent confusion between unacknowledged and acknowledged alarms. It should be salient to alert the operator to the malfunction of the alarm display system. In addition, other alerting mechanisms such as warning messages may be used to inform the operator of a malfunction in the alarm display system.

HSI Design Criteria

NuScale plant notifications will not incorporate this guideline.

Reference: NUREG-0700-4.4.1

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3.2.2.13.5 Testing Capabilities

ES-0304-1381-10886

Guideline: Test controls should be available to initiate operability tests for all essential aspects of the alarm system (including processing logic, audible alarms, and visual alarm indications).

Additional Information: For those portions of the alarm system (such as audible alarms and visual indications), the test capability should be simple and available to the operators. The more complex portions (such as sensor inputs and logic processing) should also be testable, but by I&C technicians and engineers. Advanced alarm systems, having capability for continuous, on-line, self-testing may satisfy some of these recommendations.

HSI Design Criteria

The NuScale HSI will provide a useful notification testing schema as discussed in Appendix E.

Reference: NUREG-0700-4.4.2

3.2.2.13.6 Testing Requirement

ES-0304-1381-10888

Guideline: Periodic testing of the alarm system should be required and controlled by administrative procedure.

Additional Information: Simple functional tests are normally required once per operating shift. Reliability analyses of the alarm system may be used to determine appropriate intervals and degree of testing to be performed on the alarm system.

HSI Design Criteria

The NuScale HSI will provide a useful notification testing schema as discussed in Appendix E.

Reference: NUREG-0700-4.4.2

3.2.2.13.7 Design for Maintainability

ES-0304-1381-10890

Guideline: The alarm system should be designed so that maintenance activities can be performed with minimal interference with the activities of the users.

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Additional Information: Desirable design features may include built-in test capabilities, modular components that can be rapidly removed and replaced and rear access panels which prevent maintenance activities for obstructing the users' view of controls and displays.

HSI Design Criteria

The NuScale HSI will provide a useful notification maintenance schema as discussed in Appendix E.

Reference: NUREG-0700-4.4.3

3.2.2.13.8 Tagged-Out Alarms

ES-0304-1381-10892

Guideline: Tagging out an alarm (taking it out of service) should require disabling of the associated visual and audio signals.

Additional Information: A tagged-out alarm should never be lit or flashing, and should never cause any audible device to sound.

HSI Design Criteria

The NuScale HSI will provide a useful notification tagging schema as discussed in Appendix E.

Reference: NUREG-0700-4.4.3

3.2.2.13.9 Out-of-Service Alarm Indication

ES-0304-1381-10894

Guideline: Cues for prompt recognition of an out-of-service alarm should be designed into the system.

Additional Information: Tagging out an alarm should not prevent its identification and should not obscure any other alarm or interfere with operations.

HSI Design Criteria

The NuScale HSI will provide a useful notification tagging schema as discussed in Appendix E.

Reference: NUREG-0700-4.4.3

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3.2.2.13.10 Extended Duration Illumination

ES-0304-1381-10896

Guideline: If an alarm tile must be 'on' for an extended period during normal operations because of equipment repair or replacement, it should be: (1) distinctively coded for positive recognition during this period, and (2) controlled by administrative procedures.

HSI Design Criteria

The NuScale HSI will provide a useful notification coding schema as discussed in Appendix E.

Reference: NUREG-0700-4.4.3

3.2.2.13.11 Tile Cover Replacement

ES-0304-1381-10898

Guideline: If a lamp replacement requires legend tile removal, there should be a way to ensure that the tile is replaced in the correct location.

Additional Information: The alarm element and/or the replacement task should be designed to prevent incorrect positioning of the cover, legend, or tile. For example, annunciator tiles might be permanently marked with a unique identifier specifying their position in the alarm window matrix. Alternatively, it might be administratively required that no more than one tile cover be removed from the matrix at a time.

HSI Design Criteria

NuScale plant notifications will not incorporate tile-type indicators at this time.

Reference: NUREG-0700-4.4.3

3.2.2.13.12 Hazard Avoidance

ES-0304-1381-10900

Guideline: Lamp replacement should not pose an electrical shock hazard.

HSI Design Criteria

NuScale plant notifications will not incorporate tile-type indicators at this time.

Reference: NUREG-0700-4.4.3

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3.2.2.13.13 Aids for Alarm System Maintenance

ES-0304-1381-10902

Guideline: Aids should be provided, if needed, to assist personnel in performing alarm system maintenance.

Additional Information: Aids include instructions and specialized tools. For example, aids may be needed to support changing indicator lights in the notification system.

HSI Design Criteria

NuScale plant notifications will not incorporate indicators at this time.

Reference: NUREG-0700-4.4.3

3.2.2.13.14 Alarm System Failure Indication

ES-0304-1381-10904

Guideline: Users should be given prompt indication of a failure of the alarm system or its major subcomponents.

HSI Design Criteria

The NuScale HSI will provide a useful notification coding schema as discussed in Appendix E.

Reference: NUREG-0700-4.4.4

3.2.2.14 Alarm Response Procedure

3.2.2.14.1 ARP Scope

ES-0304-1381-10906

Guideline: ARPs should be available for alarm conditions that require a response that affects the plant process control system or plant equipment.

Additional Information: Minor alarms associated with data input errors or computer space navigation errors may not require ARPs. In addition, other alarms such as those in alarm systems that are separate from the main process alarm systems and require simple responses may not need ARPs. In this latter case, the lack of ARPs should be specifically considered and justified.

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HSI Design Criteria

The NuScale HSI will provide access to ARPs.

Reference: NUREG-0700-4.5

3.2.2.14.2 ARP Access

ES-0304-1381-10908

Guideline: Users should have immediate access to ARPs from the location at which the alarm messages are read.

Additional Information: An operator should not be required to leave the location at which the alarm message is displayed in order to access ARP information. In a tile system, the identification and indexing of ARPs should be consistent with the method of identifying the alarm. The means used for identifying row and column locations of alarms should be distinct so that possible confusion of these identifiers is avoided. A computerized system may display the appropriate procedure for a given alarm on a VDU when the operator "selects" the alarm message.

HSI Design Criteria

The NuScale HSI will provide access to ARPs.

Reference: NUREG-0700-4.5

3.2.2.14.3 ARP Content

ES-0304-1381-10910

Guideline: ARPs should contain the following information:

- The system/functional group to which the alarm belongs,
- The exact alarm text or legend,
- The alarm source (i.e., the sensor(s) sending the signal, processors and signal validation logic, and the actuating device(s) for the alarm with a reference to a schematic diagram on which such devices can be found),
- Alarm setpoints,
- Priority,
- Potential underlying causes for the alarm (e.g., low water level - inadequate feed flow),
- Required immediate actions, including actions that can be taken to confirm the existence of the alarm condition,

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- Actions which occur automatically when the alarm occurs (and which should be verified as having taken place),
- Follow-up actions,
- Explanations of relevant alarm processing (e.g., comparisons and combinations of plant parameters; alarm filtering and suppression; alarm setpoints that are conditional, such as setpoint values and time delays used to prevent the occurrence of nuisance alarms when a parameter oscillates in an out of the alarm range), and
- Pertinent references.

Additional Information: Users should be given information (such as that associated with 'alarm source' in the guideline) that they can use to confirm the existence of alarmed conditions.

HSI Design Criteria

The NuScale ARPs will comply with all information listed in this guideline.

Reference: NUREG-0700-4.5

3.2.2.14.4 Information Consistency with the HSI

ES-0304-1381-10912

Guideline: Information contained in the ARPs should be consistent with information on control boards, in the alarm system, in I&C procedures used to calibrate alarm setpoints, in controlling documents that determine setpoints (e.g., technical specifications and accident analyses), in P&IDs, in emergency operating procedures, and in other plant procedures.

HSI Design Criteria

The NuScale HSI will provide access to ARPs thus providing consistency with all information provided to the operator.

Reference: NUREG-0700-4.5

3.2.2.14.5 Presentation Consistency with the HSI

ES-0304-1381-10914

Guideline: The terminology, conventions, standards, and codes used in the presentation of the ARPs should be consistent with the rest of the HSI.

Additional Information: The ARPs should use the same conventions, such as terminology for plant systems and equipment's, identification codes for plant components and parameters, and measurement units that are used in the main HSI displays and

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procedures. Defined values, such as alarm setpoints, should be consistent. In addition, information coding schemes used in the ARPs should be consistent with the rest of the HSI. For example, if graphical displays are used in the presentation of the ARPs , then coding conventions, such as symbols, icons and color, should be consistent with the rest of the HSI, such as information presented via plant displays and computer-based systems for emergency operating procedures. For example, if color codes are used to indicate priority, it should have the same meaning across all displays of the HSI.

HSI Design Criteria

The NuScale HSI will provide access to ARPs thus providing consistency with all information provided to the operator.

Reference: NUREG-0700-4.5

3.2.2.14.6 ARP Format

ES-0304-1381-10916

Guideline: The ARP format should:

- Highlight the ARP identifier on each page of the procedure,
- Highlight important items,
- Locate information categories in the same position on each page,
- Consistently present information throughout the ARP, and
- Minimize the need for paging back and forth to obtain the information.

HSI Design Criteria

NuScale ARPs will follow a standard format.

Reference: NUREG-0700-4.5

3.3 Safety Display and Indication System

The Safety Display and Indication System shall provide indication in the main control room that the module protection system (MPS) is maintaining the reactor conditions within the allowable limits for all design basis events applicable to each mode of operation of an operating module.

The SDI shall provide indication in the MCR that the plant protection system (PPS) is maintaining the plant conditions within allowable limits for all design basis events applicable to each mode of operation.

SDI shall provide status indication of the state of MPS and PPS.

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3.3.1 Definitions

Information Display

The NuScale SDI devices used to display information and interface with the system will include a single function flat panel display that presents a single page containing a set of variables.

The organization of this information (e.g., grouping) of related data is important for supporting prompt recognition and comprehension of plant status. The information presented by these monitoring systems includes parameters and indications of functions important to plant safety. Important presentation characteristics include the conciseness of the display format, the arrangement of information according to plant modes, the range of conditions displayed, the display system's response to transient and accident conditions, the data sampling rate, the display's accuracy, the continuous presentation of information, the visibility of displayed data, limit marks for variables, and the indication of magnitudes and trends for variables.

General guidelines for the review of display devices, formats, and elements, and data quality are provided in Section 3.1.

Design Diversity

Design diversity is the use of different approaches including both software and hardware to solve the same of similar problems. The two SDI hubs and display interface modules (DIMs) are independent stand-alone divisions and will utilize different programmable technology. The rationale for design diversity is that different designs will have different failure modes and will not be susceptible to all the same common influences; however, a factor that weakens this argument is that the different designs may nonetheless use similar elements or approaches. SDI equipment utilizing one programmable technology will be located in separate rooms from the other to reduce coupling factors that lead to a common cause failure of both programmable sets.

This topic refers to features necessary for ensuring the continued operation of the SDI system. Reliability addresses the resistance of the system to failures. It affects the degree of trust that operators have regarding the displayed information and whether the system will continue to operate correctly when needed.

Maintenance

The SDI is designed to allow maintenance during normal operation.

Integration with other HSI Elements

This characteristic addresses the consistency and compatibility of the SDI monitoring system with the rest of the HSI. Because the SDI system is used in coordination with other display and control devices of the HSI to verify plant safety and support operators

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in determining corrective actions, the consistency and compatibility of conventions used for presenting and coding information and means of user-system interaction are important review considerations.

In addition, the physical integration of the safety parameter and function monitoring systems with the rest of the HSI is an important review consideration to ensure that the system can be readily accessed and does not interfere with the use of other portions of the HSI.

3.3.2 Requirements and Guidelines

3.3.2.1 Information Display

3.3.2.1.1 Convenient and Ready Access to Data

ES-0304-1381-10948

Guideline: Plant parameters and variables important to safety should be displayed in a way that is convenient and readily accessible.

HSI Design Criteria

The information displayed on the SDI panel in the MCR will be accessible to all personnel as well as at their respective workstations.

Reference: NUREG-0700-5.1

3.3.2.1.2 Critical Safety Function Display Visibility

ES-0304-1381-10950

Guideline: Critical safety function displays should be readable from the workstations of users needing access to these displays.

HSI Design Criteria

The SDI location is designed to be readable from Shift Technical Advisor (STA) location.

Reference: NUREG-0700-5.1

3.3.2.1.3 Critical Variables and Parameters

ES-0304-1381-10952

Guideline: Critical plant variables and parameters should be displayed to help users evaluate the plant's safety status.

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Additional Information: The set of critical plant variables is plant-specific and should be determined by the licensee/applicant. However, the display system, at a minimum, should provide information to plant operators about the following critical safety functions: reactivity control; reactor core cooling and heat removal from the primary system; reactor coolant system integrity; and containment conditions.

HSI Design Criteria

The NuScale PRA, Safety Analysis, and Plant Operations groups considering the guidance of NUREG-1342 determined the critical safety functions and the selection of the variable type (A, B, C, D, or E). The minimum set of parameters chosen for display are available on the SDCV SDI display panel for each unit in the MCR.

Reference: NUREG-0700-5.1

3.3.2.1.4 Severe Accident Symptoms

ES-0304-1381-10954

Guideline: The display system should display information about severe accident symptoms associated with the plant safety parameters and functions.

HSI Design Criteria

The NuScale PRA, Safety Analysis, and Plant Operations groups considering the guidance of NUREG-1342 determined the critical safety functions and the selection of the variable type (A, B, C, D, or E). The minimum set of parameters chosen for display are available on the SDCV SDI display panel for each unit in the MCR.

Reference: NUREG-0700-5.1

3.3.2.1.5 Concise Display of Information

ES-0304-1381-10956

Guideline: Critical plant variables should be displayed in a concise format.

Additional Information: The display format should support users in comparing data from across related plant functions and assessing the safety status of the plant. A concise format might be achieved by presenting a group of critical variables on a single display or by arranging a set of displays (e.g., separate indicators) in a single location.

HSI Design Criteria

The SDI display page will be arranged in a concise consistent format that contains all the information the operators will need to safely monitor the plant under all conditions.

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Reference: NUREG-0700-5.1

3.3.2.1.6 Display Response to Transient and Accident Sequences

ES-0304-1381-10958

Guideline: The display's respond to transient and accident sequences should keep the user informed of the current plant status.

HSI Design Criteria

The SDI display page will be arranged in a concise consistent format that contains all the information the operators will need to safely monitor the plant under all conditions.

Reference: NUREG-0700-5.1

3.3.2.1.7 Rapid and Reliable Recognition of Safety Status Change

ES-0304-1381-10960

Guideline: Critical safety function displays should allow users to comprehend a change in safety status in a matter of seconds.

Additional Information: These displays should incorporate accepted HFE principles to ensure user performance. For example, display formats containing patterns or visual coding that depict relationships between variables may support rapid comprehension. Patterns may be used that noticeably distort when an unsafe conditions is approached.

HSI Design Criteria

The SDI display page will provide visual cues for the initiation and completion of a safety function by highlighting a reserved area on the display page indicating the current status of that function. Each safety function has its own status area reserved on the display page.

Reference: NUREG-0700-5.1

3.3.2.1.8 Data Sampling Rate

ES-0304-1381-10962

Guideline: The sampling rate for each critical plant variable should be consistent with the users' needs for performing tasks.

Additional Information: There should be no meaningful loss of information in the presented data. The time delay from when the sensor signal is sampled to when it is displayed should be consistent with other displays of the HSI.

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HSI Design Criteria

The update frequency shall be fast enough to avoid the potential of misleading the operator with respect to plant conditions. It is considered prudent that this update period is less than or equal to two seconds.

Reference: NUREG-0700-5.1

3.3.2.1.9 Display Accuracy

ES-0304-1381-10964

Guideline: Each critical variable should be displayed with sufficient accuracy for the user to discriminate between normal conditions and those affecting plant safety status.

HSI Design Criteria

The SDI HSI display page parameters accuracies are provided in Chapter 7 of the Final Safety Analysis Report and shall be established based on the assigned function.

Reference: NUREG-0700-5.1

3.3.2.1.10 Magnitudes and Trends of Critical Variables

ES-0304-1381-10966

Guideline: The display should provide magnitudes and trends for critical plant variables or derived variables.

Additional Information: Trends should be displayed with sufficient resolution in time and magnitude to ensure that rapidly changing variables can be observed and accurately interpreted. The time history should cover enough time and be accurate enough to depict the onset and development of conditions that vary from preceding normal operating conditions.

HSI Design Criteria

The SDI trends will be appropriately scaled to the magnitudes of the variables in 5-10 divisions based on the parameter(s) being displayed. The trends will be designed to trend like variables such that the scaling will provide the adequate space for observation. All trend areas will have a 30 min data display requirement with no auto-ranging capability.

Reference: NUREG-0700-5.1

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3.3.2.1.11 Continuous Display

ES-0304-1381-10968

Guideline: Displays for monitoring safety parameters and functions should continuously display this information.

Additional Information: The display system may be considered continuous even though all critical variables cannot be seen at one time. An example is a hierarchical network of displays from which the user can access specific displays for assessing the safety status of the plant.

HSI Design Criteria

The SDI display page will be arranged in a concise consistent format that contains all the information the operators will need to safely monitor the plant under all conditions.

Reference: NUREG-0700-5.1

3.3.2.1.12 Separate Display Pages for Plant Modes

ES-0304-1381-10970

Guideline: Where plant operating modes impose different demands, separate display pages should be provided for each mode.

Additional Information: Some typical modes of plant operation are power operation, startup, hot standby, and hot shutdown. For each mode, the displays should contain at least the minimum set of data needed to assess the safety status of the plant. One means for accommodating the plant modes is to have a top-level display that is independent of plant mode and a set of mode-dependent subordinate display pages.

HSI Design Criteria

NuScale will provide only one display page that covers all five modes of operation. This is appropriate based on the plant's simple, passive design where all required information can be displayed on a single HSI page. This approach allows for a more simplistic SDI panel coding platform and provides the operators with consistent display page behavior across all SDI VDU's.

Reference: NUREG-0700-5.1

3.3.2.2 User-System Integration

3.3.2.2.1 Critical Parameter Monitoring Support

ES-0304-1381-10972

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Guideline: The system should assist the user in monitoring critical parameters, especially parameters that change very rapidly or very slowly, by alerting the user when values are out of range.

Additional Information: The user may not be able to maintain attention on the slow-changing indication due to competing task demands and, thus, may not be aware that the parameter is out of range. For rapidly changing parameters, the unacceptable range might be reached before the user is able to begin monitoring the parameter. Setpoints used to indicate a change in status should be chosen to provide users with sufficient time to respond appropriately.

HSI Design Criteria

The SDI display page will utilize the trending feature to help the operators maintain attention to slow and rapidly changing parameters.

Reference: NUREG-0700-5.2

3.3.2.2.2 Alerts for Abnormal Conditions

ES-0304-1381-10974

Guideline: Where feasible, the system should provide perceptual (audible or visual) cues to alert personnel to abnormal operation conditions that potentially warrant corrective action.

HSI Design Criteria

The SDI display page will provide visual cues for the initiation and completion of a safety system actuation. Due to the limitations of the MPS and PPS I&C system no alarm or caution icons and their associated behavior's (flashing) as well as audible cues will be given at the SDI panel.

The abnormal operational condition behaviors (both visual and audible) of important parameters will be provided in the MCR by the MCS/PCS HSI.

Reference: NUREG-0700-5.2

3.3.2.2.3 Alert to Higher Level Displays

ES-0304-1381-10976

Guideline: While viewing secondary (lower-level) displays, a perceptual (audible or visual) cue should be provided by the safety parameter or function monitoring system to alert the user to return to the primary (higher- level) display format if significant information in that display requires user attention.

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HSI Design Criteria

The SDI display page will be arranged in a concise consistent format that contains all the information the operators will need to safely monitor the plant under all conditions.

No audible cues will be provided by the SDI panel.

Reference: NUREG-0700-5.2

3.3.2.2.4 Ease of Interaction

ES-0304-1381-10978

Guideline: User interactions with the display system should be within the skill capability of the control room crew and should not significantly increase personnel workload.

Additional Information: No additional operating staff beyond the normal control room operating crew should be needed to operate the display during normal and abnormal plant operation. Interactions with the display system should not impose workload demands that detract from other tasks performed by control room personnel during normal and abnormal plant operations.

HSI Design Criteria

The SDI display page will be arranged in a concise consistent format that contains all the information the operators will need to safely monitor the plant under all conditions.

Reference: NUREG-0700-5.2

3.3.2.3 Display Indication Features

3.3.2.3.1 Display Reliability

ES-0304-1381-10980

Guideline: The display should not give false indications of plant status.

Additional Information: Both the processing of display information and the display device should be highly reliable. The operating and failed states should be indicated to users as described in ES-0304-1381-7961.

HSI Design Criteria

The SDI display page will be arranged in a concise consistent format that contains all the information the operators will need to safely monitor the plant under all conditions.

SDI panel hardware will be highly reliable.

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Reference: NUREG-0700-5.3

3.3.2.3.2 Data Reliability/Validation for Critical Plant Variables

ES-0304-1381-10982

Guideline: Critical plant variables should be reliable and should be validated in real time.

Additional Information: There are several methods of ensuring that critical variables are reliably presented to the operators. These methods should be used as appropriate to achieve a high data quality and veracity. Lack of data validation places the burden of identifying valid readings on the operator. One method of achieving this would be to have an estimate of data quality and a data quality indicator associated with each critical variable, including derived synthetic variables. Other recommended methods include: range checks for failed instruments; comparison of redundant sensors; and analytical redundancy. Range checks for failed instruments can ensure that failed instruments are identified and that they are not averaged with other, valid readings, possibly masking the failed instrument. Comparing and possible averaging redundant instruments can improve the quality and reliability of data. Analytical redundancy refers to the intercomparison of measured variables, through the use of mathematical models based upon known physical relationships among variables to determine whether there are inconsistencies in the values of the measured variables. For example, 'reactor power,' 'reactor coolant temperature rise through the reactor core,' and 'reactor coolant flow rate' are interrelated variables based upon the physical principles of heat transfer. A measured value for coolant flow should be consistent with the analytically calculated value for coolant flow derived mathematically from the corresponding measured values of reactor power and coolant temperature rise.

HSI Design Criteria

The SDI display page will contain a display refresh icon that is updated by the control system clock. When active the operator can have confidence that the data on the display page is to most recent value. A frozen refresh icon indicates to the operator that all of the active data on that display page is unreliable.

Reference: NUREG-0700-5.3

3.3.2.3.3 Display of Data Reliability/Validation for Critical Plant Variables

ES-0304-1381-10984

Guideline: The status of the data should be displayed to the operator with an appropriate data quality indicator (e.g., valid, invalid, or unvalidated; or a derived numerical estimate).

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Additional Information: Operators should also have available (e.g., on a separate display page) the individual sensor readings, so they can pinpoint an indicated problem, if the validation fails.

HSI Design Criteria

The SDI display page parameters and components will change from their respective valid colors (On/Off, Open/Closed, etc.) to a pure white indication in the event that the control system senses a failure of that component. This color change will indicate to the operator that data point is no longer reliable.

Reference: NUREG-0700-5.3

3.3.2.3.4 Operator Information to Support Plant Safety

ES-0304-1381-7947

Requirement: Plant parameters and variables important to safety shall be displayed in a way that is convenient and readily accessible to the operator.

HSI Design Criteria

Separate panels will be provided in the main control room to display plant safety parameters.

The SDI system information is provided to the control room via a separate control system.

Appendices A through H will provide the common themed design criteria that will make all plant parameters being displayed convenient and readily accessible to the users of the NuScale HSI.

Reference: NUREG-0700-1.1

3.3.2.4 Integration with other HSI Elements

3.3.2.4.1 Interference with Crew Movement

ES-0304-1381-10986

Guideline: The location of displays for monitoring safety parameters and functions should not interfere with the normal movement of the control room crew.

HSI Design Criteria

The SDI display location will not interfere with normal crew movements with in the MCR.

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Reference: NUREG-0700-5.4

3.3.2.4.2 Visual Interference with Other Controls and Displays

ES-0304-1381-10988

Guideline: The display system should not interfere with visual access to other control room operating systems or with displays that are important to safe operation of the plant.

HSI Design Criteria

The SDI display location will not interfere with other equipment with in the MCR.

Reference: NUREG-0700-5.4

3.3.2.4.3 Labeling

ES-0304-1381-10990

Guideline: Display devices for monitoring safety parameters and functions should be labeled and readily distinguished from other devices.

HSI Design Criteria

Each SDI VDU will be uniquely labeled with the unit and division number. Each critical section “Containment”, “Reactivity” and “Core Heat Removal” will be clearly outlined within the confines of the page. All other components, parameters or trends will have clear labeling that will be placed in a consistent location that will distinguish the display page items from one another.

Control room indication of Type B and Type C variables will be uniquely identified as accident monitoring variables with a characteristic designation so that the operator can easily discern information intended for use under accident conditions. On a multi-variable video display, accident monitoring variables will be specifically identified.

Reference: NUREG-0700-5.4

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3.4 Computer-Based Procedure System

Procedures are typically written documents (including both text and graphic formats) that present a series of decision and action steps to be performed by plant personnel (e.g., operators and technicians) in order to accomplish a goal safely and efficiently. NPPs use procedures for a wide variety of tasks from administration to testing, and plant operation. Computer-based procedure (CBP) systems were developed to assist personnel by computerizing paper-based procedures (PBPs). Their purpose is to guide operators' actions in performing their tasks in order to increase the likelihood that the goals of the tasks would be safely achieved. CBPs define decisions to be made and actions to be taken where the goals are unambiguous and the correct or desired course of action is generally known.

While the primary focus of the characterization presented below is focused on emergency operating procedures (EOPs), it is recognized that normal and abnormal operating procedures have been important contributors to many significant events and play a significant role in plant safety. Thus, the guidelines in this section may also apply to procedures used in testing, surveillance, troubleshooting, and maintenance, when they are delivered by CBP systems.

The design review of CBP systems requires two types of guidance: procedure guidance and HSI guidance. The first type addresses the human factors aspects of procedure design and is intended to ensure that procedures are technically correct and usable. There is considerable guidance on procedure design, e.g., NUREG/CR-6634. In addition, HFE considerations related to the development of procedures are addressed by NUREG-0711, Rev.3 (Element 8, Procedures) and NUREG-0800 (Chapters 13 and 18).

The second type, HSI guidance, covers their design characteristics. CBPs use other HSI resources, e.g., information is presented on VDUs, and operators interact with the CBP information using dialogue and navigation capabilities provided by the computer system. Many of the characteristics of CBP design are addressed by human factors guidelines in the general sections of this document. The guidelines provided in this section emphasize HSI characteristics specific to implementing procedures in computerized form, such as features that help users manage concurrent procedures or monitor continuously applicable steps in an ongoing operation.

Two aspects of CBP system design and implementation are not addressed in this section. First, the CBP guidance does not address software aspects of CBPs. Second, procedure maintenance and configuration control are not addressed. While procedure maintenance and configuration control are equally important for CBPs and PBPs, these two procedure systems are likely to use different mechanisms. The following are aspects to be considered for CBPs: how procedures are entered into the computer system; how their quality is verified (e.g., no typos or omissions); how errors are identified, tracked and corrected; how changes are incorporated; and how configuration control (i.e., control over revisions and modification) is provided. NUREG/CR-6634, NUREG-0711, Rev. 3,

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and NUREG-0800 contain general guidance for procedure maintenance and configuration control developed for PBPs.

The following characterizations identify CBP design features and functions important to personnel performance that can be used to describe a CBP system during an HFE design review.

The NuScale CBP system will consist of three types of procedures.

- Type 1 (Electronic Procedure)

  Type 1 procedures represent procedure text documents for operational use on a computer-generated visual display. These types of procedures can be accessed by anyone on the "Plant Network" and may or may not contain live plant data.

- Type 2 (Interactive Electronic Procedure)

  Type 2 procedures use dynamic process data for the display of live plant data, to evaluate conditions or procedure logic, or to monitor plant conditions during procedure-defined intervals of applicability.

  Type 2 procedures reside on the "Control Networks" but typically cannot issue control commands, however they may provide access to soft control capabilities that exist outside of the control systems e.g. performing maintenance on the fire protection system.

- Type 3 (Embedded Procedure)

  Type 3 procedures include soft controls that may be used to issue control commands to plant equipment. This type of procedure is "embedded" into the HSI display page software code such that anyone with access to a computer with the HSI software loaded on it can access these types of procedures.

  Type 3 procedures may include automatic sequences of steps (i.e., procedure-based automation) that are determined to require limited operator oversight, and for which there are procedures and training that would allow the operator to perform the steps manually, if necessary or desired.

  To interface with the embedded type procedure NuScale has created the Process Library interface. This interface helps the operator quickly access any procedure for various plant operations and also aids in directly controlling components. The Process Library is available to every operator in the MCR, and the interface includes a percent complete section that allows design team members to monitor each other's progress as they address a concern. Appendix H contains more information on this first of a kind interface concept.

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3.4.1 Definitions

Information Display

The display elements for CBP systems include the following: procedure identification information; procedure steps; warnings, cautions, notes, and supplementary information; lists; procedure organization; and format and screen layout. Each is briefly described below.

Procedure Identification Information

Procedures are identifiable to the operators and maintainers through the title, procedure number, revision number, and date. Procedures also contain statements of the high-level objective and its applicability, including the procedure category, e.g., emergency or abnormal.

Procedure Steps

Steps are the basic unit of the procedure. Each step is composed of a verb and a direct object. In general, the rules of English grammar are followed and the syntax reflects concise language that is simply stated, explicit, and consistent. Decision steps provide instructions to evaluate conditions and then to choose appropriate action(s) from a predefined set. The decisions may involve conditional logic, i.e., where actions are to be performed only if a specified set of conditions exists. Action steps identify actions to be taken; i.e., instructions to perform physical (e.g., "Depress") and mental (e.g., "Verify") actions as well as describing the objective of those actions. Some procedure steps (e.g., in EOPs) have a dual nature, with an action to be accomplished in one column and a second action if the first is not successful. Some procedure steps may also require calculations.

Implementation of procedures has a temporal flow, i.e., some steps are taken when encountered, others are performed continuously (i.e., steps of continuous applicability), while others are done based on time or process criteria. Performance of a procedure step may be supported by information, such as cautions and notes, that qualifies the actions and decisions required.

Warnings, Cautions, Notes, and Supplementary Information

Warnings alert operators to potential hazards of their actions that may result in death or injury to workers or the public. Cautions alert operators to potential hazards of their actions that may damage machinery or equipment. Notes call attention to important supplemental information that may enhance an operator's understanding and performance of the procedure.

Procedure steps may reference supplementary material that helps the operator implement the step; it can be in the form of tables, figures, lists, text, or numeric information.

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Lists

As noted in Section 3.1, Information Display, a list is a display containing alphanumeric strings arranged in a single column by rows. Procedures frequently use list to present groups of items such as actions, conditions, components, criteria, and systems. When lists are used in CBPs, additional consideration must be given to the grouping of items, provision of checkoff capability, and operator alerts to items that may be overlooked.

Procedure Organization

Nuclear plant procedures are not like simple checklists in which a user starts at the top and linearly proceeds step-by-step to the end. Based on plant conditions, the operator may be required to branch from one part of a procedure to another or from one procedure to another. Thus, the organization of procedures is an important consideration.

Format and Search Layout

PBPs generally present the basic steps in text or flowchart format. Both of these formats may be used in CBPs. However, unlike PBPs, CBPs are viewed through the limited display area of one or more VDUs. Thus, whether the procedure format is text or flowchart, the designer must still decide whether the procedure will be presented to the operator in a continuous, scrollable display or divided into discrete display pages.

The overall screen layout for presentation of the procedure elements refers to the

- determination as to what information should be continuously presented
- manner in which individual procedure elements are presented.

For example, the procedure title and identification information may be continuously presented at the top of the CBP screen, while the steps are shown on scrollable window. Cautions may be represented in a separate window. The CBP may also display such supporting features as bookmarks, checklists, and operator comments.

Presentation formats, such as text and flowcharts, can be enhanced by the coding capabilities of computer-based displays, e.g., color, flashing, animation, and auditory cueing. Coding is generally used to increase the salience of important information. CBPs use coding for conditions such as:

- whether procedure step logic is satisfied or not
- whether information is static or dynamic with plant state
- when a caution is in effect
- when a change in the status of a continuously monitored step has occurred

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CBPs can be designed to allow operators to choose the level of detail in which procedures are presented. For example, operators may select to have less detail displayed when a procedure step is satisfied. Alternatively, an operator may choose to show all of the individual evaluations that led to the conclusion that the step is satisfied.

General guidelines for information display are presented in Section 3.1.

A significant difference between PBPs and CBPs is in the type of functions offered by CBP systems for viewing and using the procedures. Procedure functions can be organized into four cognitive categories: Monitoring and Detection, Situation Assessment, Response Planning, and Response Implementation. In terms of monitoring and detection, operators must monitor process parameters referenced by procedures. Operators must also monitor their own procedure-related actions.

The degree of situation assessment needed in using procedures is high. While EOPs enable operators to act without diagnosing the disturbance, operators must assess whether EOP entry conditions exist. Within the procedure, operators assess each decision step by comparing actual values to the procedure's reference values, evaluating whether cautions are applicable, assessing whether each step is complete or not, and tracking and remembering their path through the procedure (the procedure history), steps of continuous applicability, and steps that are time- or parameter-value dependent. This can be difficult because steps must be evaluated while others are being performed. Operators must also assess the applicability of individual steps because PBPs are generic and not context sensitive (context sensitivity is the selection of procedural information based on plant state). Finally, operators must evaluate the success of the current procedure in achieving the high-level procedure goals and the procedure's termination conditions.

Procedures were originally designed to support response planning. In the case of EOPs, for example, the procedures were intended to assist operators in responding to events by setting out the steps necessary to achieve safety goals. It relieved the operator of the burden of formulating response plans in real time. Instead, the actions necessary to restore and maintain critical safety functions were analyzed in advance by the procedure developer and supplied as a set of detailed instructions. However, operators must still evaluate whether transitions to other parts of the procedure or other procedures are warranted. At rare times, they may have to modify a procedure when the current plant conditions render the existing procedure inapplicable.

With respect to response implementation, the operator's responses involve actions on the procedures themselves, such as making the transition from one step to the next, to other parts of the procedure, or to other procedures. Responses also include controlling equipment based on procedural guidance. CBPs may support operators' interaction both with the procedures and with plant equipment.

While PBPs support response planning, they provide little active support for monitoring, situation assessment, and response. CBPs, on the other hand, may support these

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cognitive functions as well; the extent to which they do so is determined by the CBP design.

Table 3-8 provides an overall scheme in which the level of automation of CBPs can be organized. This table illustrates the widely varying levels of automation and functional capabilities that CBPs may possess. It also can be used to catalogue the functional capabilities of a particular system.

In the rows, the general cognitive functions (as described above) are identified along with the procedure- related activities associated with each. In the columns, four levels of automation are identified: manual, advisory, shared, and automated. The meanings of these levels of automation are

- Manual – The function is performed by the operators with no assistance from the CBP.
- Advisory – The CBP gives advice only. For example, the CBP may advise the operator that Pump A should be started, but does not perform the action.
- Shared – The CBP and the operators both perform the function. For example, a CBP system could monitor a process but be unable to access all necessary information about the system (e.g., valve position) due to lack of instrumentation. When this type of information needs to be monitored, the operator obtains the information.
- Automated – The CBP performs the function automatically without direct intervention from the operator. This may or may not involve notification to the operators of the automated actions taken.

A given level of automation is not necessarily meaningful for all functions. For example, with respect to process monitoring, it is not meaningful to have an advisory level of automation. The CBP system will either have monitoring capability or it will not. This is indicated by NA (not applicable) in the table.

A given procedure system may make no provisions for a given function. For example, a CBP may not address control of equipment in any capacity, not even manual. In such a system, equipment would be operated using the other resources of the HSI. Thus, the entire function is not applicable for that specific CBP.

Individual CBP systems differ in terms of the levels of automation they provide. To achieve these varying levels of automation, CBPs may need to provide features that go beyond those identified above as the basic procedure elements. For example, to provide for manual control of plant components, the CBP would need to include a control, e.g., a soft control, for that equipment.

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Table 3-8. Levels of automation of procedure functions

Procedure Functions	Level of Automation[1]			
	Manual	Advisory	Shared	Automatic
Monitoring and Detection				
Process parameter values		NA		
Operator actions		NA		
Situation Assessment				
Procedure entry conditions		NA		
Resolution of procedure step logic		NA		
Step status (incomplete or completed)		NA		
Procedure history		NA		
Context sensitive step presentation		NA		
Assessment of continuous, time, and parameter steps		NA		
Assessment of cautions		NA		
High-level goal attainment and procedure exit conditions		NA		
Response Planning				
Selection of next step or procedure				
Procedure modification based on current situation				
Response Implementation				
Transition from one step to the next				
Transition to other parts of procedure of other procedures				
Control of plant equipment				

[1] NA means "not applicable." For a given CBP system, a level of automation may not be applicable or an entire function may not be applicable.

User-System Interaction

CBP systems have special requirements to support the operator's interaction with the system, procedure maintenance and configuration control. CBP-specific interface management considerations (such navigation aids) include the need to make transitions between procedure steps and between different procedures. In addition, procedure use can be supported by automated facilities that monitor and record the operator's actions and provide support for interface management tasks when needed.

The types of devices used to operate the CBP system should be identified, including computer-based input devices (e.g., alphanumeric keyboards, trackballs, mice, and touch screens), conventional controls, and soft controls.

Backup Capabilities

CBPs can fail or malfunction. When important operations cannot be suspended or put off while the system is repaired, backup to the CBP is necessary. In the case of EOPs, a delay in operations in the event of a failure is not acceptable therefore, some form of procedure backup is warranted.

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Integration with other HSI Elements

The integration of the CBP with other resources of the HSI must be considered. Depending on the level of automation, as shown in Table 3-8, CBP systems will require varying types of interfacing with the remainder of the HSI. The consistency and compatibility of the CBP with the rest of the HSI can affect operator performance. Thus, important considerations in the CBP review include the degree to which

(1) the display of plant variables in the CBP is compatible with the normal monitoring displays, (2) compatible coding schemes are used, and (3) control implementation modes of the CBP are consistent with the rest of the HSI (e.g., with modes of automated control systems).

In the course of developing the guidance for CBPs, several considerations were identified that are important to crew performance and safety, but for which the technical basis was insufficient to develop specific HFE guidelines. These aspects of computer-based procedure design should be addressed on a case-by-case basis.

3.4.2 Requirements and Guidelines

3.4.2.1 Procedure Identification Information

3.4.2.1.1 Procedure Title and Identification Information

ES-0304-1381-11478

Guideline: Each procedure should contain identifying information including title, procedure number, revision number, date, and organizational approval.

Additional Information: This information helps the user establish the appropriate context for using the procedure.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.1

3.4.2.1.2 High-Level Goals

ES-0304-1381-11480

Guideline: Each procedure should state its high-level goals and applicability, including its procedure category, e.g., emergency or abnormal.

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Additional Information: Information should be given allowing the user to understand the purpose or goal of a series of steps and supporting the user's assessment of the success of the procedure in achieving its safety goal.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.1

3.4.2.2 Procedure Steps

3.4.2.2.1 Concise Steps

ES-0304-1381-11482

Guideline: Procedure steps should be concise.

Additional Information: Steps should be designed to communicate information clearly and unambiguously so that they can be easily understood and interpreted without error.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.2 Short Sentences

ES-0304-1381-11484

Guideline: Procedure steps should be written as short sentences.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

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3.4.2.2.3 Active Voice

ES-0304-1381-11486

Guideline: Procedure steps should be written in active voice.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.4 Positive Commands

ES-0304-1381-11488

Guideline: Procedure steps should be written as positive commands.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.5 Simple Wording

ES-0304-1381-11490

Guideline: Short, simple words from standard American English should be used.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.6 Standard Punctuation

ES-0304-1381-11492

Guideline: Punctuation should conform to standard American English usage.

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers’ Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.7 Consistent Word References

ES-0304-1381-11494

Guideline: Words, phrases, and equipment names and numbers should be used consistently within and among procedures, drawings, other HSIs, and equipment labels.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers’ Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.8 Abbreviations and Acronyms

ES-0304-1381-11496

Guideline: Abbreviations and acronyms should be used consistently and limited to those well known to the users.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers’ Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.9 Units of Measures

ES-0304-1381-11498

Guideline: Numerical information should include units of measure.

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.10 Numerical Precision

ES-0304-1381-11500

Guideline: Numbers should be specified at the appropriate precision.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.11 Number Ranges

ES-0304-1381-11502

Guideline: Ranges of numbers should be specified, rather than error bands.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.12 Use Arabic Numerals

ES-0304-1381-11504

Guideline: Arabic numerals should be used.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

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Reference: NUREG-0700-8.1.2

3.4.2.2.13 Spelled Numbers

ES-0304-1381-11506

Guideline: Numbers that are spelled out should be consistently spelled under the same conditions.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.14 Presentation of Conditional Steps

ES-0304-1381-11508

Guideline: Conditional steps should be shown in traditional text formats following the guidance in Appendix B of NUREG-0899.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.2.15 Specification of Preconditions for Steps

ES-0304-1381-11510

Guideline: The procedure should specify any conditions that must be met before an action can be undertaken.

Additional Information: Information about preconditions in the procedure should be located so that users read the information before acting. Information given in other locations may be overlooked, or require additional actions to retrieve it, which may be distracting and time consuming. Further, if conditions are implied, users may easily miss or misinterpret them.

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.2

3.4.2.3 Warnings, Cautions, Notes, and Supplementary Information

3.4.2.3.1 Parallel Display with Procedure Step

ES-0304-1381-11512

Guideline: The warnings and cautions applicable to a single step (or to a series of steps) should be displayed when the step(s) is on the screen.

Additional Information: Displaying warnings and cautions at the same time as their associated procedure steps will help ensure that users read the information when they evaluate the step. Information provided elsewhere may be overlooked, or may require retrieval by distracting and time-consuming actions.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.3

3.4.2.3.2 Position Before Action Steps

ES-0304-1381-11514

Guideline: Warnings, cautions, and notes should be presented so that they will be read before the applicable action steps.

Additional Information: Displaying warnings, cautions, and notes before action steps will help ensure that users will read the information before taking action. Information provided in other places may be overlooked or may be distracting and time consuming to retrieve.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

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Reference: NUREG-0700-8.1.3

3.4.2.3.3 Action References

ES-0304-1381-11516

Guideline: Warnings, cautions, and notes should not include implied or actual action steps.

Additional Information: Actions should be specified in procedure steps only.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.3

3.4.2.3.4 Distinction from Other Procedure Elements

ES-0304-1381-11518

Guideline: Warnings, cautions, and notes should be uniquely presented, so that they are easily distinguished from each other and from other display elements.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.3

3.4.2.3.5 Supplementary Information

ES-0304-1381-11520

Guideline: All supplementary information (such as tables and figures) required for a procedure step and available to the CBP should be shown on the screen concurrently with the step, or on another easily viewed display.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

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Reference: NUREG-0700-8.1.3

3.4.2.4 Lists

3.4.2.4.1 Appropriate Application of Lists

ES-0304-1381-11522

Guideline: Groups of three or more related items (e.g., actions, conditions, components, criteria, systems) should be presented as a list.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.4

3.4.2.4.2 Distinction from Other Procedure Elements

ES-0304-1381-11524

Guideline: Formatting should be used to differentiate items in a list from other procedure elements.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.4

3.4.2.4.3 Identification of Precedence

ES-0304-1381-11526

Guideline: The presence or absence of precedence among items in lists should be indicated.

Additional Information: It should be clear to users whether some items take precedence over others.

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.4

3.4.2.4.4 List Overviews

ES-0304-1381-11528

Guideline: Overviews should introduce each list.

Additional Information: An example of an overview is "Ensure that all of the following tests were completed:".

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.4

3.4.2.4.5 Assuring Users' Attention

ES-0304-1381-11530

Guideline: The method for assuring that each item in a list has received the users' attention should be consistent. Users should make some form of acknowledgment of procedure steps and recommendations for terminations and transitions.

Additional Information: For example, an electronic checklist may be provided so that users can check off items they have attended to. If users proceed before all items are checked off, the CBP may alert them to the unchecked items.

OR, users may acknowledge that a step is satisfied by depressing the "Return" key, or clicking on an onscreen acceptance button. Such acknowledgment helps the users to maintain awareness of the procedure's status.

The indication can be manual or automatic, depending on whether the CBP has the specific criteria and information to determine this.

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.1, NUREG-0700-8.2.2, NUREG-0700-8.1.4

3.4.2.5 Procedure Organization

3.4.2.5.1 Hierarchical, Logical Organization

ES-0304-1381-11532

Guideline: The procedures should be organized in a hierarchical, logical, consistent manner.

Additional Information: Organization will make it easier for users to see the relationships among procedures.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.5

3.4.2.5.2 Organization of Procedure Steps

ES-0304-1381-11534

Guideline: Each procedure should be organized into sections of related steps.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.5

3.4.2.6 Format and Search Layout

3.4.2.6.1 Organization Format of Procedures

ES-0304-1381-11536

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Guideline: The procedure's format should reflect its organization.

Additional Information: Formatting methods to indicate the organization of a procedure may include the use of headings or colors to distinguish parts of the procedure.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.6

3.4.2.6.2 Format of Procedures

ES-0304-1381-11538

Guideline: A consistent format should be used to display procedures.

Additional Information: Whether procedures are presented in text, flowchart, or otherwise, a consistent approach across procedures will facilitate using and moving between multiple procedures.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.6

3.4.2.6.3 Partitioning Procedures

ES-0304-1381-11540

Guideline: A consistent approach to partitioning procedures should be used.

Additional Information: Partitioning refers to how a procedure is organized to be displayed on the VDU screen. For example, it may be divided into distinct pages, and users would navigate from one to the next. Alternatively, it may be presented as one continuous display that the user scrolls.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

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Reference: NUREG-0700-8.1.6

3.4.2.6.4 Organization of Display Screen

ES-0304-1381-11542

Guideline: Each display screen should locate information and HSI features consistently.

Additional Information: When the information and features, such as procedure steps, controls, and navigation aids are consistently located, users' performance improves because expectations can guide the search for information, and reduce the time and workload associated with finding it.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.6

3.4.2.6.5 Continuously Presented Procedure Information

ES-0304-1381-11544

Guideline: The procedure's title and identification should be continuously presented.

Additional Information: This information helps set the context for the overall procedure within which its steps are interpreted. It is especially important when more than one procedure can be open at one time.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.6

3.4.2.6.6 Continuously Presented Status of High-Level Goals

ES-0304-1381-11546

Guideline: The status of high-level procedure goals should be continuously presented.

Additional Information: This information helps set the overall context in which procedure steps are interpreted. Continuous presentation of high-level goal status, such as status

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of critical safety functions, will facilitate users' awareness of them, particularly when more than one procedure is open simultaneously.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.1.6

3.4.2.7 Supervision and Control

3.4.2.7.1 Users' Control of Procedure Path

ES-0304-1381-11548

Guideline: Users should be in control of the sequence of steps that are followed.

Additional Information: Most procedures have specifically defined steps that have to be performed sequentially, and others that can be varied at the user's discretion; CBPs should identify which one is applicable. However, users should have the flexibility to move around within the procedure, so that they can check and make verifications.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.1

3.4.2.7.2 Users' Control of Pace of Procedures

ES-0304-1381-11550

Guideline: Users should be in control of the pace at which procedure steps are followed.

Additional Information: Users need to maintain situation awareness of procedure-related decisions. To accomplish this, they must be in control of the pace at which steps are followed.

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.1

3.4.2.7.3 Understandability of Analysis of Procedure Steps

ES-0304-1381-11552

Guideline: The methods by which CBPs analyze procedure steps should be consistent with the methods by which users analyze steps in procedure logic steps, so that the results are understandable.

Additional Information: Users must be able to judge the acceptability of the CBP's advice and recommendations.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.1

3.4.2.7.4 Users' Verification of CBP Information

ES-0304-1381-11554

Guideline: The users should be able to verify the system's assessment of plant status.

Additional Information: This verification includes process parameters, equipment status, analysis of procedure step logic, and evaluation of cautions. Any analysis done by the CBP should be accessible to users for review.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.1

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3.4.2.7.5 Users' Override of CBP

ES-0304-1381-11556

Guideline: Users should be able to override any CBP information, calculation, evaluation, or assessment.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.1

3.4.2.8 Monitoring and Assessment

3.4.2.8.1 Automatic Identification of Procedures

ES-0304-1381-11558

Guideline: The CBP should alert users when entry conditions to a procedure are satisfied.

Additional Information: This capability will help users determine the appropriate procedures for the existing plant situation.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.2 Automatic Monitoring of Plant Parameters and Equipment Status

ES-0304-1381-11560

Guideline: The CBP should frequently monitor procedure-defined parameters and should automatically provide accurate and valid information on the values of parameters and status of equipment, when they are available to the system.

Additional Information: Frequent monitoring, such as twice a second, promptly notifies users of status changes.

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It should be clear to users what specific information is used as the source of these actual values and states.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.3 Automatic Calculation of Procedure-Referenced Values

ES-0304-1381-11564

Guideline: The system should undertake calculations, such as subcooling margin, that are required when using procedures.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.4 Analysis of Step Logic

ES-0304-1381-11566

Guideline: The CBP should evaluate the logic of each procedure step and show the results to the user.

Additional Information: Procedure steps often contain logical relationships; for example, actions are to be performed if an identified set of conditions exists. The analysis of these logical relationships must be carefully verified to avoid underspecification. This occurs when the logic used to resolve a procedure step is too simplified, and does not address all of the considerations that users do when evaluating the step.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

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3.4.2.8.5 Continuous Analysis of Non-Current Step Logic

ES-0304-1381-11568

Guideline: Steps of continuous applicability, time-dependent steps, and process-dependent steps should be monitored by the CBP and the user should be alerted when conditions in those steps become effective.

Additional Information: The analysis must be carefully verified to avoid underspecifying its logic. The alert should not automatically remove the user's current display. Instead, it should be presented as a supplemental display or as an alert.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.6 Coding of Logical Analysis

ES-0304-1381-11570

Guideline: When procedure's step logic indicates a violation of the step, the information should be coded to make that step more salient to users.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.7 Analysis of Cautions

ES-0304-1381-11572

Guideline: The conditions described in cautions should be automatically monitored by the CBP system, and the user should be alerted when the caution is in effect.

Additional Information: Evaluating cautions and alerting users to their applicability will ensure that users will read the information at the appropriate time, and reduce the chance that it may be overlooked. The conditions for cautions must be established with care such that the logic is not underspecified.

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.8 Coding Applicable Cautions

ES-0304-1381-11574

Guideline: CBPs should use coding to indicate when a caution is in effect.

Additional Information: Coding techniques, such as color coding, may be used to enhance the salience of important information.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.9 Identification of User Input Requirements

ES-0304-1381-11578

Guideline: The CBP should provide users with clear, timely indications when they need to input any information not available to it.

Additional Information: CBPs may rely on users to process parameter values, equipment status (such as whether a valve is open or closed), analyses of logic steps where users' judgment is involved, or to assess any conditions not within the capability of the CBP.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

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3.4.2.8.10 Adjustable Level of Detail

ES-0304-1381-11580

Guideline: Users should be able to choose the level of detail with which procedures are presented.

Additional Information: While plant practices on using procedures may be specified by management, there may be flexibility in the level of detail that can be provided. For example, users may want less detail when a procedure step is satisfied. Alternatively, a user may choose to see all of the individual evaluations leading to the conclusion that the step was satisfied. This must be done with care so that it does not affect the interpretation of procedure information. In addition, users should be trained as to how and when to vary levels of detail.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.11 Context-Specific Guidance

ES-0304-1381-11582

Guideline: Procedure guidance should be context sensitive where possible.

Additional Information: For example, the CBP system should not indicate an action to start a pump when it can determine that the pump is already running.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.12 Assessment of High-Level Goal Status

ES-0304-1381-11584

Guideline: The CBP should continuously assess and present the status of higher-level safety goals, such as critical safety functions, and alert the user to any challenges.

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.8.13 Assessment of Conditions Terminating a Procedure

ES-0304-1381-11586

Guideline: The CBP should automatically identify when conditions are met for transitioning or exiting from a procedure.

Additional Information: This capability will help users determine when procedures they are using are no longer appropriate for the existing situation.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.2

3.4.2.9 Monitoring of User Actions

3.4.2.9.1 Monitoring Users

ES-0304-1381-11588

Guideline: User responses to procedures should be monitored and recorded by the CBP.

Additional Information: Monitoring information on users' input to information requested by the procedure and their subsequent actions is necessary if the CBP is to properly assess appropriate procedural pathways.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

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Reference: NUREG-0700-8.2.3

3.4.2.9.2 Alert Users to Deviations in Procedure

ES-0304-1381-11590

Guideline: Users should be alerted if their input is incorrect, or when their actions are not consistent with CBP evaluations.

Additional Information: The alert should be advisory and not discourage the user's actions. This feature must be supported with training, so users are not reluctant to go against the CBP's evaluations.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.3

3.4.2.10 Planning and Implementation

3.4.2.10.1 Display of Action Status

ES-0304-1381-11592

Guideline: The status of procedure-related actions should be displayed by the CBP.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.4

3.4.2.10.2 Timing of Procedures

ES-0304-1381-11594

Guideline: The CBP's timing, such as status update rates, screen changes, and navigation features, should be consistent with the time demands of the task.

HSI Design Criteria

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NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.2.4

3.4.2.11 Path Monitoring

3.4.2.11.1 Alert User to Incomplete Procedure Steps

ES-0304-1381-11598

Guideline: Users should be alerted to incomplete procedure steps.

Additional Information: The alert should be advisory and not discourage the crew's actions.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.1

3.4.2.11.2 Coding Current Location

ES-0304-1381-11600

Guideline: The current procedure step(s) should be indicated.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.1

3.4.2.11.3 Automatic Path Monitoring

ES-0304-1381-11602

Guideline: The pathway taken through procedures should be stored and made available to users.

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Additional Information: A history should be maintained and available for display on request. Step completion can be time stamped to facilitate post-hoc incident analysis.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.1

3.4.2.11.4 Indication of Multiple Active Procedures

ES-0304-1381-11604

Guideline: The user should be informed when multiple procedures or multiple procedure steps are to be followed concurrently. A list of all currently active procedures should be available.

Additional Information: It may be helpful for the list of active procedures to include start and stop times for the procedures in use.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.1

3.4.2.12 Navigation

3.4.2.12.1 Flexible Navigation

ES-0304-1381-11606

Guideline: Navigation support should allow users to freely and easily move between procedure steps, to other parts of the same procedure, and to other procedures.

Additional Information: Users should not be forced to access procedures in a fixed sequence of the procedure nor should their access to supporting information be limited. (See also the additional information for ES-0304-1381-11549.)

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.2

3.4.2.12.2 Support Parallel Access to Information

ES-0304-1381-11608

Guideline: The CBP should have the ability to access more than one piece of information at once.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.2

3.4.2.12.3 Navigational Links to Related Information

ES-0304-1381-11610

Guideline: Navigational links to cross-referenced information and to notes, cautions, warnings, reference material, and communication and help facilities should be provided.

Additional Information: Techniques such as hyperlinks can expedite navigation to information material cross-referenced in a procedure or its supporting material.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.2

3.4.2.12.4 Access to Contingency Actions

ES-0304-1381-11612

Guideline: Users should be able to easily access appropriate contingency actions.

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HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.2

3.4.2.13 Help

3.4.2.13.1 Explanation Facilities

ES-0304-1381-11614

Guideline: CBPs should have facilities to enable the user to determine how CBP functions are performed.

Additional Information: When CBPs support users' decision making, such as offering advice on how to select procedures, analyze step logic or follow procedure paths, users should be able to query the basis for the advice. Cooperative dialogue enables the user to better understand and utilize the system.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.3

3.4.2.13.2 Help Facilities

ES-0304-1381-11616

Guideline: Help for performing procedure specified activities should be provided.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.3.3

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3.4.2.13.3 Note Taking

ES-0304-1381-11618

Guideline: There should be a way for users to record their notes and comments in the CBP.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers’ Manual.

Reference: NUREG-0700-8.3.3

3.4.2.14 Hardware

3.4.2.14.1 Number of VDUs

ES-0304-1381-11620

Guideline: The number of VDUs on which CBP information is displayed should be sufficient to provide all the procedure-related information needed for a procedure step, including cautions and reference material.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers’ Manual.

Reference: NUREG-0700-8.4

3.4.2.15 Backup

3.4.2.15.1 Paper-Based Procedure Availability

ES-0304-1381-11622

Guideline: PBPs should be available in the event of CBP failure.

HSI Design Criteria

Paper backup copies will be available

Reference: NUREG-0700-8.5

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3.4.2.15.2 Consistency of PBPs and CBPs

ES-0304-1381-11624

Guideline: The content and presentation of procedure information in PBPs and CBPs should be consistent.

Additional Information: Smooth transfer between CBPs and PBPs and vice versa will be facilitated by the degree to which their formatting is consistent; this also will facilitate training in procedure use.

HSI Design Criteria

Forcing consistency here ensures commonality especially with the potential that different groups will write the PBP and CBP.

Reference: NUREG-0700-8.5

3.4.2.15.3 Support for Transfer to PBPs

ES-0304-1381-11626

Guideline: Upon transfer to PBPs, a means should be provided to support the user's determination of currently open procedures, location in the procedures, completed and not completed steps, and currently monitored steps.

Additional Information: When the CBP is lost, it may be difficult for users to reconstruct this information from memory. Therefore, the user should be supported in making a safe, easy transition. For example, a CBP system might automatically print out a status sheet with this information once every minute so that if it fails, the user can retrieve the latest sheet and use it to establish the crew's tasks for using PBPs.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.5

3.4.2.16 Integration with other HSI Elements

3.4.2.16.1 Consistency with HSI

ES-0304-1381-11628

Guideline: The detailed CBP design should be fully consistent with the rest of the HSI.

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Additional Information: HSI features for format and functionality (such as labeling, acronyms, dialog conventions, use of colors, and input devices) should be consistent between the CBP and other HSI components. Consistency may be a special consideration when reviewing 'off-the-shelf' systems.

HSI Design Criteria

NuScale Computer-Based procedures will meet the standards addressed here as well established industry standards such as those outlined in PPA AP-907-005 Procedure Writers' Manual.

Reference: NUREG-0700-8.6

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3.5 Communications Systems

Crew communication is essential to performance, including communication between personnel in the main control room, between the main control room and local sites within the plant, and across sites within the plant. The communication system supports these activities. The broad variety of communication media that may be employed can be generally categorized as speech-based and computer-based communications, as described below.

3.5.1 Definitions

Speech-Based Communications

Within the main control room, personnel generally communicate directly via unaided speech. An exception may be when personnel are separated by a large distance, such as when an operator at a main control panel must communicate with another operator located at a back panel or an auxiliary area in the control room. In such cases, a communication device may be used. In addition, communication devices are often used to communicate between the main control room and local sites within the plant, and across sites within the plant. Varieties of communication devices that may be used to support speech-based communication are described below.

Conventional Phone System

Earphones and microphones may have variety of configurations including handsets, headsets, and surface-mounted (i.e., as in a speaker phone configuration). Headsets may cover one ear (monaural) or two (binaural). A telephone system may interface with an announcing (public address) system.

Sound-Powered Phone System

Sound-powered telephone systems do not require a separate electrical power supply to transmit signals; the force of the user's speech upon the mouthpiece generates small electrical impulses, which are transmitted as a signal. Therefore, they may be beneficial for situations in which electricity is not available. Sound-powered telephones are connected to transmission wires and may be made portable by providing jacks at locations where the phone is to be used. If a sound-powered telephone system has multiple connections, it may be implemented as a “party line” unless a switching function is implemented. The switching function may be manual, unless supplemental power is provided for this function. Sound-powered telephones are often implemented with headsets. Sound-powered telephone systems require supplemental electrical power (e.g., a hand-operated crank) to energize a ringing function. In addition, the sound-powered transmitter may have an interface with a paging system so that the desired party can be called to the line.

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Portable Radio Transceivers

Portable radio transceivers include battery-powered communication devices that transmit messages through the airways rather than through wires.

Announcing (Public Address) System

These systems generally feature loudspeakers installed in predetermined locations. In some installations, microphone input may be provided through a telephone system connection. This allows users to access the announcing system from multiple locations. Some announcing systems provide two-way communication (e.g., via distributed microphones) allowing them to function as point-to-point intercom systems in addition to being public address systems.

Fixed-Based UHF Transceivers

Like portable radio transceivers, fixed-base UHF transceivers transmit messages through the airways. Fixed-base UHF transceivers are not portable but may have greater frequency response than portable radio transceivers.

Point-to-Point Intercom System

These systems provide two-way communications via a distributed set of microphones and speakers.

Emergency Communications

Emergency (i.e., backup) communications systems support internal and external communications during abnormal conditions.

Computer-Based Communications

Because of continued advances in computer-based technologies, many types of computer-based communications systems are possible. The systems use computers to support personnel in preparing, sending, and receiving messages. Computer-based communication systems may allow messages to be prepared, stored, and received in a variety of formats. For example, voice mail systems handle messages primarily in verbal format, while electronic mail may handle messages in text, graphic, and auditory forms. In addition, computer-based communication systems can initiate messages automatically, such as by sending a text or verbal message to a recipient when a particular condition occurs.

Computer-based communication systems also have the following are characteristics:

- Purpose – The purpose provides a basis for identifying and assessing the relevance and appropriateness of the functional capabilities and design features of a computer-based communication system. Some considerations to be addressed include the

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intended users of the system, the types of communication, the locations to be covered, and the conditions under which the system is to be used (e.g., normal operations versus emergencies).

- Functional Capabilities – Functional capabilities refers to the functions performed by the computer- based communication system. Specific considerations include: support for message preparation (e.g., data entry, formatting), message sending (e.g., address directories, message priority and reply capabilities), and message receipt (e.g., message filtering and selection; time stamps; storage and retrieval; methods of receipt such as via file, display, and printer; and annotation of received messages).
- Information Display – Information display, as described in Section 1, refers to the way that information is organized and presented to the user in terms of display elements, formats, and networks. It also includes the data quality and update characteristics and characteristics of the display devices. For an HFE design review, these characteristics should be identified for the computer-based communication system. General guidelines for information display are presented Section 3.1.
- User-System Interaction – User-system interaction refers to the types of interaction provided between the user and the computer-based communication system. It includes input formats, cursor characteristics, system response, the management of displays, the management of information, error response, and system security.
- Controls – The types of devices used to interact with the computer-based communication system should be identified, including computer-based input devices, conventional controls, and soft controls.
- Backup Capabilities – If the failure or loss of availability of the computer-based communication system may affect operator tasks that are important to plant safety, then backup systems and capabilities should be included in the characterization.
- Integration with Other HSI Components – The consistency and compatibility of the computer-based communication system with the rest of the HSI can affect operator performance. Thus, important review considerations include the degree to which controls and displays of the computer-based communication system are compatible with other controls and displays of the HSI. This extends to such considerations as display formats, coding schemes, and methods of operation.

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3.5.2 Requirements and Guidelines

3.5.2.1 General

3.5.2.1.1 Accessibility

ES-0304-1381-11690

Guideline: Communications functions and/or equipment should be accessible from the user's normal working location.

Additional Information: Where communication requirements necessitate the use of several handsets, the accessibility of their standby locations should be determined by operational priority, i.e., the most frequently or urgently needed handset should be the most accessible. The handsets may also be color coded.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.1

3.5.2.1.2 Instructions

ES-0304-1381-11692

Guideline: Instructions should be provided for use of each communication system, including suggested alternatives if a system becomes inoperable.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.1

3.5.2.1.3 Outgoing Emergency Messages

ES-0304-1381-11694

Guideline: Priority procedures should be established for the transmission of emergency messages from the control room by any of the communication systems.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.1

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3.5.2.1.4 Incoming Emergency Messages

ES-0304-1381-11696

Guideline: Procedures should be established for handling communications during an emergency, and these procedures must be known by all users.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.1

3.5.2.1.5 Minimal User Actions

ES-0304-1381-11698

Guideline: Communication systems should be designed to minimize required user actions.

Additional Information: In some applications, for example, software logic might prepare and transmit messages automatically, derived from data already stored in the computer; software logic might provide automatic reformatting of stored data for transmission, where format change is required; and interface software might provide automatic insertion into messages of standard header information, and distribution lists.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.1

3.5.2.1.6 Communication Flexibility

ES-0304-1381-11700

Guideline: Users should have flexibility in communications methods.

Additional Information: Where communications are critical, users should not be precluded from communicating with other plant personnel by the loss of one method.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.1

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3.5.2.2 Speech-Based Communications

3.5.2.2.1 Comfort

ES-0304-1381-11702

Guideline: Communication equipment to be worn should be designed to preclude discomfort.

Additional Information: Supporting structures for earpieces should not impose discomforts of weight, concentrated pressures, or metal contact with the skin.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.2 Hands-Free Operation

ES-0304-1381-11704

Guideline: Communication equipment should be designed to permit hands-free operation.

Additional Information: Hands-free operation may have to be compromised to accommodate a push-to- talk switch in anticipation of possible use in areas of high ambient noise.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.3 Frequency Response

ES-0304-1381-11706

Guideline: Microphones and associated amplification equipment should be designed to respond optimally to that part of the speech spectrum most essential to speech intelligibility (i.e., 200 to 6,100 Hz).

Additional Information: Where system engineering necessitates speech-transmission dynamic range bandwidths narrower than 200 to 6,100 Hz, the minimum acceptable frequency range is 250 to 4,000 Hz. The system should achieve at least standard telephone sound quality.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.4 Microphone Dynamic Range

ES-0304-1381-11708

Guideline: The dynamic range of a microphone used with a selected amplifier should be great enough to admit variations in signal input of at least 50 dB.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.5 Microphone Noise Shields

ES-0304-1381-11710

Guideline: When ambient noise is high (85 dB(A) or greater), the microphone should be put in a noise shield.

Additional Information: Noise shields should be designed to meet the following requirements:

- Volume of at least 15.25 cubic inches (250 cubic centimeters) to permit a pressure gradient microphone to function normally
- A good seal against the face with the pressure of the hand or tension of straps
- A hole or combination of holes covering a total area of 0.1 in (65 mm) in the shield to prevent pressure buildup
- Prevention of a standing wave pattern by shape or by use of sound absorbing material
- No impediment to voice effort, mouth or jaw movement, or breathing

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

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3.5.2.2.6 Noise-Canceling Microphones

ES-0304-1381-11712

Guideline: In very loud, low frequency noise environments (100 dB overall), noise-canceling microphones should be used.

Additional Information: The noise-canceling microphones should be capable of effecting an improvement of not less than 10 dB peak speech-to-root-mean-square-noise ratio, as compared with non-noise- canceling microphones of equivalent transmission characteristics.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.7 Signal Processing

ES-0304-1381-11714

Guideline: If the environment or the speech transmission equipment is such that the signal-to-noise ratio of the speech is degraded, signal-processing techniques should be used to maintain speech intelligibility.

Additional Information: Where speech signals are to be transmitted over channels showing less than 15 dB peak speech-to-root-mean-square-noise ratios, peak clipping of 12 to 20 dB may be employed at system input. If necessary, clipping may be preceded by frequency pre-emphasis. The frequency pre- emphasis should have a positive slope frequency characteristic no greater than 18 dB per octave from 140 to 1,500 Hz, and no greater than 9 dB per octave over the frequency range 1,500 to 4,800 Hz, when no clipping is used. When transmission equipment employs pre-emphasis and peak clipping is not used, reception equipment should employ frequency de-emphasis of characteristics complementary to those of pre-emphasis only if it improves intelligibility. Frequency de-emphasis should be a negative-slope frequency response not greater than 9 dB per octave over the frequency range 140 to 4,800 Hz.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

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3.5.2.2.8 Speaker Frequency Range

ES-0304-1381-11716

Guideline: Loudspeakers, earpieces, and headphone elements should respond uniformly (plus or minus 5 dB) over the range 100 to 4,800 Hz.

Additional Information: Headphones and loudspeakers are subject to the same frequency response restrictions as microphones and transmission equipment.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.9 Binaural Headsets For High Noise Environments

ES-0304-1381-11718

Guideline: If listeners will be working in high ambient noise (85 dB(A) or above), binaural headsets should be provided rather than monaural headsets.

Additional Information: Unless operational requirements dictate otherwise, binaural headsets should be wired so that the sound reaches the two ears in opposing phases. Their attenuation qualities should be capable of reducing the ambient noise level to less than 85 dB(A). Provisions should be incorporated to furnish the same protection to those who wear glasses.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.10 Loudspeakers for Multi-Channel Monitoring

ES-0304-1381-11720

Guideline: When several channels are to be monitored simultaneously by means of loudspeakers, the speakers should be mounted at least 10 degrees apart in the horizontal plane frontal quadrant, ranging radially from 45 degrees left to 45 degrees right of the user's normal forward facing position.

Additional Information: When additional channel differentiation is required, apparent lateral separation should be enhanced by applying low-pass filtering (frequency cutoff, Fc = 1,800 Hz) to signals fed to loudspeakers on one side of the central user position. If

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there are three channels involved, one channel should be left unfiltered, a high pass filter with 1,000 Hz cutoff should be provided in the second channel, and a low-pass filter with 2,500 Hz cutoff should be provided in the third channel. A visual signal should be provided to show which channel is in use.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.11 Volume Controls

ES-0304-1381-11722

Guideline: Accessible volume or gain controls should be provided for each communication receiving channel (e.g., loudspeakers or headphones) with sufficient electrical power to drive sound pressure level to at least 100 dB overall when using two earphones.

Additional Information: The minimum setting of the volume control should be limited to an audible level; i.e., it should not be possible to inadvertently disable the system with the volume control. While separation of power (on-off) and volume control adjustment functions into separate controls is preferred, should conditions justify their combination, a noticeable detent position should be provided between the OFF position and the lower end of the continuous range of volume adjustment. When combined power and volume controls are used, the OFF position should be labeled. Speaker volume should be adjusted to ensure that speaker communications will not prevent detection of other audio signals, e.g., alarms.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.12 Squelch Control

ES-0304-1381-11724

Guideline: When communication channels are to be continuously monitored, each channel should be provided with a signal-activated switching device (squelch control) to suppress channel noise during no-signal periods.

Additional Information: A manually operated on-off switch should be provided to deactivate the squelch when receiving weak signals.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.2.13 Periodic Maintenance Tests

ES-0304-1381-11726

Guideline: Periodic tests should be performed on all communication systems to ensure that messages remain intelligible under changes in ambient noise levels that may have occurred since the last check.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.1

3.5.2.3 Conventional Phone System

3.5.2.3.1 Handset Size and Shape

ES-0304-1381-11728

Guideline: The size and shape of handsets should be compatible with user's hand size and mouth-ear distance (standard telephone dimensions are acceptable).

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

3.5.2.3.2 Handset Design

ES-0304-1381-11730

Guideline: Handset earpieces should maintain firm ear contact while the transmitter is positioned in front of the mouth.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

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3.5.2.3.3 Retractable Handset Cords

ES-0304-1381-11732

Guideline: Cords should be of non-kink or self-retracting type.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

3.5.2.3.4 Handset Cord Length

ES-0304-1381-11734

Guideline: Cords should be of sufficient length to permit reasonable user mobility.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

3.5.2.3.5 Handset Cord Position

ES-0304-1381-11736

Guideline: Cords should be positioned so as to avoid entangling critical controls or endangering passing traffic.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

3.5.2.3.6 Handset Cradles

ES-0304-1381-11738

Guideline: Vertically mounted handset cradles should be designed and located to prevent the handset from being knocked out of the cradle by passing traffic.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

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Reference: NUREG-0700-10.2.2

3.5.2.3.7 Multiple Instruments

ES-0304-1381-11740

Guideline: Where multiple telephone instruments are located close together (e.g., on a single desk), they should be coded to indicate circuit or function.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

3.5.2.3.8 Press-to-Talk Button

ES-0304-1381-11742

Guideline: If a press-to-talk button is used, the button should be convenient to both left- and right-hand operation.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

3.5.2.3.9 Switching Mechanism

ES-0304-1381-11744

Guideline: Switching should be designed and/or programmed to minimize delay in making desired connections under both normal and emergency conditions.

Additional Information: Usually the switching function is accomplished by dial switching, and the switching mechanism is located in-plant. Switching should be programmed to give the control room automatic priority of access to the switching system.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

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3.5.2.3.10 Telephone Ringing

ES-0304-1381-11746

Guideline: The volume of ringing should be adjustable at the individual telephone instrument.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

3.5.2.3.11 Announcing Use

ES-0304-1381-11748

Guideline: The transmitter should be compatible with the rest of the announcing system when used as the microphone input to the announcing system.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.2

3.5.2.4 Sound-Powered Phone System

3.5.2.4.1 Feedback

ES-0304-1381-11750

Guideline: Within engineering constraints imposed by sound-powering, the system should provide in-phase feedback to the user.

Additional Information: In control room use, sound-powered phones are generally of the headset variety (either one or two earphones and a boom microphone in an assembly fitting on the head). Sound-powered phones are independent of external power, a feature of value in emergency use. Additionally, the headset configuration, used with conveniently located plug-in jacks, provides mobility for the user when moving to remote locations (back panels or outside the control room).

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.3

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3.5.2.4.2 Ringing

ES-0304-1381-11752

Guideline: If ringing is not installed, the user should be able to switch the sound-powered transmitter to the paging system so that a desired party can be called to the line.

Additional Information: Sound-powered phones require supplemental power, which is often hand- generated, to energize a ringing function. Often sound-powered phone circuits have no provision for ringing. Need for ringing must be determined for the individual plant depending on the sound-powered phone procedures.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.3

3.5.2.4.3 Jack Provisions

ES-0304-1381-11754

Guideline: Plug-in jacks for the sound-powered system should be provided within the control room.

Additional Information: Jacks should be located close to the workstations to prevent the need for unduly long cords. Jacks should not accommodate plugs of the conventionally powered phone system, in order to avoid wrong instrument-system connections.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.3

3.5.2.4.4 Switching

ES-0304-1381-11756

Guideline: When used, patch panels should be conspicuously marked and located in reasonably accessible places.

Additional Information: These requirements are particularly critical in back-panel areas. A complete set of cords should be provided at each panel if cord-type patching is used. The requirements for switching must be assessed for the individual plant depending on procedures for use of sound-powered phones.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.3

3.5.2.4.5 Cushioning of Earpieces

ES-0304-1381-11758

Requirement: Earphone cushioning to provide comfort for extended periods of wear.

HSI Design Criteria

While the communications system is not part of the NuScale HFE groups effort the HFE design team is in the Communication System Requirements review chain where we will ensure this requirement is included in the design.

Reference: NUREG-0700-10.2.3

3.5.2.4.6 Fit of Earpieces

ES-0304-1381-11760

Guideline: Earpieces should cover the outer ear without causing uncomfortable pressure.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.3

3.5.2.4.7 Fit of Headsets

ES-0304-1381-11762

Guideline: The headset should be held firmly in place, yet be easy to remove.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.3

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3.5.2.4.8 Storage of Headsets

ES-0304-1381-11764

Guideline: A well-marked and accessible place should be provided for headset stowage.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.3

3.5.2.5 Portable Radio Transceivers

3.5.2.5.1 Appropriate Use

ES-0304-1381-11766

Guideline: Walkie-talkies should be used in both emergency and normal operations for two-way communications beyond the range of installed telephone connections or as a convenient alternative to the sound-powered telephone.

Additional Information: However, each licensee/applicant who intends to use radio communications should determine the extent to which radio interference could adversely affect control room operations.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.4

3.5.2.5.2 Sound Quality

ES-0304-1381-11768

Guideline: Walkie-talkies should realize the same quality desired throughout all of the communications systems within the engineering constraints imposed by radio frequency spectrum availability and by design for easy portability.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.4

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3.5.2.5.3 Area Coverage

ES-0304-1381-11770

Guideline: Modulation and a radio frequency should be chosen, as FCC regulations permit, to provide broad-area walkie-talkie communication to the control room.

Additional Information: One consideration for frequency selection should be radio-wave penetration of metal or reinforced concrete barriers, which at certain frequencies, would tend to attenuate or bounce the signal. Use of walkie-talkies should be prohibited in areas close to low-level analog or digital equipment, unless EMI noise susceptibility tests have been conducted that demonstrate that the equipment is not affected by the frequency bands used.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.4

3.5.2.5.4 Portability

ES-0304-1381-11772

Guideline: To the extent permitted by design for effective electrical/radio frequency function, walkie-talkies should be small, light, and easy to carry. The microphone should be integrated into the transceiver package.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.4

3.5.2.5.5 Party Identification

ES-0304-1381-11774

Guideline: Procedures should provide for unambiguous identification of the speaker when there are more than two parties on a channel operating at separate locations.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.4

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3.5.2.5.6 Battery Replenishment

ES-0304-1381-11776

Guideline: A supply of fresh replacement batteries should be stowed in an accessible, well-marked space.

Additional Information: The stock should be kept large enough to support long periods of continuous operation in case of emergency.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.4

3.5.2.6 Announcing (Public Address) System

3.5.2.6.1 Intelligibility and Coverage

ES-0304-1381-11778

Guideline: The system should provide rapidly intelligible messages to all areas where personnel subject to a page may be located.

Additional Information: Adequate coverage requires that speakers should be placed so that they are available in all necessary areas and that there are no "dead spots" within any area.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.5

3.5.2.6.2 Microphone Characteristics

ES-0304-1381-11780

Guideline: If the powered telephone system is used to provide microphone input to the announcing system, the telephone system should contain transmitters of quality compatible with that of the announcing system.

Additional Information: Frequency response should be compatible with that of the rest of the system. Microphones should have high sensitivity to speech signals. Microphone input should be provided within the control room.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.5

3.5.2.6.3 Loudspeaker Location

ES-0304-1381-11782

Guideline: Speakers should be provided in the control room and other areas where personnel might be (e.g., restrooms, eating areas, and locker rooms).

Additional Information: Speakers should be placed to yield an intelligible level of signal throughout the area.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.5

3.5.2.6.4 Speech Clarity

ES-0304-1381-11784

Guideline: Since proper speech over an announcing system differs from normal conversation, users should be familiarized with the proper way to speak on the announcing system.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.5

3.5.2.6.5 Loudspeaker Volume

ES-0304-1381-11786

Guideline: Speaker volume should be adjusted to ensure that speaker communications will not prevent detection of auditory alarms.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.5

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3.5.2.6.6 Priority

ES-0304-1381-11788

Guideline: Control room inputs to the plant announcing system should have priority over any other input.

Additional Information: The control room input should be capable of interrupting an announcement in progress, or of bypassing queued announcements.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.5

3.5.2.7 Other Types of Communication Systems

3.5.2.7.1 Fixed-Base UHF Transceivers

ES-0304-1381-11790

Guideline: A fixed-base UHF transceiver may be used for normal emergency communications between the control room and the following locations similarly equipped with fixed-base transceivers: Dispatcher, Security, and Utility Headquarters (if within UHF range).

Additional Information: Procedures should be established (and conspicuously posted) for use of the system. Each licensee/applicant who intends to use radio communications should determine the extent to which radio interference could affect control room operations.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.6

3.5.2.7.2 Point-to-Point Intercom Systems

ES-0304-1381-11792

Guideline: Intercom systems should be provided to interconnect the control room with important plant areas and other areas where control room or operating personnel might be.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.6

3.5.2.8 Emergency Communications

3.5.2.8.1 Backup Equipment

ES-0304-1381-11794

Guideline: Provisions should be made to assure complete internal and external communications capabilities during emergencies.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.7

3.5.2.8.2 Equipment Usability

ES-0304-1381-11796

Guideline: Communications equipment should be usable by personnel wearing protective gear without impediment to their tasks.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.7

3.5.2.8.3 Voice Communications with Masks

ES-0304-1381-11798

Guideline: Emergency facemasks should be equipped with diaphragms that are specially designed to transmit speech.

Additional Information: The diaphragms should be able to separate voice from exhaust valve action. If not equipped with diaphragms, masks should be equipped with electronic speech systems that pick up the voice with an internal microphone and transmit it to a loudspeaker attached outside the mask.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.2.7

3.5.2.9 Computer-Based Communications

3.5.2.9.1 Interaction With Ongoing Tasks

ES-0304-1381-11802

Guideline: Users should be able to communicate with each other without canceling ongoing tasks.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.1

3.5.2.9.2 Interactive Communication

ES-0304-1381-11800

Guideline: Users should be able to communicate interactively with other users who are currently using the same system.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.1

3.5.2.9.3 Functional Integration

ES-0304-1381-11804

Guideline: Computer-based communications should be integrated with other information handling functions within a system.

Additional Information: A user should not have to log off from the process monitoring system and log on to some other special system in order to send or receive a message. If data transmission facilities are in fact implemented as a separate system, that separation should be concealed in user interface design, so that a user can move from general information handling to message handling without interruption.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.1

3.5.2.9.4 Consistent Procedures

ES-0304-1381-11806

Guideline: Procedures for sending and receiving messages should be consistent from one transaction to another.

Additional Information: Procedures should be the same for handling different kinds of messages and for messages sent to different destinations, although procedures for handling high-priority messages might incorporate special actions to ensure special attention.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.1

3.5.2.9.5 Control by Explicit User Action

ES-0304-1381-11808

Guideline: Both sending and receiving messages should be accomplished by explicit user action.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.1

3.5.2.9.6 Automatic Queuing

ES-0304-1381-11810

Guideline: The computer should provide automatic queuing of outgoing messages pending confirmation of transmission, and incoming messages pending their review and disposition.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.1

3.5.2.9.7 Interrupt

ES-0304-1381-11812

Guideline: Users should be able to interrupt message preparation, review, or disposition, and then resume any of those tasks from the point of interruption.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.1

3.5.2.9.8 Message Highlighting

ES-0304-1381-11814

Guideline: Software capabilities should be provided to annotate transmitted data with appropriate highlighting to emphasize alarm/alert conditions, priority indicators, or other significant information that could affect message handling.

Additional Information: Highlighting will aid the handling and interpretation of messages. Such annotation might be provided automatically by software logic (e.g., a computer-generated date-time stamp to indicate currency), or might be added by the sender of a message to emphasize some significant feature (e.g., attention arrows), or by the receiver of a message as an aid in filing and retrieval.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.1

3.5.2.9.9 Automatic Record Keeping

ES-0304-1381-11816

Guideline: A log of data transmissions should be automatically maintained.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.1

3.5.2.10 Messaging

3.5.2.10.1 Automatic Message Formatting

ES-0304-1381-11818

Guideline: When message formats should conform to a defined standard or structure, prestored formats should be provided to aid users in message preparation.

Additional Information: When information must be transmitted in a particular format, computer aids should be provided to generate the necessary format automatically.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.2

3.5.2.10.2 Message Composition Compatible with Data Entry

ES-0304-1381-11820

Guideline: Procedures for composing messages should be compatible with general data entry procedures, especially those for text editing.

Additional Information: A user should not have to learn procedures for entering message data that are different from those for general data entry.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.2

3.5.2.10.3 Variable Message Length

ES-0304-1381-11822

Guideline: Users should be able to prepare messages of any length.

Additional Information: In particular, data transmission facilities should not limit the length of a message to a single display screen or to some fixed number of lines. There will

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usually be some implicit limit on message length imposed by storage capacity or the amount of time it would take to transmit a very long message. However, a user might sometimes choose to increase storage or accept transmission delays in order to send a long message required by a particular task.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.2

3.5.2.10.4 Incorporate Existing Files

ES-0304-1381-11824

Guideline: Users should be able to incorporate an existing data file in a message, or to combine several files into a single message for transmission.

Additional Information: It should not be necessary for a user to re-enter for transmission any data already entered for other purposes or available in the system. It should be possible to combine stored data with new data when preparing messages for transmission.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.2

3.5.2.10.5 Message Editing

ES-0304-1381-11826

Guideline: Users should be able to save and edit messages prior to transmission.

Additional Information: Users should be able to save draft messages during their preparation. A user should not be forced to recreate a message if its preparation is interrupted for some reason. Users should be able to specify how to save draft messages (i.e., in what file), just as they may decide how to save copies of transmitted and received messages.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.2

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3.5.2.10.6 Destination Selection

ES-0304-1381-11828

Guideline: Users should be able to specify the destination(s) to which messages will be transmitted.

Additional Information: Specification of message destination might be in terms of system users, as individuals or groups, or other workstations and terminals (including remote printers), or users of other systems. Standard destinations may be specified as a matter of routine procedure, with special destinations designated as needed for particular transactions. For most applications, it is important that users be able to send a message to multiple destinations with a single transmission action. For multiple recipients, it will usually be helpful to show all addresses to all recipients, so that they will know who else has received the message.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.7 Address Directory

ES-0304-1381-11830

Guideline: Users should be provided with a directory showing all acceptable forms of message addressing for each destination in the system, and for links to external systems.

Additional Information: In addition to the names of people, users may need to find addresses for organizational groups, functional positions, other computers, data files, workstations, and devices. The directory should include specification of system distribution lists as well as individual addresses.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.8 Aids for Directory Search

ES-0304-1381-11832

Guideline: Computer aids should be provided so that a user can search an address directory by specifying a complete or partial name.

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Additional Information: Users will often remember a partial address, even if they cannot remember its complete form.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.9 Extracting Directory Addresses

ES-0304-1381-11834

Guideline: Users should be able to extract selected addresses from a directory or select a distribution list for direct insertion into a header in order to specify the destination(s) for a message.

Additional Information: Direct insertion of addresses from a directory will avoid errors that a user might make in manual transcription and entry, and is faster.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.10 Automatic Addressing of Reply

ES-0304-1381-11836

Guideline: The appropriate address(es) should be provided automatically for users responding to messages.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.11 Assignment of Priority

ES-0304-1381-11838

Guideline: When messages will have different degrees of urgency, the sender of a message should be allowed to designate its relative priority.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.12 Information About Communication Status

ES-0304-1381-11840

Guideline: Users should be allowed access to status information concerning the identity of other system users currently on-line, and the availability of communication with external systems.

Additional Information: Such information may influence a user's choice of destinations and choice of communication methods, as well as the decision when to initiate transmission. For example, a user might choose to link directly with another user who is currently on-line, but might compose a message for deferred transmission to an inactive user.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.13 Sender Identification

ES-0304-1381-11842

Guideline: When a message is sent, the computer should show the sender's address, and the date and time of message creation and/or transmission.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.14 Deferring Message for Automatic Transmission

ES-0304-1381-11844

Guideline: Users should be able to defer the transmission of prepared messages, to be released by a later action.

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Additional Information: A user might wish to defer data transmission until some specified date-time or until a specific event has occurred.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.15 Automatic Feedback

ES-0304-1381-11846

Guideline: Automatic feedback for data transmission confirming that messages have been sent or indicating transmission failures should be provided to permit effective user participation in message handling.

Additional Information: If message transmission is not successful, the sender should be notified, if possible with an explanation of the problem. It may help a user to know whether transmission has failed because of faulty addressing, communication-link failure, or some other reason, in order to take appropriate corrective action.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.16 Saving Undelivered Messages

ES-0304-1381-11848

Guideline: If message transmission is not successful, automatic storage of undelivered messages should be provided.

Additional Information: Transmission failure should not cause loss or destruction of messages, and should not disrupt the sender's work in any other way.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

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3.5.2.10.17 Message Cancellation

ES-0304-1381-11850

Guideline: Users should be able to recall any message whose transmission has been initiated, if it has not yet been received by its addressee(s).

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.18 User Review of Data Before Transmission

ES-0304-1381-11852

Guideline: When human judgment may be required to determine whether data are appropriate for transmission, users (or a system administrator) should be provided some means to review outgoing messages and confirm their release before transmission.

Additional Information: Sometimes message release may require coordination among several reviewers in the interest of data protection.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

3.5.2.10.19 Saving Transmitted Data Until Receipt is Confirmed

ES-0304-1381-11854

Guideline: A copy of any transmitted message should be saved automatically until correct receipt has been confirmed.

Additional Information: The primary objective is to prevent irretrievable data loss during transmission. For many system applications, however, the originator of a message will probably want to retain a copy in any case. Any subsequent deletion of that copy should probably be handled as a separate transaction, distinct from data transmission.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.3

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3.5.2.10.20 Message Notification at Logon

ES-0304-1381-11856

Guideline: When users log on to a system, they should be notified of any transmissions received since their last use of the system.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.21 Display of Messages

ES-0304-1381-11858

Guideline: The display of messages from other users should be visually and spatially distinct from the display of system messages.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.22 Nondisruptive Message Notification

ES-0304-1381-11860

Guideline: Notification of incoming messages should be nondisruptive.

Additional Information: Notification of incoming messages should not interrupt the user's current task and should not automatically overwrite the screen areas where the user is working. For example, the system might indicate message arrival to the user by an advisory notice in a portion of the display reserved for that purpose.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

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3.5.2.10.23 Indicating Priority of Received Messages

ES-0304-1381-11862

Guideline: Where incoming messages will have different degrees of urgency, recipients should be notified of message priority and/or other pertinent information.

Additional Information: Notification of urgent messages might be routed to a special area of a user's working display for immediate reference, whereas notification of routine messages might be deferred, or perhaps routed to a printer for review at the user's convenience. If incoming messages are queued so that their arrival will not interrupt current user tasks, then users should be advised when an interruption is, in fact, necessary.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.24 Filters for Message Notification

ES-0304-1381-11864

Guideline: Users should be able to specify "filters" based on message source, type, or content, that will control what notification is provided for incoming messages.

Additional Information: For example, a user might wish the arrival of all messages from a particular source to produce a special notification.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.25 Time-Stamp Messages

ES-0304-1381-11866

Guideline: Messages should be time-stamped.

Additional Information: The time stamp should provide information needed to manage messages. Some types of time stamps include: date and time of message origin, release, receipt at receiving station, and opening by user.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.26 Indicate Message Size

ES-0304-1381-11868

Guideline: Some indication of message size should be included at the beginning of each message.

Additional Information: For example, message size might be calculated as number of lines and indicated in its header.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.27 Indication of Message Overflow

ES-0304-1381-11870

Guideline: The user should be informed when a message has been truncated, such as when a message exceeds the available space.

Additional Information: An end-of-message indicator that is automatically generated when a message is transmitted can help the user verify that the message is complete.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.28 Message Storage and Retrieval

ES-0304-1381-11872

Guideline: Messages should be stored in a message queue that is available to the user.

Additional Information: For example, the user might be able to scroll through a log file containing the message, time, date, and origin.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.29 Information about Queued Messages

ES-0304-1381-11874

Guideline: Users should be able to review summary information about the type, source, priority, and size of queued incoming messages.

Additional Information: In some applications, a user might need notification only of urgent messages, and may rely on periodic review to deal with routine messages. Summary information about queued incoming messages should help guide message review.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.30 User Selection of Messages

ES-0304-1381-11876

Guideline: The user should be allowed to select any message from an ordered queue with a simple action.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.31 Annotating Received Messages

ES-0304-1381-11878

Guideline: Users should be able to append notes to a received message, and ensure that the annotation will be displayed so that it will be distinct from the message itself.

Additional Information: Users should not be allowed to make changes in received messages. Any such changes would simply provide too much chance for resulting confusion. However, users should be able to append, file, and display their own

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comments about received messages in some distinctively separate form. If changes are desired in a message itself, then its recipient might make a copy of that message (with appropriate change of its header information) and then edit the copy.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

3.5.2.10.32 Specifying Device Destination

ES-0304-1381-11880

Guideline: Users should be able to choose the method of receipt, i.e., what device (file, display, and printer) will be the local destination. If a specified receiving device is not operable, such as a printer that is not turned on, the user should be advised.

Additional Information: When messages are received via display, queuing of incoming messages should be provided so that they will not interfere with use of that display for other information handling tasks. Device destination might be specified differently for various types of messages, or for messages received from different sources. Transmitted data might be received directly into computer files. Incoming messages might be routed to an electronic display for quick review, and/or to a printer for hardcopy reference.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-10.3.4

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3.6 Workstation Design

3.6.1 Definitions

Workstation Configuration

HSI elements are organized into workstations, where the operators perform their functions and tasks. Types of workstations include sit-stand workstations, stand-up consoles, sit-down consoles, vertical panels, and desks (e.g., used by personnel when performing tasks related to the operation and safety of the plant in the main control room). The operators' performance may be affected by design characteristics that affect reach, vision, and comfort. Unique considerations for these types of workstations include the following:

- Workstation height (i.e., for workstations that the operator must see over)
- Benchboard slope, angle, and depth for consoles and sit-stand workstations (i.e., accommodations for reach; provision of writing space)
- Control device location (i.e., placement of highest and lowest controls; distance from front edge of workstation)
- Display device location (i.e., placement of highest and lowest display devices, orientation relative to line of sight, viewing distance, position of frequently and infrequently monitored display devices)
- Lateral spread of control and display devices at a console or workstation
- Clearances for legs and feet.

In addition, the workstation design includes the seating provided for personnel at the consoles or desks. Important considerations include mobility; rests for back, arms, and feet; seat adjustability, and cushioning. Review guidelines for workstation configuration are provided as follows: stand-up consoles in Section 3.6.2.1, sit-down consoles in Section 3.6.2.2, sit-stand workstations in Section 3.6.2.3, vertical panels in Section 3.6.2.4, desks in Section 3.6.2.5, and chairs in Section 3.6.2.6.

Control and Display Layout

Control and display devices are not usually used in isolation. Often groups of devices are used together to perform a task. Therefore, the following relationships among devices should be addressed:

- Grouping of related controls or displays (i.e., by sequence of use, frequency of use, and importance)
- Control devices (i.e., spacing; interference with access; inadvertent actuation of adjacent controls; simultaneous actuation of controls)
- Display devices (i.e., row arrangement; string length)

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- Control-display layout integration (e.g., orientation, proximity, obscuration, and indication of association) for
    - a single control and display pair
    - multiple controls and a single display
    - a single control and multiple displays
- Dynamic control-display relationships (i.e., response compatibility between controls, including rotary and linear devices, and displays, such as linear scales, digital displays, indicator light strings, and circular meter points)
- Between-group and within-group relationships (i.e., control and display modules; repeated groups and functions; mirror-image layouts)

Review guidelines for control and display device layout are provided in Section 3.6.2.7.

Labeling and Demarcations

Labels and demarcations can help operators find and identify controls, displays, and other equipment.

Labels

Permanent labels may be used for panels, groups of controls and displays, individual items, instructions, control direction, and access openings. In addition, temporary labels may be used for such purposes as tagging-out equipment. The following characteristics of labels are important to operator performance:

- Location (i.e., proximity of adjacent labels; orientation; surface mounting considerations)
- Content (i.e., information content, distinguishability, consistency, and agreement with procedures)
- Lettering (i.e., character height, width, font, spacing, stroke width, and contrast with background)

Demarcation

Demarcation lines are used to identify workstation sections and groups of controls and displays. Important characteristics include contrast, consistency, and permanence. Another important consideration is the rationale that was used in applying them (e.g., the types of controls and displays they enclose). Review guidelines for labels and demarcations are provided in Section 3.6.2.8.

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3.6.2 Requirements and Guidelines

3.6.2.1 Stand-Up Console

3.6.2.1.1 Console Height to See Over

ES-0304-1381-11914

Guideline: Console height (with or without annunciator panels) should not exceed 58 inches when it is necessary for a user standing at the console to see over its top.

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

3.6.2.1.2 Control Height

ES-0304-1381-11916

Guideline: The highest control on a stand-up console should be within the highest reach of the 5th percentile female without stretching or using a stool or ladder, while the lowest controls should be within the lowest reach of the 95th percentile male without bending or stooping, as shown in Table 3-9**.**

Additional Information: The range of suitable control height on stand-up consoles is defined by the reach radius of the 5th and 95th percentiles. Measurements should be made using shoulder height and functional reach with the shoulder in line with the leading edge of the benchboard, as shown in Figure 3-13. The figure shows the results of two console designs with differing benchboard slope and depth. Controls may be placed somewhat higher on consoles with shallower and/or more steeply angled benchboards, which allow the shoulder reference point to be closer to the back of the benchboard and to the vertical panel.

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

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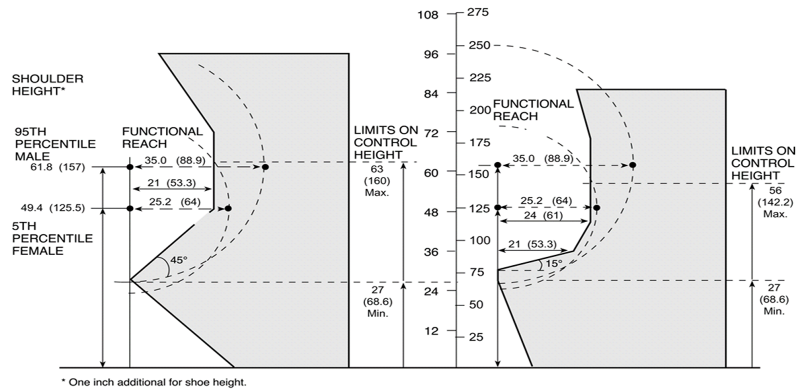

Figure 3-13. Reach capabilities and control height for two stand-up consoles

Table 3-9. Anthropometric data used to set limits for equipment dimensions

Standing (without shoes)	Bounding Measurements (inches)	
	5th %-ile Adult Female	95th %-ile Adult Male[1]
Stature	60.0	73.5
Eye height from floor	55.5	68.6
Shoulder height	48.4	60.8
Elbow height	37.4	46.8
Fingertip height[2]	24.2	28.8
Functional reach[3]	25.2	35.0
Extended functional reach[4]	28.9	39.0
Central axis of body to leading edge of console[5]	5.0	5.3
Eye distance forward of central axis to body[5]	3.0	3.4
Seated	**Bounding Measurements (inches)**	
	5th %-ile Adult Female	95th %-ile Adult Male[1]
Popliteal height (bend at back of knee)	15.0	19.2
Sitting height above seat surface (erect)	31.1	38.5
Sitting height above seat surface (relaxed)	30.5	37.6
Eye height above seat, sitting erect	26.6	33.6
Shoulder height above seat surface	19.6	25.8
Elbow height above seat surface	6.4	11.3
Functional reach	25.2	35.0
Extended functional reach	28.9	39.0
Thigh clearance height	4.1	7.4
Buttock-popliteal length	17.1	21.5
Knee height	18.5	23.6
Central axis of body to leading edge of console[5]	5.0	5.3
Eye distance forward of central axis of body[5]	3.0	3.4

(Source: MIL-STD-1472D, Section 5.6.)

1. MIL-STD-1472D gives separate values for male troops and aviators. The two were averaged for presentation here.

2. Data for male aviators only, 5th and 95th percentiles.

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3. Measured from wall to tip of right index finger, with arm extended horizontal to floor, both shoulders against wall.

4. Measured as stated above, except right shoulder extended as far as possible with left shoulder against wall.

5. These measurements are not given in MIL-STD-1472D. Values provided in Seminara et al. are presented although they are based on measures of a different population. Differences in other measurements between the MIL-STD population and the EPRI population are small enough that these EPRI values should provide reasonable app

3.6.2.1.3 Benchboard Slope

ES-0304-1381-11995

Guideline: The benchboard slope, in conjunction with its depth, should result in all controls being within the reach radius of the 5th percentile female, as shown in Table 3-9 and illustrated in Figure 3-13.

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

3.6.2.1.4 Minimum Distance of Controls from the Front Edge of the Console

ES-0304-1381-11997

Guideline: Controls should be set back a minimum of 3 inches from the front edge to protect against accidental activation.

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

3.6.2.1.5 Maximum Distance of Controls from the Front Edge of the Console

ES-0304-1381-11999

Guideline: Controls should be no more than 25 inches from the front edge of the console.

Additional Information: This accommodates the maximum reach of the 5th percentile female adult as illustrated in Figure 3-13.

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HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

3.6.2.1.6 Display Height and Orientation

ES-0304-1381-12001

Guideline: All displays, including alarm indicators, should be within the upper limit of the visual field (75 degrees above the horizontal line of sight) of the 5th percentile female (see Table 3-9), and should be mounted so that the interior angle between the line of sight and the display face is 45 degrees or greater (see Figure 3-14).

Additional Information: The 5th percentile female determines the upper limit. The 95th percentile male determines the lower limit. The principal factors affecting the readability of displays, including annunciator tiles, are: (1) display height and orientation relative to the user's line of sight when standing directly in front of the display; (2) display distance and orientation relative to the user's straight-ahead line of sight when the user must read the display from an off-side position; and (3) the size of display markings relative to the distance at which the display must be read. Character size is addressed in Appendix A, Text, and is not considered here. Except as specifically noted, measurements of angles should be made with the eye point in line with the leading edge of the benchboard.

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

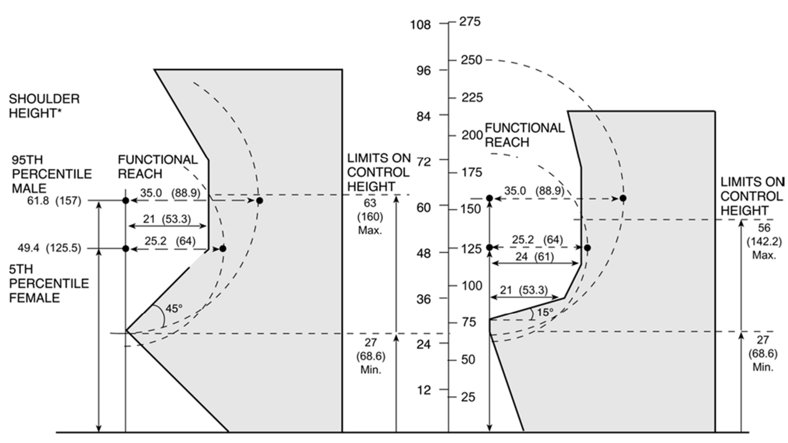

Figure 3-14. Display height and orientation relative to a standing user's line of sight

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3.6.2.1.7 Location of Frequently Monitored Displays

ES-0304-1381-12004

Guideline: Displays that require frequent or continuous monitoring, or that may display important (e.g., alarm) information, should be located not more than 35 degrees to the left or right of the user's straight-ahead LOS, and not more than 35 degrees above and 25 degrees below the user's horizontal LOS, measured from the normal workstation.

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

3.6.2.1.8 Location of Infrequently Monitored Displays

ES-0304-1381-12006

Guideline: Displays that do not require frequent or continuous monitoring, and that will not display important (e.g., alarm) information, should be located not more than 95 degrees to the left or right of the user's straight- ahead LOS, as measured from normal workstations.

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

3.6.2.1.9 Lateral Spread of Controls and Displays

ES-0304-1381-12008

Guideline: The maximum lateral spread of controls and displays at a single-user workstation should not exceed 72 inches.

Additional Information: The user should be able to perform task sequences at a given work station with minimum repositioning. The amount of movement required depends on the arrangement of controls and displays, not simply on the lateral dimensions of the segments of the control board.

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

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3.6.2.1.10 Foot Room

ES-0304-1381-12010

Guideline: Enough foot room should be provided to allow the user to get close to the board without leaning.

Additional Information: A clearance of 4 inches vertically and horizontally is recommended.

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.1

3.6.2.2 Sit-Down Console

3.6.2.2.1 Console Height to See Over

ES-0304-1381-12012

Guideline: Console height should be no more than approximately 27 inches above the seat to accommodate the 5th percentile adult female when a seated user must see over the console. Assuming seat height is adjusted to 18 inches, maximum console height therefore should be 45 inches above the floor.

Additional Information: See-over console heights above 45 inches may be acceptable, for example, where the seated user need only monitor (not read) status lights and annunciators beyond the console, if they are at a suitable distance and height.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

3.6.2.2.2 Control Height

ES-0304-1381-12014

Guideline: All controls on a sit-down console should be within the reach radius of the 5th percentile female, as shown in Table 3-9 and illustrated in Figure 3-15.

Additional Information: Measurements should be made using seated shoulder height with the shoulder in line with the leading edge of the benchboard.

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HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

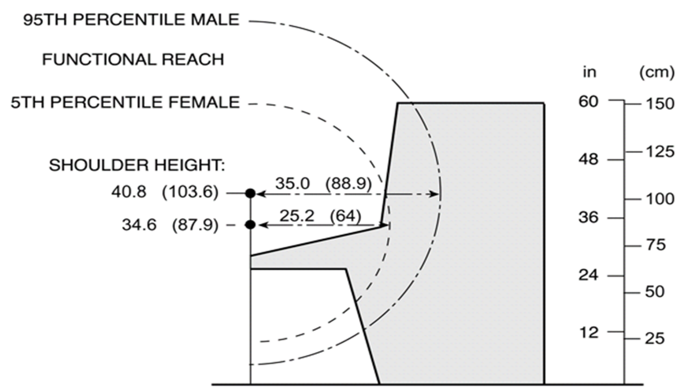

Figure 3-15. Reach capabilities for sit-down consoles

3.6.2.2.3 Benchboard Slope

ES-0304-1381-12018

Guideline: The benchboard slope, in conjunction with its depth, should be such that all controls are within the functional reach radius of the 5th percentile female (as shown in Table 3-9 and illustrated in Figure 3-15) and all displays and markings can be read.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

3.6.2.2.4 Minimum Distance of Controls from the Front Edge of the Console

ES-0304-1381-12020

Guideline: Controls should be set back a minimum of 3 inches from the front edge to protect against accidental activation.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

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3.6.2.2.5 Display Height and Orientation

ES-0304-1381-12022

Guideline: All displays, including alarm indicators, should be within the upper limit of the visual field (75 degrees above the horizontal line of sight) of the 5th percentile female (see Table 3-9), and should be mounted so that the interior angle between the line of sight and the display face is 45 degrees or greater (see Figure 3-16).

Additional Information: The 5th percentile female determines the upper limit. Practically, there is no lower limit for a plausible sit-down console design. The principal factors affecting the readability of displays, including alarm indicators, are: (1) display height and orientation relative to the user's LOS when standing directly in front of the display; (2) display distance and orientation relative to the user's straight-ahead LOS when the user must read the display from an off-side position; and (3) the size of display markings relative to the distance at which the display must be read. Character size is addressed in Appendix A, Text, and is not considered here. Except as specifically noted, measurements of angles should be made with the eye point in line with the leading edge of the benchboard.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

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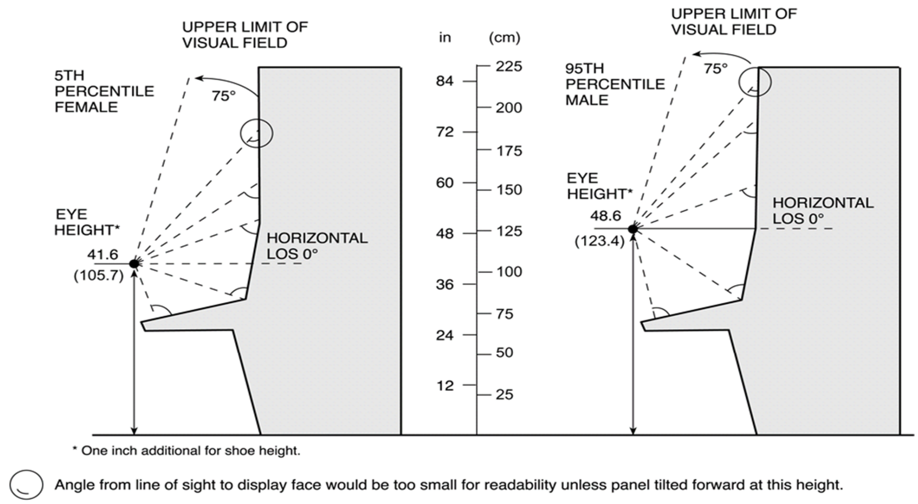

Figure 3-16. Display height and orientation relative to a seated user's line of sight

3.6.2.2.6 Location of Frequently Monitored Displays

ES-0304-1381-12026

Guideline: Displays that require frequent or continuous monitoring, or that may display important (e.g., alarm) information, should be located not more than 35 degrees to the left or right of the user's straight-ahead LOS, and not more than 20 degrees above and 40 degrees below the user's horizontal LOS, as measured from the normal workstation.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

3.6.2.2.7 Location of Infrequently Monitored Displays

ES-0304-1381-12028

Guideline: Displays that do not require frequent or continuous monitoring, and that will not display important (e.g., alarm) information, should be located not more than 95 degrees to the left or right of the user's straight- ahead LOS, as measured from normal workstations.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

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Reference: NUREG-0700-11.1.2

3.6.2.2.8 VDU Viewing Distance

ES-0304-1381-12030

Guideline: The viewing distance should be 13-30 inches (33 to 80 cm), with 18-24 inches (46-61 cm) preferred.

Additional Information: Display size, symbol size, brightness ranges, line-pair spacing and resolution should be appropriate for the maximum expected viewing distance.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

3.6.2.2.9 Lateral Spread of Controls and Displays

ES-0304-1381-12032

Guideline: All necessary controls and displays needed for critical or frequently performed activities should be within the maximum extended reach and viewing range of a seated user from a single reference point as shown in Table 3-9 and illustrated in Figure 3-17.

Additional Information: For sustained or precise control action, the user should be able to reach the controls without having to bend/stretch significantly. The acceptable lateral spread of controls and displays on sit-down consoles depends primarily on the reach of the users, panel orientation, grouping of controls and displays, and the freedom of the user to adjust seat position (center reference point) given task sequence requirements. Figure 3-17 illustrates reach and viewing range related to lateral and forward distance from a center reference point.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

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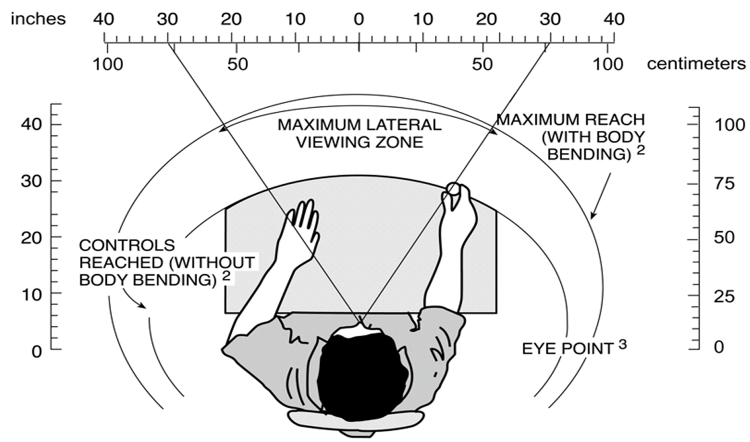

[1] 28 inches forward of the eye point is the maximum distance for displays when viewing is limited by reach (control-display relationship). Viewing distance may be extended provided display is properly designed. Greater lateral spread of displays would require a wraparound panel.

[2] Based on 5th percentile male data; less for 5th percentile females.

[3] Console edge approximately 4" to 6" forward of eye point for 5th-95th percentile.

Figure 3-17. Reach and visual range from center point

3.6.2.2.10 Leg and Foot Room

ES-0304-1381-12036

Guideline: Sufficient leg and foot room should be provided to enable seated users to avoid awkward and uncomfortable positions. Figure 3-18 shows the dimensions involved and gives minimums and ranges necessary to accommodate the 5th percentile female and 95th percentile male, as defined in Table 3-9**.**

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

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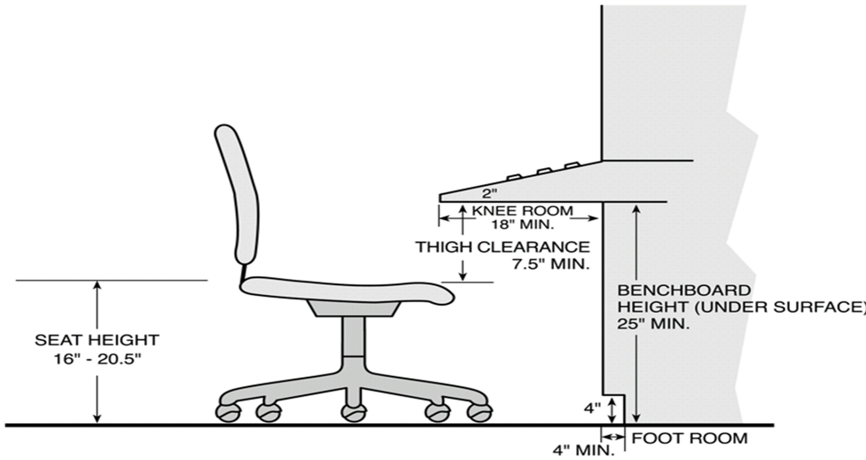

Figure 3-18. Leg- and foot-room dimensions

3.6.2.2.11 Writing Space on Consoles

ES-0304-1381-12040

Guideline: If writing space is needed by users working at consoles, an area at least 16 inches deep and 24 inches wide should be provided, where these dimensions in the total configuration would fit users' reach capabilities.

Additional Information: Less space may be adequate considering the frequency and duration of writing requirements at control room consoles. If writing space is provided on the console itself, it should not interfere with viewing and manipulation of controls and displays. If writing is necessary but space on the console is not available, other arrangements such as a nearby desk or table should be provided.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

3.6.2.2.12 Use of Procedures and Other Reference Materials at Consoles

ES-0304-1381-12042

Guideline: Provision should be made so that the procedures, manuals, and other reference materials can be consulted easily while task sequences are performed at the consoles.

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Additional Information: Lack of space in which to lay down procedures can encourage the poor practice of placing them on the console. A rolling bookcase is a convenient place for storing procedures and manuals and also provides space for laying down procedures during use.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.2

3.6.2.3 Sit-Stand Workstation

3.6.2.3.1 Appropriate Use

ES-0304-1381-12044

Guideline: Sit-stand combinations should be used when users need mobility to monitor large panel areas but also need the stability of seated operation for precise task sequences.

Additional Information: This is especially true when such task sequences go on for fairly long periods and require sustained attention (e.g., reactor startup/shutdown).

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.3

3.6.2.3.2 Control and Display Positioning

ES-0304-1381-12046

Guideline: The height and lateral limits for controls and displays should conform to the guidelines given for stand-up consoles (see Section 3.6.2.1, Stand-Up Console Dimensions).

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.3

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3.6.2.3.3 Seat Height

ES-0304-1381-12048

Guideline: The user should be provided with a high seat so that the seated eye height is approximately the same as standing eye height.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.3

3.6.2.3.4 Knee Room

ES-0304-1381-12050

Guideline: Knee room and comfortable foot support should be provided.

HSI Design Criteria

NuScale Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.3

3.6.2.4 Vertical Panels

3.6.2.4.1 Control Height

ES-0304-1381-12052

Guideline: Controls should be placed in an area between 34 inches and 70 inches above the floor. Controls requiring precise or frequent operation and emergency controls should be placed in an area between 34 inches and 53 inches above the floor (see Figure 3-19).

HSI Design Criteria

NuScale Stand-Up workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.4

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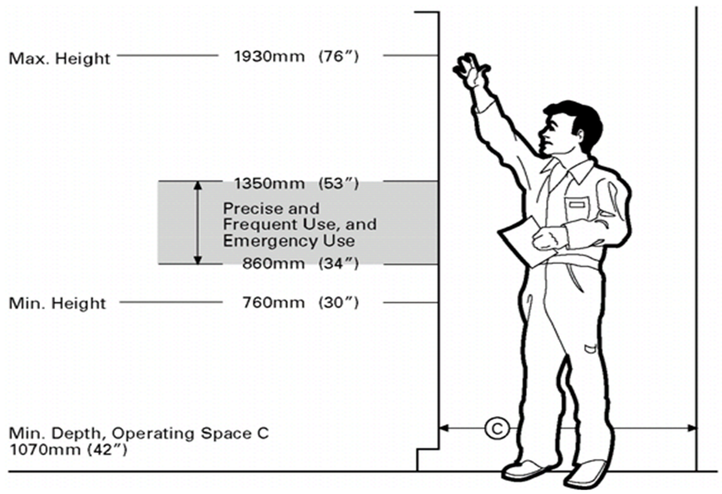

Figure 3-19. Control height

3.6.2.4.2 Display Height

ES-0304-1381-12056

Guideline: Displays should be placed in an area between 41 inches and 70 inches above the floor. Displays that must be read frequently or precisely should be placed in an area between 50 inches and 65 inches above the floor (see Figure 3-20).

HSI Design Criteria

NuScale vertical panels will incorporate this design standard.

Reference: NUREG-0700-11.1.4

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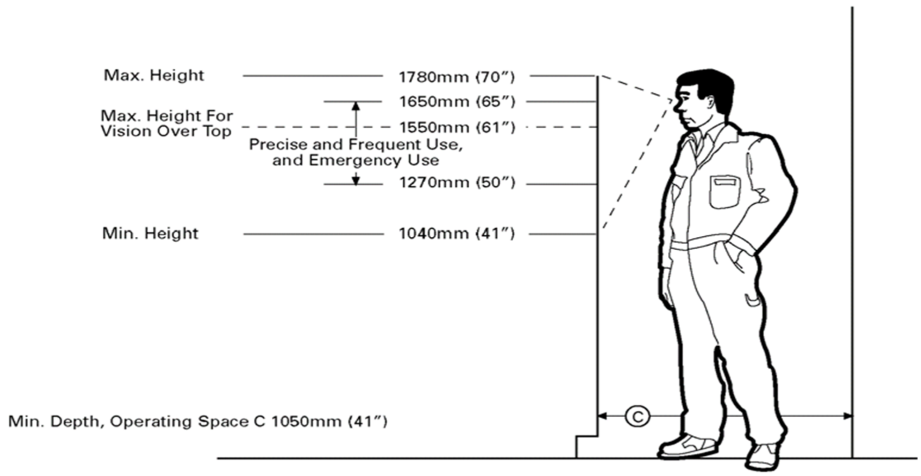

Figure 3-20. Display height

3.6.2.5 Desk Dimensions

3.6.2.5.1 Working Space

ES-0304-1381-12060

Guideline: Desks should provide enough clear working space for all materials required for task performance.

HSI Design Criteria

NuScale desks will incorporate this design standard.

Reference: NUREG-0700-11.1.5

3.6.2.5.2 Chair Positions

ES-0304-1381-12062

Guideline: The desk should allow for different chair positions as required, with adequate knee space.

HSI Design Criteria

NuScale desks will incorporate this design standard.

Reference: NUREG-0700-11.1.5

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3.6.2.5.3 Comfort

ES-0304-1381-12064

Guideline: The relationships of working surface height and area, knee room, and chair height should allow users to work comfortably.

HSI Design Criteria

NuScale desks will incorporate this design standard.

Reference: NUREG-0700-11.1.5

3.6.2.5.4 Dimensions

ES-0304-1381-12066

Guideline: Desk dimensions should conform to those shown in Figure 3-21.

Additional Information: Desk dimensions should be as follows:

- For seated work only, 26 to 31 inches above the floor (29 inches is a standard height)
- For sit-stand desks, 36 to 38 inches above the floor
- Work surface area depth should be 16 inches minimum
- Work surface area width should be 24 inches minimum if tasks involve reading and writing only; 30 inches minimum if other kinds of tasks are required
- For knee room height, a distance of approximately 25 inches from the floor to the under-surface of the desk top should provide adequate clearance for 5th to 95th percentile male and female adults at sit-down-only stations
- For knee room depth, 18 inches minimum
- Knee room width should be 20 inches (an even greater width is preferred)

HSI Design Criteria

NuScale desks will incorporate this design standard.

Reference: NUREG-0700-11.1.5

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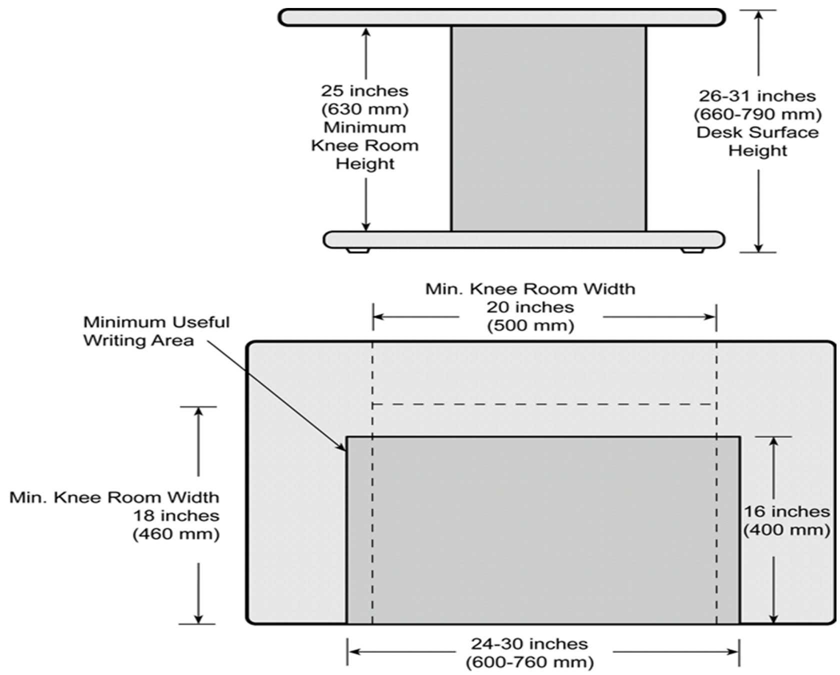

Figure 3-21. Recommended desk dimensions

3.6.2.6 Chairs

3.6.2.6.1 Mobility

ES-0304-1381-12070

Guideline: Chairs should pivot so that operators can readily adjust position.

Additional Information: Mobile bases (casters) are recommended for chairs at sit-only stations.

HSI Design Criteria

NuScale MCR chairs will incorporate this design standard.

Reference: NUREG-0700-11.1.6

3.6.2.6.2 Backrests

ES-0304-1381-12072

Guideline: Chairs should support at least the lower back curvature (lumbosacral region).

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Additional Information: The recommended angle between the back and the seat is about 100 degrees for office tasks (such as keyboard tasks). A greater angle is preferred for reading and resting.

HSI Design Criteria

NuScale MCR chairs will incorporate this design standard.

Reference: NUREG-0700-11.1.6

3.6.2.6.3 Armrests

ES-0304-1381-12074

Guideline: Where personnel may remain seated for relatively long periods, chairs with armrests should be provided.

Additional Information: Adjustable or retractable armrests may be necessary to allow the elbows to rest in a natural position and for compatibility with a particular desk/console.

HSI Design Criteria

NuScale MCR chairs will incorporate this design standard.

Reference: NUREG-0700-11.1.6

3.6.2.6.4 Cushioning

ES-0304-1381-12076

Guideline: The seat and backrest should be cushioned with at least 1 inch of compressible material, enough so that some resilience remains when the chair is occupied.

HSI Design Criteria

NuScale MCR chairs will incorporate this design standard.

Reference: NUREG-0700-11.1.6

3.6.2.6.5 Seat Dimensions

ES-0304-1381-12078

Guideline: The seat should be at least 18 inches wide and between 15 and 17 inches deep.

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Additional Information: The thighs and the backs of the knees should not be compressed so as to cause fatigue and circulation problems.

HSI Design Criteria

NuScale MCR chairs will incorporate this design standard.

Reference: NUREG-0700-11.1.6

3.6.2.6.6 Seat Adjustability

ES-0304-1381-12080

Guideline: For chairs at sit-down stations, seat height should generally be adjustable from 16 to 20.5 inches. For chairs at sit-stand stations, seat height should be adjustable from 26 to 32 inches.

HSI Design Criteria

NuScale MCR chairs will incorporate this design standard.

Reference: NUREG-0700-11.1.6

3.6.2.6.7 Footrests

ES-0304-1381-12082

Guideline: An adjustable footrest or heel catch should be provided to support the feet at a level no more than 18 inches below the seat surface.

Additional Information: If a footrest is part of the chair, a circular design is recommended, diameter 18 inches. The footrest might be provided on the console base.

HSI Design Criteria

NuScale MCR chairs will incorporate this design standard.

Reference: NUREG-0700-11.1.6

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3.6.2.7 Controls and Displays

3.6.2.7.1 Proximity

ES-0304-1381-17980

Guideline: A visual display that will be monitored during control manipulation should be located sufficiently close that a user can read it clearly and without parallax from a normal operating posture.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.1

3.6.2.7.2 Obscuration

ES-0304-1381-12086

Guideline: Controls and displays should be located so that displays are not obscured during control operation.

Additional Information: To avoid having the user's hand obscure the display, controls should be located below (see 'B' in Figure 3-22) the associated display. When this is not possible, the control should be located to the right of the display (see 'A' in Figure 3-22).

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.1

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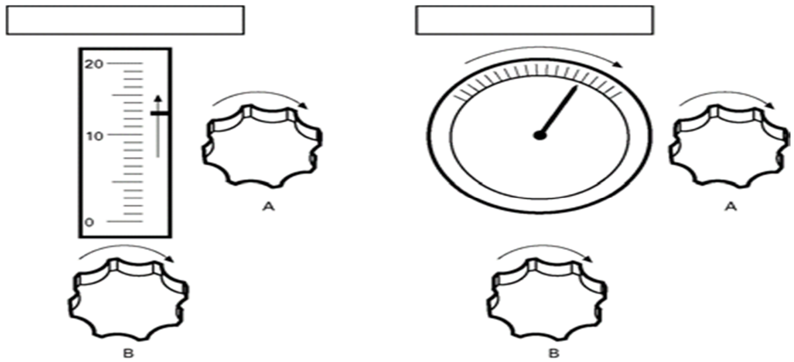

Figure 3-22. Position of control actuator and associated display

3.6.2.7.3 Association

ES-0304-1381-12090

Guideline: Related controls and displays should be easily identified as being associated.

Additional Information: This association can be established (or enhanced) by (1) location, (2) labeling, (3) coding, (4) demarcation, and (5) consistency with user expectations. The following relationships should be immediately apparent to the user: (1) association of displays with controls; (2) the direction of movement of control and display; and (3) the rate and limits of movement of the control and display. See Figure 3-23.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.1

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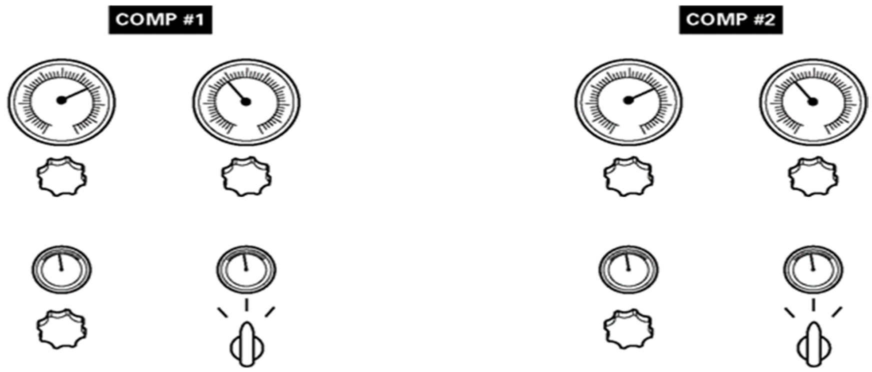

Figure 3-23. Association by grouping

3.6.2.7.4 Controls Mounted Below Display

ES-0304-1381-12094

Guideline: Multiple controls should be mounted below the single display.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.1

3.6.2.7.5 Alternative Control Position

ES-0304-1381-12096

Guideline: If it is not feasible to mount multiple controls directly below the single display, controls should be mounted to the right of the display.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.1

3.6.2.7.6 Controls Centered on Display

ES-0304-1381-12098

Guideline: Multiple controls should be centered on the single display.

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HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.1

3.6.2.7.7 Grouping of Controls

ES-0304-1381-12100

Guideline: Multiple controls should be grouped in a line or matrix.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.1

3.6.2.7.8 Arrangement of Controls

ES-0304-1381-12102

Guideline: Where there is a normal order of use, multiple controls should be arranged for use in left-to-right, top-to- bottom, or other natural sequence.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.1

3.6.2.7.9 Enhancement of Control Layout

ES-0304-1381-12104

Guideline: Layout enhancement techniques should be employed where the above techniques cannot apply, or where for other reasons the relationships are not readily apparent.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.1

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3.6.2.7.10 Displays Located Above Control

ES-0304-1381-12106

Guideline: Multiple displays should be located above the single control.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

3.6.2.7.11 Alternative Position for Displays

ES-0304-1381-12108

Guideline: If it is not feasible to mount multiple displays above the single control, they should be mounted to the left of the control.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

3.6.2.7.12 Control Centered Below Displays

ES-0304-1381-12110

Guideline: The single control should be placed as near as possible to the display, and preferably underneath the center of the display array.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

3.6.2.7.13 Grouping of Displays

ES-0304-1381-12112

Guideline: Multiple displays should be arranged horizontally or in a matrix.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

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Reference: NUREG-0700-11.2.2.2

3.6.2.7.14 Arrangement of Displays

ES-0304-1381-12114

Guideline: Where there is a normal order of use, multiple displays should read from left-to-right, top-to-bottom, or in other natural sequence.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

3.6.2.7.15 Visibility During Control Manipulation

ES-0304-1381-12116

Guideline: Multiple displays should not be obscured during control manipulation.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

3.6.2.7.16 Enhancement of Display Layout

ES-0304-1381-12118

Guideline: Layout enhancement techniques should be employed where the above techniques cannot apply, or where for other reasons the control-display relationship is not clearly apparent.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

3.6.2.7.17 Display Selector Motion

ES-0304-1381-12120

Guideline: The display selector control should move clockwise from OFF (if appropriate) through settings 1, 2, 3...n.

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HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

3.6.2.7.18 Display Selector Sequence

ES-0304-1381-12122

Guideline: The display selector control position sequence should conform to the display sequence.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

3.6.2.7.19 Display Selector Labeling

ES-0304-1381-12124

Guideline: Display selector control position indications should correspond with display labels.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

3.6.2.7.20 Display Selectors Scale

ES-0304-1381-12126

Guideline: Displays should read off scale, not zero, when not selected, especially if zero is a possible parameter displayed.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.2

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3.6.2.7.21 Rotary Controls

ES-0304-1381-12128

Guideline: Rotary controls should turn clockwise to cause an increase in parameter value. Associated display movements should be: (1) analog scales, up or to the right; (2) digital displays, increasing in value; (3) strings of indicator lights, bottom-to-top or left-to-right; and (4) circular meter pointers, clockwise.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.3

3.6.2.7.22 Linear Controls

ES-0304-1381-12130

Guideline: Linear controls should move up or to the right to cause an increase in parameter value. The associated display relationships should be: (1) analog scales, up or to the right; (2) digital displays, increasing in value; and (3) strings of indicator lights, bottom-to-top or left-to-right.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.3

3.6.2.7.23 Display Response Time Lag

ES-0304-1381-12132

Guideline: When there is a time lag between control actuation and ultimate system state, there should be an immediate feedback indication of the process and direction of parameter change.

Additional Information: In some cases, there will be a time lag between the actuation of a control and the resulting change in system condition. That condition should be reflected by displays in real time.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.3

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3.6.2.7.24 Precision of Control

ES-0304-1381-12134

Guideline: Controls should provide a capability to affect the parameter controlled easily, with the required level of precision.

Additional Information: They should be effective in sufficient time, under expected dynamic conditions, and within the limits of manual dexterity, coordination, and reaction time.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.3

3.6.2.7.25 Resolution of Display

ES-0304-1381-12136

Guideline: Displays should provide a capability to distinguish significant levels of the system parameter controlled.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.3

3.6.2.7.26 Excess Precision

ES-0304-1381-12138

Guideline: The precision of displays and controls should not greatly exceed that required.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.3

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3.6.2.7.27 Feedback

ES-0304-1381-12140

Guideline: Feedback from the display should be apparent for any deliberate movement of a control.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.2.3

3.6.2.7.28 Functional Grouping

ES-0304-1381-12142

Guideline: Multiple controls or displays related to the same function should be grouped together.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.3

3.6.2.7.29 Sequence of Use

ES-0304-1381-12144

Guideline: Sequence of use should be as follows: (1) left to right, (2) top to bottom, or (3) the above combined (normal reading order).

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.3

3.6.2.7.30 Display Above Each Control

ES-0304-1381-12146

Guideline: The preferred configuration is with the display above each control.

Additional Information: If this configuration is used, the following should apply: (1) each display should be located directly above its associated control; and (2) the display/control pairs should be arranged in rows.

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HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.3

3.6.2.7.31 Controls and Displays in Rows

ES-0304-1381-12148

Guideline: Displays may be arrayed in rows as the upper portion of a panel, matched to controls arrayed in similar rows below (see Figure 3-24).

Additional Information: Each control should occupy the same relative position as the display to which it is associated. Controls and displays should have corresponding labels.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.3

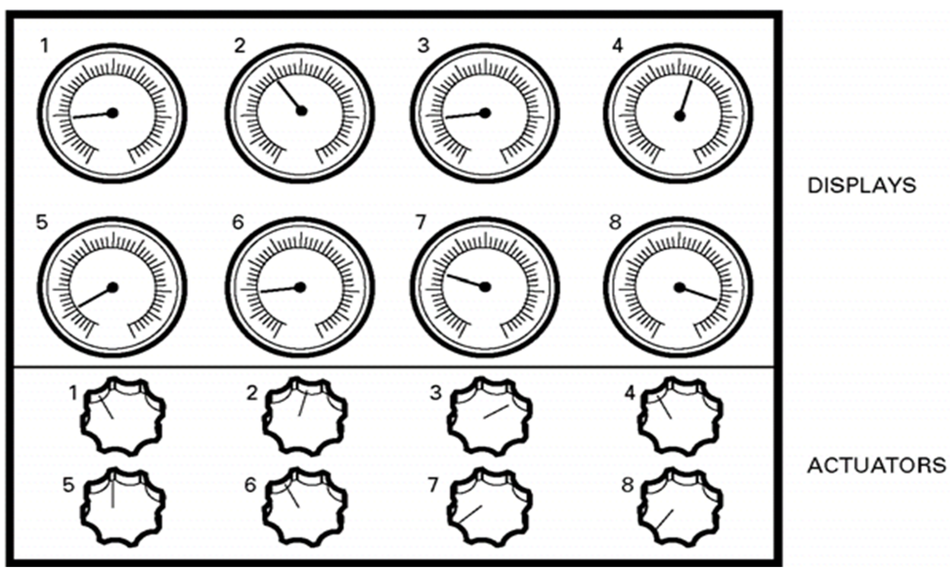

Figure 3-24. Controls and displays in rows

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3.6.2.7.32 Multi-Row Displays with Single-Row Controls

ES-0304-1381-12152

Guideline: Two or more rows of displays may be arranged above a single row of controls (see Figure 3-25).

Additional Information: Displays should be ordered left to right and top to bottom (in normal reading order), and matched to controls ordered left to right. Controls and displays should have corresponding labels.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.3

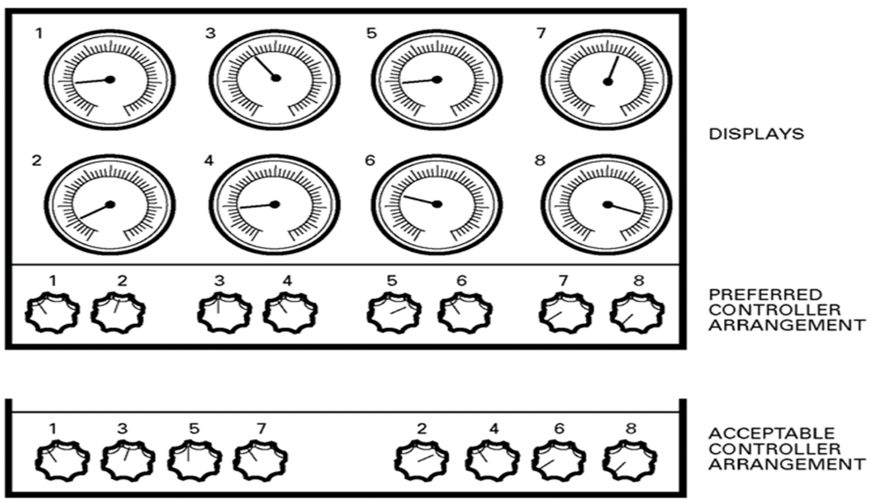

Figure 3-25. Two rows of displays with a single row of controls

3.6.2.7.33 Consistent Practice

ES-0304-1381-12156

Guideline: Arrangements of functionally similar controls and displays should conform to the same convention throughout the control room.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.3

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3.6.2.7.34 Control/Display Packages

ES-0304-1381-12158

Guideline: Modules should be selected and arranged to achieve maximum conformity with the principles described above.

Additional Information: When controls and related displays are assembled using modular packaged units, the design of the packages will limit the location and arrangement that can be achieved.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.3

3.6.2.7.35 Separated Controls and Displays

ES-0304-1381-12160

Guideline: Where displays are on separated panels, they should be on the adjacent upper panel from their associated controls.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.3

3.6.2.7.36 Facing Panels

ES-0304-1381-12162

Guideline: Related controls and displays should not be located on separate panels that face each other.

HSI Design Criteria

NuScale MCR controls and displays will incorporate this design standard.

Reference: NUREG-0700-11.2.3

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3.6.2.8 Labeling

3.6.2.8.1 Need for Labeling

ES-0304-1381-12164

Guideline: Controls, displays, and other equipment items that must be located, identified, or manipulated should be appropriately and clearly labeled to permit rapid and accurate human performance.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.1

3.6.2.8.2 Hierarchical Scheme

ES-0304-1381-12166

Guideline: A hierarchical labeling scheme should be used to reduce confusion, search time, and redundancy.

Additional Information: See Figure 3-26**.**

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.1

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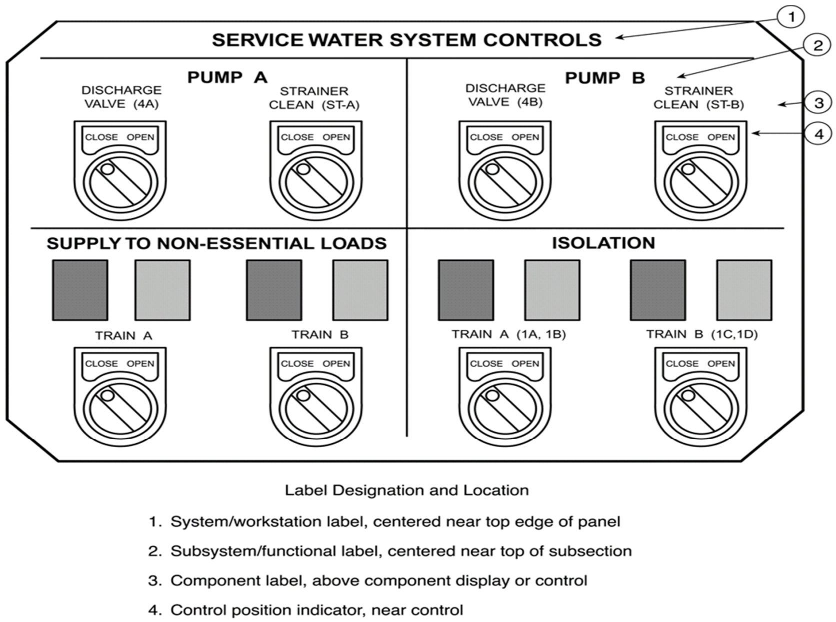

Figure 3-26. Example of good panel labeling

3.6.2.8.3 Content of Hierarchical Labels

ES-0304-1381-12170

Guideline: Major labels should be used to identify major systems or workstations, subordinate labels should be used to identify subsystems or functional groups, and component labels should be used to identify each discrete panel or console element.

Additional Information: Labels should not repeat information contained in higher-level labels.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.1

3.6.2.8.4 Letter Size in Hierarchical Labels

ES-0304-1381-12172

Guideline: Labels should be graduated in letter size such that system/work station labels are about 25 percent larger than subsystem/functional group labels, subsystem/functional group labels are about 25 percent larger than component labels, and component labels are about 25 percent larger than control position labels.

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HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.1

3.6.2.8.5 Normal Placement

ES-0304-1381-12174

Guideline: Labels should be placed above the panel element(s) they describe.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.6 Panel Labeling

ES-0304-1381-12176

Guideline: The placement of labels on control panels should conform to the principles in Section 3.6.2.8, Labeling Principles.

Additional Information: See Figure 3-24.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.7 Labeling Elements Above Eye Level

ES-0304-1381-12178

Guideline: Labels for elements located above eye level should be positioned to ensure label visibility.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

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3.6.2.8.8 Proximity

ES-0304-1381-12180

Guideline: Labels should be placed close to the panel element.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.9 Labels on Controls

ES-0304-1381-12182

Guideline: Labels should not appear on the control itself when an adjustment or manipulation is required that causes the user's hand to obscure the label for an extended time period.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.10 Adjacent Labels

ES-0304-1381-12184

Guideline: Adjacent labels should be separated by sufficient space so that they are not read as one continuous label.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.11 Integrity

ES-0304-1381-12186

Guideline: Labels should be mounted in such a way as to preclude accidental removal.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

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Reference: NUREG-0700-11.3.1.2

3.6.2.8.12 Surface

ES-0304-1381-12188

Guideline: Labels should be mounted on a flat surface.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.13 Horizontal Orientation

ES-0304-1381-12190

Guideline: Labels should be oriented horizontally so that they may be read quickly and easily from left to right.

Additional Information: Although not normally recommended, vertical orientation may be used only where space is limited.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.14 Curved Patterns

ES-0304-1381-12192

Guideline: Curved patterns of labeling should be avoided.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.15 Other Information Sources

ES-0304-1381-12194

Guideline: Labels should not cover any other information source or detract from or obscure figures or scales that must be read by the user.

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HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.16 Concealment

ES-0304-1381-12196

Guideline: Labels should not be covered or obscured by other units in the equipment assembly.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.17 Controls

ES-0304-1381-12198

Guideline: Labels should be visible to the user during control actuation.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

3.6.2.8.18 Cleaning

ES-0304-1381-12200

Guideline: Administrative procedures should be in place for the periodic cleaning of labels.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.2

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3.6.2.8.19 Principal Function

ES-0304-1381-12202

Guideline: Labels should describe the function of equipment items.

Additional Information: If needed for clarity, engineering characteristics or nomenclature may also be described.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.20 Wording of Instruction Labels

ES-0304-1381-12204

Guideline: The label should briefly and simply express the intended action.

Additional Information: Words on labels should be concise and still convey the intended meaning. Label text should not be so brief that its meaning is not clear to operating personnel. Instructions should be clear and direct.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.21 Commonly Used Terms and Symbols

ES-0304-1381-12206

Guideline: Terms, abbreviations, and symbols used on panel labels should have commonly accepted meanings for all intended users.

Additional Information: Unusual technical terms should be avoided. Use of Roman numerals should be avoided. Words should be spelled correctly. Abstract symbols should be used only if they have a commonly accepted meaning (e.g., %).

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

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3.6.2.8.22 Distinguishability

ES-0304-1381-12208

Guideline: Symbols should be unique and distinguishable from each other.

Additional Information: A commonly accepted standard configuration should be used.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.23 Consistency

ES-0304-1381-12210

Guideline: Labels should be consistent within and across panels in their use of words, acronyms, abbreviations, and part/system numbers.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.24 Agreement with Procedures

ES-0304-1381-12212

Guideline: There should be no mismatch between nomenclature used in procedures and that printed on the labels.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.25 Administrative Control

ES-0304-1381-12214

Guideline: A list of standard names, acronyms, abbreviations, and part/system numbers should be in place and administratively controlled.

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HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.26 Label Similarity

ES-0304-1381-12216

Guideline: Words and abbreviations of similar appearance should be avoided where an error in interpretation could result.

Additional Information: When labels containing similar words, abbreviations, or acronyms are located in close proximity to each other, different words should be selected or means of coding should be used to reduce the probability of selecting the wrong control or reading the wrong display.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.27 Functional Relationship

ES-0304-1381-12218

Guideline: Labels should be used to identify functionally grouped controls or displays.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.28 Label Location

ES-0304-1381-12220

Guideline: Labels should be located above the functional groups they identify.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

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3.6.2.8.29 Control Position Labels

ES-0304-1381-12222

Guideline: All discrete functional control positions should be identified.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.30 Direction

ES-0304-1381-12224

Guideline: Direction of motion (increase, decrease) should be identified for continuous motion rotary controls.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.31 Visibility

ES-0304-1381-12226

Guideline: Control position information should be visible to the user during operation of the control.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.8.32 Access Opening Labeling

ES-0304-1381-12228

Guideline: Access openings should be labeled to identify the functions of items accessible through them.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

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Reference: NUREG-0700-11.3.1.3

3.6.2.8.33 Danger, Warning, and Safety Instruction Labels

ES-0304-1381-12230

Guideline: All danger, warning, and safety instruction labels should be in accordance with appropriate safety standards.

HSI Design Criteria

NuScale labeling of equipment will incorporate this design standard.

Reference: NUREG-0700-11.3.1.3

3.6.2.9 Temporary Labels and Tagouts

3.6.2.9.1 Necessity

ES-0304-1381-12232

Guideline: Temporary labels should be used only when necessary.

Additional Information: If used, temporary labels should conform to the good human engineering principles listed in this section.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.4

3.6.2.9.2 Visibility

ES-0304-1381-12234

Guideline: Temporary labels should not obscure prior permanent labels unless the old label is to be replaced.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.4

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3.6.2.9.3 Identification

ES-0304-1381-12236

Guideline: Tag-out labels should clearly identify out-of-service components and equipment.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.4

3.6.2.9.4 Mounting

ES-0304-1381-12238

Guideline: Tag-outs should be securely affixed.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.4

3.6.2.9.5 Obscuration

ES-0304-1381-12240

Guideline: Tag-outs should not obscure the label associated with the non-operable device.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.4

3.6.2.9.6 Activation

ES-0304-1381-12242

Guideline: Tag-outs should be designed to physically prevent actuation of a control.

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HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.4

3.6.2.9.7 Adjacent Devices

ES-0304-1381-12244

Guideline: Tag-outs should not obscure any adjacent devices or their associated labels.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.4

3.6.2.9.8 Administrative Procedures

ES-0304-1381-12246

Guideline: The use of temporary labels should be administratively controlled.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.4

3.6.2.9.9 Review Procedures

ES-0304-1381-12248

Guideline: The use and control of temporary labels should be periodically reviewed.

Additional Information: A review procedure should determine:

- when temporary labels are needed
- how they will be used
- content (given human engineering requirements)
- installation

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- impact of their use on other system equipment (e.g., annunciators, mimics)
- documentation requirements
- re-training requirements
- their periodic review
- their removal.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.4

3.6.2.9.10 Character Height

ES-0304-1381-12250

Guideline: Character height should subtend a visual angle of 15 minutes (viewing distance multiplied by 0.004) as a minimum; a visual angle of 20 minutes (viewing distance multiplied by 0.006) is preferred.

Additional Information: Letter height should be identical for all labels within the same hierarchical level, based on the maximum viewing distance.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.5

3.6.2.9.11 Contrast

ES-0304-1381-12252

Guideline: Colors should be chosen for maximum contrast against the label background.

Additional Information: Table 3-10 rates various color combinations in terms of relative legibility. To ensure adequate contrast and prevent loss of readability because of dirt, dark characters should be provided on a light background. If colored print is used for coding purposes, it should conform to the established color coding scheme for the control room (see Appendix B).

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HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.5

Table 3-10. Relative legibility of color combinations

Legibility Rating	Color Combination
Very good	Black letters on white background
Good	Black on yellow
	Dark blue on white
	Grass green on white
Fair	Red on white
	Red on yellow
	White on black
Poor	Green on red
	Red on green
	Orange on black
	Orange on white

3.6.2.9.12 Character Selection

ES-0304-1381-12263

Guideline: Labels should be prepared in capital letters with letters and numerals without flourishes or serifs.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.5

3.6.2.9.13 Character Width

ES-0304-1381-12265

Guideline: Letter width-to-height ratio should be between 1:1 and 3:5. Numeral width-to-height ratio should be 3:5 except for the numeral "4," which should be one stroke width wider, and the numeral "1," which should be one stroke in width.

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HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.5

3.6.2.9.14 Stroke Width

ES-0304-1381-12267

Guideline: Stroke width-to-character height ratio should be between 1:6 and 1:8.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.5

3.6.2.9.15 Spacing

ES-0304-1381-12269

Guideline: The minimum space between characters should be one stroke width. The minimum space between words should be one character width. The minimum space between lines should be one-half of the character height.

HSI Design Criteria

NuScale guidance pertaining to the handling of temporary labels or tagouts will incorporate this standard.

Reference: NUREG-0700-11.3.1.5

3.6.2.10 Demarcations

3.6.2.10.1 Use

ES-0304-1381-12272

Requirement: Lines of demarcation can be used to enclose functionally related controls and displays, and group related controls and displays (see Figure 3-27).

HSI Design Criteria

The window Template Appendix (D) will discuss the use of demarcations.

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Reference: NUREG-0700-11.3.2

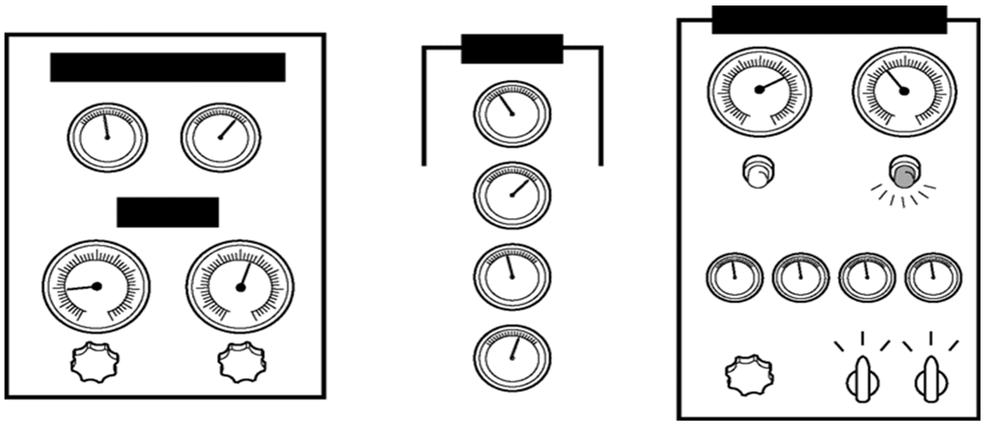

Figure 3-27. Demarcation lines

3.6.2.10.2 Contrast

ES-0304-1381-12276

Guideline: Lines of demarcation should be visually distinctive from the panel background.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.3.2

3.6.2.10.3 Permanence

ES-0304-1381-12278

Guideline: Lines of demarcation should be permanently attached.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.3.2

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3.6.2.10.4 Consistency

ES-0304-1381-12280

Guideline: The color coding scheme should be used consistently throughout the control room.

Additional Information: Refer to the guidelines in Appendix B, for specific recommendations on the use of color.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.3.2

3.6.2.10.5 User Expectations

ES-0304-1381-12282

Guideline: Color should be dedicated to specific functions or conditions throughout the control room in order for the code to elicit the expected user response.

Additional Information: Refer to the guidelines in Appendix B, for specific recommendations on the use of color.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.3.2

3.6.2.10.6 Grouping by Task

ES-0304-1381-12284

Guideline: Controls and displays should be assigned to work stations based on the tasks the user must carry out.

Additional Information: To the extent practical, this assignment should consider both normal and emergency procedures. It should be practical to perform all frequently occurring routine tasks, and time- sensitive emergency tasks, with a minimum of movement from panel to panel.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

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Reference: NUREG-0700-11.4.1

3.6.2.10.7 Grouping by System Function

ES-0304-1381-12286

Guideline: Within the constraints of grouping by task sequence, controls and displays should be assigned to panels in functional groups related to system structure.

Additional Information: This grouping should promote easy understanding of the relationship between controls and system, and should assist graphic or pictorial display of system relationships.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.1

3.6.2.10.8 Grouping by Importance and Frequency of Use

ES-0304-1381-12288

Guideline: Controls and displays should be assigned to panels depending on their importance and frequency of use, within the constraints of grouping by task sequence and system function.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.1

3.6.2.10.9 Less Important Controls/Displays

ES-0304-1381-12290

Guideline: Controls or displays that are neither important to plant safety nor frequently used should be installed in ancillary panel locations.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.1

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3.6.2.10.10 Spacing

ES-0304-1381-12292

Guideline: Spacing between groups should be at least the width of a typical control or display in the group.

Additional Information: Spacing consists of physically separating groups of components on a panel with enough space between groups so that the boundaries of each group are obvious.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.1

3.6.2.10.11 Color Shading

ES-0304-1381-12294

Guideline: When color shading is used, colors should provide adequate contrast and should be consistent with other color coding in the control room.

Additional Information: This practice is also known as 'color padding' or 'color blocking' (see Figure 3-28).

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.1

3.6.2.10.12 Emergency Controls

ES-0304-1381-12296

Guideline: Distinctive techniques should be used to enhance the recognition and identification of emergency controls.

Additional Information: For example, a unique style of demarcation or color shading might be applied exclusively to emergency controls.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

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Reference: NUREG-0700-11.4.1

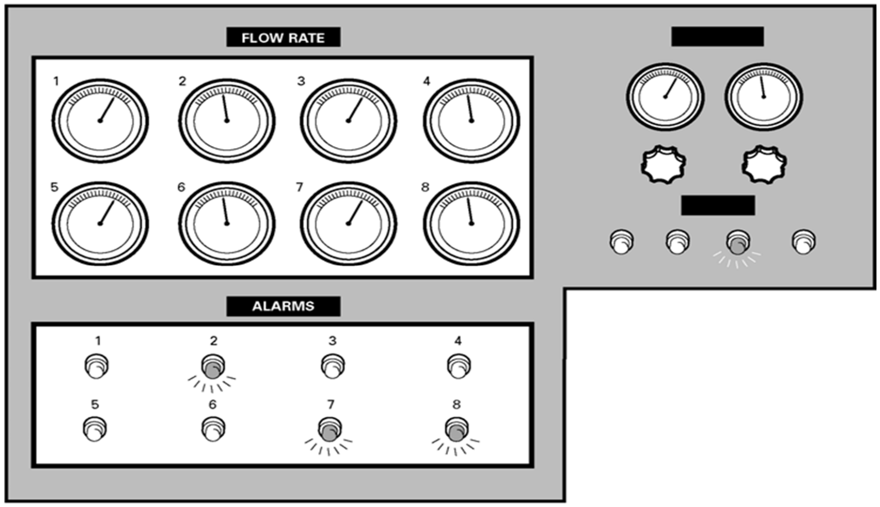

Figure 3-28. Color shading

3.6.2.10.13 Sequence

ES-0304-1381-12300

Guideline: Controls and displays should be grouped together when they are observed/operated in a specified sequence.

Additional Information: Controls and displays should be positioned so that they are normally used in a left-to-right, top-to-bottom, or other natural sequence.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.2

3.6.2.10.14 Frequency of Use

ES-0304-1381-12302

Guideline: Frequently used controls and displays should be near the center of the preferred visual and manual areas.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

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Reference: NUREG-0700-11.4.2

3.6.2.10.15 Functional Considerations

ES-0304-1381-12304

Guideline: Functionally related controls and displays should be grouped together when they are used together to perform tasks related to a specific function or are identical in purpose.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.2

3.6.2.10.16 Order and Labeling

ES-0304-1381-12306

Guideline: Components should be arranged left-to-right and/or top-to-bottom and identified in alphabetic or numeric sequence.

Additional Information: For example, four related displays in a row should be designated A, B, C, D or 1, 2, 3, 4; correspondingly, any controls related to these displays should also be designated A, B, C, D and 1, 2, 3, 4.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.2

3.6.2.10.17 Other Expectations

ES-0304-1381-12308

Guideline: Components should be arranged to match other user expectations when these can be identified.

Additional Information: Well-designed system mimics will help direct and satisfy user expectations.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

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Reference: NUREG-0700-11.4.2

3.6.2.10.18 Inter- and Intra-Panel Consistency

ES-0304-1381-12310

Guideline: The location of arrangement of recurring functional groups and individual components of those groups should be similar from panel to panel or within a panel.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.2

3.6.2.10.19 Repeated Functions

ES-0304-1381-12312

Guideline: The layout of identical control or display sets should be consistent at all locations.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.2

3.6.2.10.20 Mirror-Imaging

ES-0304-1381-12314

Guideline: Layouts of repeated functions should not be mirror-imaged (see Figure 3-29).

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.2

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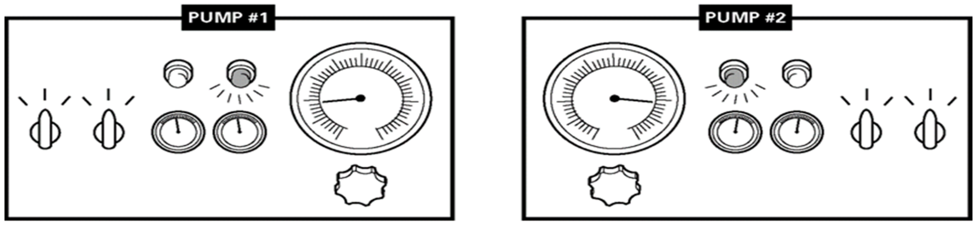

Figure 3-29. Example of a mirror-image arrangement of controls and displays

3.6.2.10.21 Panel-to-Panel Standardization

ES-0304-1381-12318

Guideline: Standardization should be maintained where similar functions or panels are located at several workstations or units.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.2

3.6.2.10.22 Simulator-to-Control Room Standardization

ES-0304-1381-12320

Guideline: Standardization should be maintained where simulator or procedures trainers are used that simulate the actual operational equipment.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.2

3.6.2.10.23 Access

ES-0304-1381-12322

Guideline: Control access should not be impeded by any position of an adjacent control.

Additional Information: Recommended minimum separation distances for controls are shown in Table 3-11and Figure 3-30. In most cases, control room operations will require greater separation.

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HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.3

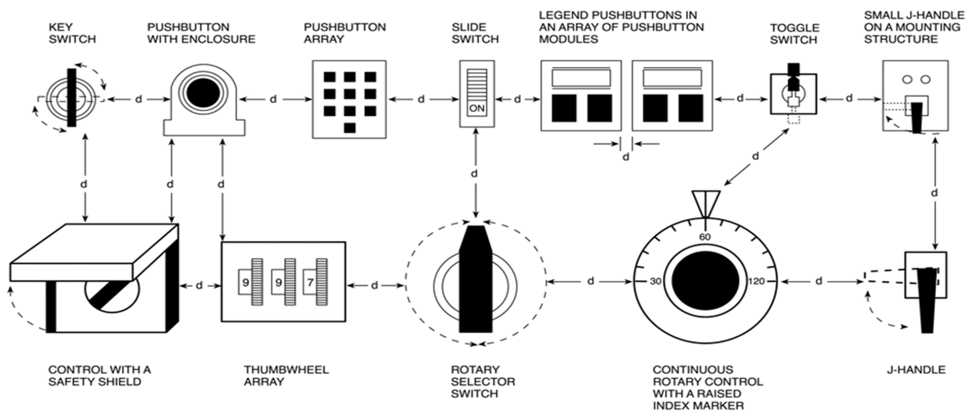

Figure 3-30. Measurement of minimum separation between controls

3.6.2.10.24 Inadvertent Actuation

ES-0304-1381-12326

Guideline: Control actuation should not result in inadvertent actuation of an adjacent control.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.3

3.6.2.10.25 Simultaneous Actuation

ES-0304-1381-12328

Guideline: It should be possible to simultaneously actuate adjacent controls (where required).

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.3

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3.6.2.10.26 Orientation

ES-0304-1381-12330

Guideline: Horizontal rows of displays should be used rather than vertical columns.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.3

3.6.2.10.27 String Length

ES-0304-1381-12332

Guideline: Strings of similar small displays should not exceed 20 inches on the control board.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.3

3.6.2.10.28 Number of Components

ES-0304-1381-12334

Guideline: No more than five similar components should be laid out in an unbroken row or column.

Additional Information: If more than five similar components must be laid out together, the string or cluster should be broken up by techniques such as physical spacing or demarcation.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.3

3.6.2.10.29 Coordinate Axes for Matrices

ES-0304-1381-12336

Guideline: Large matrices of similar components should have the coordinate axes labeled for identification of any single component within the grid.

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HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.3

3.6.2.10.30 Labeling Large Matrices

ES-0304-1381-12338

Guideline: The left and top sides of large matrices should be used for labeling.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.3

3.6.2.10.31 Demarcation of Large Matrices

ES-0304-1381-12340

Guideline: Large matrices should be subdivided by appropriate demarcation.

HSI Design Criteria

NuScale guidance pertaining to demarcations will incorporate this standard.

Reference: NUREG-0700-11.4.3

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Table 3-11. Minimum separation distances for controls (see Figure 3-30)

Controls	Minimum Separation in inches and (mm)										
	Key-Operated Controls	**Pushbuttons**	**Pushbutton Arrays**	**Legend Switches**	**Slide Switches, Rocker Switches**	**Toggle Switches**	**Thumb-wheels**	**Rotary Selector Switches**	**Continuous Rotary Controls**	**J-Handles (large)**	**J-Handles (small)**
Key-operated Controls	1.0 (25)	0.5 (13)	1.5 (38)	1.0 (25)	0.75 (19)	0.75 (19)	0.5 (13)	0.75 (19)	0.75 (19)	5.0 (127)	2.0 (50)
Pushbuttons	0.5 (13)	0.5 (13)	2.0 (50)	2.0 (50)	0.5 (13)	0.5 (13)	0.5 (13)	0.5 (13)	0.5 (13)	6.0 (152)	3.0 (76)
Pushbutton Arrays[1]	1.5 (38)	2.0 (50)	2.0 (50)	2.0 (50)	1.5 (38)	1.5 (38)	1.5 (38)	2.0 (50)	2.0 (50)	6.0 (152)	3.0 (76)
Legend Switches[2]	1.0 (25)	2.0 (50)	2.0 (50)	2.0 (50)	1.5 (38)	1.5 (38)	1.5 (38)	2.0 (50)	2.0 (50)	6.0 (152)	3.0 (76)
Slide Switches, Rocker Switches	0.75 (19)	0.5 (13)	1.5 (38)	1.5 (38)	0.5 (13)	0.75 (19)	0.5 (13)	0.5 (13)	0.5 (13)	5.0 (127)	2.0 (50)
Toggle Switches	0.75 (19)	0.5 (13)	1.5 (38)	1.5 (38)	0.75 (19)	0.75 (19)	0.5 (13)	0.75 (19)	0.75 (19)	6.0 (152)	3.0 (76)
Thumbwheels	0.5 (13)	0.5 (13)	1.5 (38)	1.5 (38)	0.5 (13)	0.5 (13)	0.5 (13)	0.75 (19)	0.75 (19)	5.0 (127)	2.0 (50)
Rotary Selector Switches	0.75 (19)	0.5 (13)	2.0 (50)	2.0 (50)	0.5 (13)	0.75 (19)	0.75 (19)	1.0 (25)	1.0 (25)	5.0 (127)	2.0 (50)
Continuous Rotary Controls	0.75 (19)	0.5 (13)	2.0 (60)	2.0 (50)	0.5 (13)	0.75 (19)	0.75 (19)	1.0 (25)	1.0 (25)	5.0 (127)	2.0 (50)
J-Handles (large)	5.0 (127)	6.0 (152)	6.0 (152)	6.0 (152)	5.0 (127)	6.0 (152)	5.0 (127)	5.0 (127)	5.0 (127)	3.0 (76)	5.0 (127)
J-Handles (small)	2.0 (50)	3.0 (76)	3.0 (76)	3.0 (76)	2.0 (50)	3.0 (76)	2.0 (50)	2.0 (50)	2.0 (50)	5.0 (127)	1.0

[1] Pushbuttons within an array, 0.75 inches center-to-center.
[2] Legends switches within an array, no minimum distance, but should be separated by a barrier. Barrier should be at least 0.125 inches wide, 0.183 inches high, with rounded edges. Legend switches manufactured as elements of a module or modular array may be mounted as closely as engineering consideration permit. Toggle switches arrayed in a horizontal line, 0.75 inches center-to-center.

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3.7 Workplace Design

Workplaces are facilities that house workstations and other task-support equipment and provide the environment in which personnel perform their tasks. This section is intended for operating locations from where monitoring and control of the plant is conducted such as the MCR and RSS. This section is not applicable to the Emergency Response Facilities.

3.7.1 Definitions

Control Room

Two important aspects of a control room are its configuration (i.e., the arrangement of workstations and other equipment within it) and its environment. The important characteristics of each are described below. Many of these characteristics are also applicable to other workplaces, such as the remote shutdown station and technical support center.

Control Room Configuration

Control room configuration refers to the overall layout and arrangement of the control room; it comprises the following factors:

Accessibility of instrumentation/equipment

Accessibility refers to the ease with which control room personnel can gain access to needed instrumentation and equipment. Any instrumentation and equipment needed by control room personnel for detecting abnormal conditions and shutting down the plant, but which are not located inside the control room, should be identified. Similarly, the controls and displays required for continuous monitoring and the timing of control actions that are not located in the primary operating area of the control room should be identified. Review guidelines are provided in Section 3.7.2.1.

Consistency of staffing with equipment layout

This refers to factors that may affect the adequacy of personnel staffing levels, including: the ability of control room personnel to monitor and operate all necessary controls, displays, and other equipment during all modes of plant operation (e.g., consistency of the control room layout with staffing levels and task assignments); the ability of additional onsite or offsite personnel to augment the normal crew complement under certain unusual conditions, such as refueling (e.g., consistency of control room layout with anticipated activities and task assignments); the ability to limit access and movement of nonessential but authorized personnel to prescribed areas within the control room (e.g., adequate designations of prescribed areas; doors, gates, and other physical barriers). Review guidelines are provided in Section 3.7.2.1.

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<u>Furniture, instrumentation and equipment layout</u>

The arrangement of furniture, instrumentation, and equipment in the control room that might affect the operators' requirements for viewing, communication, accessibility, and movement. Review guidelines are provided in Section 3.7.2.1.

<u>Document organization and storage</u>

Review guidelines are provided in Section 3.7.2.2 for the availability, storage, and accessibility of procedures and other documents needed for ready reference.

<u>Spare parts, operating expendables, and tools</u>

Guidelines provided in Section 3.7.2.3 address the availability, storage, and accessibility of spare parts, operating expendables, and tools needed by personnel.

<u>Shift Manager access</u>

The accessibility of the shift manager’s office by walking and communication links is addressed by review guidelines in Section 3.7.2.4.

<u>Multiunit control rooms</u>

The characteristics of multi-unit control rooms that may affect personnel performance include whether or not the control room has a mirror-image design, design factors that distinguish the operating units, equipment layout that might affect personnel movement and communication. Review guidelines are provided in Section 3.7.2.5.

<u>Emergency equipment and protective clothing</u>

If personnel are required to wear protective clothing in the workplace, then this clothing should be considered, along with warning systems that signal the need for its use, and storage for protective clothing. Review guidelines are provided in Section 3.7.2.6.

<u>Personal storage</u>

Provisions for storing personal items (e.g., coats and other belongings) can help maintain a clutter-free work environment. Storage places, including those located outside on the control room such as lockers, should be addressed. Review guidelines are provided in Section 3.7.2.7.

<u>Ambience and comfort</u>

Eating, restroom, and lounge facilities contribute to the operators' comfort, health, and performance. Review guidelines are provided in Section 3.7.2.7.

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Control Room Environment

Environmental factors that can have important effects on operators' performance include thermal comfort, illumination, the auditory environment, and facility layout.

Thermal comfort

Thermal comfort includes temperature, humidity, and ventilation. Guidelines for these topics are provided in Section 3.7.2.7.

Illumination

Illumination encompasses general illumination levels (i.e., for the main operating area and auxiliary areas) and specific levels for particular areas, such as workstations, individual control and display devices, and areas used for reading and writing; emergency lighting systems intended for special operating conditions are also included. Review guidelines for general control room illumination are provided in Section 3.7.2.7; guidelines for emergency lighting are in Section 3.7.2.6.

Auditory environment

The auditory environment includes the background noise level and the reverberation and sound absorption characteristics of the workplace. Review guidelines for the control room environment are provided in Section 3.7.2.9.

Local Control Stations

A local control station is a place outside of the main control room where operators interact with the plant. Local control stations may include multifunction workstations and panels, as well as operator interfaces, such as controls (e.g., valves, switches, and breakers) and displays (e.g., meters and VDUs). They have many characteristics in common with the main control room. However, they may also have unique characteristics when located in environments that are not as controlled as the main control room. For example, local control stations may have higher levels of background noise and more demanding conditions for use than the main control room. Accordingly, they may have a diverse range of communication media, such as loudspeakers, public address/pager stations, and two-way communication systems (e.g., telephones and walkie-talkies). In addition, these media may have special administrative controls that regulate their use.

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3.7.2 Control Room Requirements and Guidelines

3.7.2.1 Control Room Configuration

3.7.2.1.1 Present in the Control Room

ES-0304-1381-12737

Guideline: Control room instrumentation and equipment should include all controls and displays needed for (1) detection of abnormal conditions, and (2) bringing the plant to a safe shutdown condition.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.1

3.7.2.1.2 Arranged to Facilitate Coverage

ES-0304-1381-12739

Guideline: Users should not have to leave their principal work areas to attend to instrumentation on back panels during operational sequences in which continuous monitoring or the timing of control actions may be critical.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.1

3.7.2.1.3 Coverage

ES-0304-1381-12741

Guideline: Control room staffing and task assignments should ensure complete and timely coverage of controls, displays, and other equipment required during all modes of operation.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.2

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3.7.2.1.4 Utilization of Additional Personnel

ES-0304-1381-12743

Guideline: When additional onsite or offsite personnel are needed to augment the normal crew complement under certain conditions (e.g., refueling), activities, and task assignments should be planned to ensure proper coordination.

Additional Information: Special training for this situation may be required.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.2

3.7.2.1.5 Nonessential Personnel

ES-0304-1381-12745

Guideline: Provision should be made to limit the access and movement of nonessential but authorized personnel to prescribed areas within the control room.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.2

3.7.2.1.6 Viewing

ES-0304-1381-12747

Guideline: Desks and consoles should permit users at those desks and consoles full view of all control and display panels (including alarm displays) in the main control room.

Additional Information: Placement and spacing of equipment depends on control room configuration, staffing, and other design features. Thus, guidelines are stated in terms of minimum spacing considerations for common equipment arrangements and use situations. Maintenance and testing of equipment has not been considered, and may require larger clearances than the minimums suggested.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.3

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3.7.2.1.7 Communications

ES-0304-1381-12749

Guideline: Desk and console placement should facilitate voice communications from users seated at those workstations to any point in the main operating area.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.3

3.7.2.1.8 Access to Workstations

ES-0304-1381-12751

Guideline: Users should be able to get to any workstation without having to overcome obstacles such as tripping hazards, poorly positioned filing cabinets or storage racks, and maintenance equipment.

Additional Information: Users should be able to position themselves conveniently for performing task actions at any work station.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.3

3.7.2.1.9 Adjustable Surfaces

ES-0304-1381-20365

Guideline: Adjustable workstation surfaces shall

- Use a fail-safe mechanism to prevent inadvertent movement

- Use a control locking mechanism to prevent inadvertent operation

Adjustable surfaces that hold heavy objects, such as a visual display, can present a hazard to users. For example, adjustable surfaces moving relative to each other may create pinch-point hazards, either while in operation or in the event of failure.

Elderly or disabled users may have special requirements with regard to adjustment surfaces. Some considerations for these user groups are:

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• Accessibility for individuals in wheelchairs

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: ASNI-HFES 100-2007 Section 5.2.1.3

3.7.2.1.10 Pinch Points

ES-0304-1381-20367

Guideline: Pinch points, in which fingers, arms, and legs can be caught between movable surfaces or parts, shall

- Be avoided by means of design or guarding

  In adjustable workstation furniture, surfaces move relative to one another. This may lead to pinch point hazards in which fingers, arms, or legs can be caught between moving surfaces or parts. This can occur, for example, when a motorized work surface moves past a fixed surface or when clearance between a seat adjustment lever and the bottom of the seat is inadequate. The size of the clearance gap necessary to avoid pinch points will depend on which limb might be involved, but it can be determined with reference to the appropriate 95th percentile male dimension.

  The recommended hierarchy of procedures to avoid pinch points is to

- Design to eliminate the hazard
- Guard against the hazard
- Provide warning labels and instructions to users for safe operation

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: ASNI-HFES 100-2007 Section 5.2.1.4

3.7.2.1.11 Device Cabling

ES-0304-1381-20369

Guideline: Cables that connect to devices in the workstation should

- Be placed to avoid interference with the operation of workstation components
- Be placed to avoid creating hazards for people or equipment in the workstation

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Poorly installed cables can present hazards, cause unintended motion of input devices, and/or limit device usage. The characteristics of cables to consider in the workstation configurations include length, weight, tension, flexibility, and location.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: ASNI-HFES 100-2007 Section 5.2.1.5

3.7.2.1.12 Circulation Patterns

ES-0304-1381-12753

Guideline: The control room arrangement should facilitate efficient, unobstructed movement and communication.

Additional Information: The control room arrangement should minimize interference between the members of the operational crew.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.3

3.7.2.1.13 Maneuvering Space

ES-0304-1381-12755

Guideline: Adequate space should be allowed between the back (user's position) of a desk or console and any surface or fixed object behind the user for the user to get into and out of a chair freely or to turn in the chair to view the equipment behind.

Additional Information: A minimum separation of 36 inches from the back of any desk to any opposing surface is suggested as the minimum (see Figure 3-31). A greater separation is preferable. Lateral space for a seated user should be no less than 30 inches; greater latitude is preferable. Placement and spacing of equipment depends on control room configuration, staffing, and other design features. Thus, guidelines are stated in terms of minimum spacing considerations for common equipment arrangements and use situations. Maintenance and testing of equipment has not been considered, and may require larger clearances than the minimums suggested.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

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Reference: NUREG-0700-12.1.1.3

3.7.2.1.14 Equipment-to-Opposing-Surface Distance

ES-0304-1381-12757

Guideline: Enough space should be allowed so that personnel can perform all required tasks.

Additional Information: The space should accommodate kneeling and bending, simultaneous work by more than one person, and simultaneous performance of operational and maintenance tasks as required. Recommended minimum separations are illustrated in Figure 3-32**.** Minimum separation of 50 inches is recommended between a single row of equipment/panel and a wall or other opposing surface. A minimum separation of 50 inches is also recommended between two rows of facing equipment if both rows are worked by a single person. A minimum separation of 8 feet is recommended between opposing rows of equipment where more than one person must work simultaneously on operational or maintenance tasks, and kneeling, bending, or use of test equipment may be necessary.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.3

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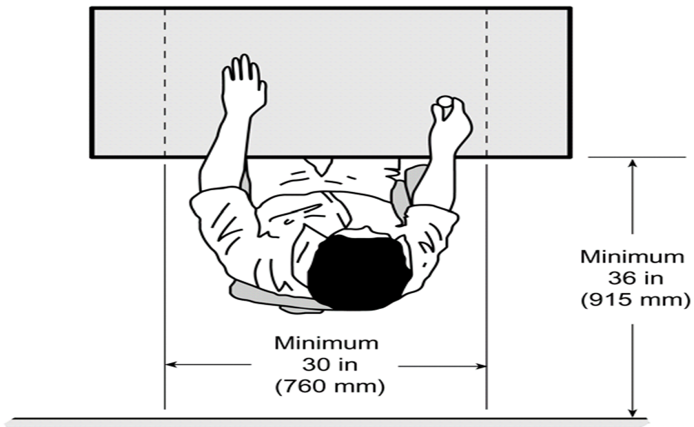

Figure 3-31. Spacing of equipment to accommodate seated users

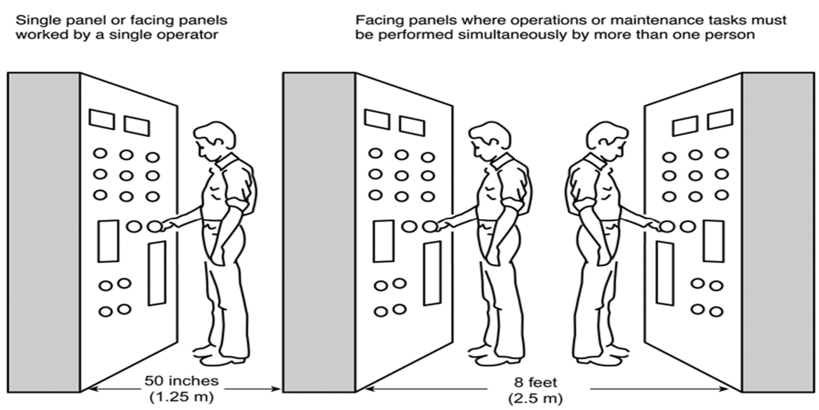

Figure 3-32. Equipment-to-equipment distances

3.7.2.1.15 Openings

ES-0304-1381-12763

Guideline: Panels should be laid out and maintained, and equipment enclosures designed, so that there are no unguarded openings through which unwanted objects can be introduced.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.3

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3.7.2.2 Procedures

3.7.2.2.1 Accessibility

ES-0304-1381-12765

Guideline: All procedures and other documents that may be needed for ready reference should be kept in the control room in places where they are easy to locate and extract for use.

Additional Information: Reference documents should not be locked up, or stored in places too low or too high for large or small personnel to access easily, in cramped spaces, or where poor illumination exists.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.4

3.7.2.2.2 Location Aids

ES-0304-1381-12767

Guideline: Clearly visible title labels should be provided to identify specific documents. Labels should distinguish documents as much as possible.

Additional Information: Putting many volumes in one location creates a search problem, especially if titles are similar. One means of reducing search time would be to put operational documentation in one location and other documentation in a secondary location.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.4

3.7.2.2.3 Convenience of Use

ES-0304-1381-12769

Guideline: Documents should not be fixed in racks; it should be possible to remove documents for use.

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HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.4

3.7.2.2.4 Bound Documents

ES-0304-1381-12771

Guideline: Documents should be bound so that they can be opened fully and will remain open at the desired place without holding.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.4

3.7.2.2.5 Protection

ES-0304-1381-12773

Guideline: Documents should be protected from wear so that they do not become dog-eared, dirty, loose, torn, and difficult to read.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.4

3.7.2.2.6 Dedicated Sets of Procedures

ES-0304-1381-12775

Guideline: Sets of procedures should be stored separately for each unit in a multiunit control room.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.4

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3.7.2.3 Parts and Tools

3.7.2.3.1 Supply

ES-0304-1381-12777

Guideline: There should be an adequate supply of expendables and spare parts (e.g., fuses, indicating lights and printer paper).

Additional Information: Spare parts, such as indicator lamps, and any tools that are needed by operating personnel should be stored in suitable, designated space(s) within the control room.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.5

3.7.2.3.2 Accessibility

ES-0304-1381-12779

Guideline: Expendables and spare parts should be readily accessible.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.5

3.7.2.3.3 Tools

ES-0304-1381-12781

Guideline: All necessary or special replacement tools should be available as needed to install expendables and spare parts.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.5

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3.7.2.3.4 Storage Space

ES-0304-1381-12783

Guideline: There should be adequate storage space for expendables and spare parts.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.5

3.7.2.3.5 Coding

ES-0304-1381-12785

Guideline: When different types, sizes, or styles of expendables and spare parts are required, they should be clearly and distinctively marked to avoid misapplication.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.5

3.7.2.3.6 Inventory

ES-0304-1381-12787

Guideline: Records should be kept as to the status of expendables and spare parts.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.5

3.7.2.4 Supervisor Access

3.7.2.4.1 Access

ES-0304-1381-12789

Guideline: The shift supervisor's office should be located so as to permit prompt physical access to the control room under all conditions, including control room isolation.

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Additional Information: The preferred location is within the control room isolation boundary, with placement to permit good visual and voice contact with the main operating area.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.6

3.7.2.4.2 Communications

ES-0304-1381-12791

Guideline: Dedicated communications links should be provided between the main operating area and the shift supervisor's office when the shift supervisor's office is not within the control room boundary.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.6

3.7.2.5 Multiunit Control Rooms

3.7.2.5.1 Equipment Arrangement

ES-0304-1381-12793

Guideline: Equipment should be arranged with movement and communication patterns in mind so that unit operations do not interfere with each other.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.7

3.7.2.5.2 Senior Operator Station

ES-0304-1381-12795

Guideline: Senior operators who supervise and assist operations of more than one unit should be stationed so that they can communicate effectively with operators in each unit and have an unobstructed visual path to the control boards of each unit.

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HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.7

3.7.2.5.3 Sharing of Personnel

ES-0304-1381-12797

Guideline: Where operators may assist those of another unit, potential task loading should be evaluated to assure that each unit can be covered adequately in all situations.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.7

3.7.2.5.4 Sharing of Procedures

ES-0304-1381-12799

Guideline: Each unit should have its own set of procedures and other reference documents as required to make sure that references are easily available to personnel in each unit, and to avoid conflicting needs for the same reference.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.7

3.7.2.5.5 Shared Equipment

ES-0304-1381-12801

Guideline: When control of some plant equipment is shared by the control rooms of multiple-unit nuclear power plants, care must be taken to ensure that status and availability data for this equipment are available in each control room, and that equipment operation from the control room for one unit will not affect other unit operations.

Additional Information: Control of plant equipment from one control room should not affect the ability of operators of other control rooms to maintain control of their respective units. The status of plant equipment under the control of one control room should be displayed in all control rooms capable of controlling that equipment. If control of plant

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equipment from one control room renders that equipment unavailable to other control rooms, availability status indications should be displayed in all control rooms. A single, centrally located control panel/console may be used for dual-unit control rooms within the same isolation boundary when this design does not conflict with the panel layout and control-display integration guidelines. Administrative procedures should be in place that assign responsibility for allocation of use of controls of shared plant equipment to a single control room.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.7

3.7.2.5.6 Dedicated Crews

ES-0304-1381-12803

Guideline: When mirror image control rooms exist, operational crews should be committed to one or the other unit and should not be allowed to alternate between the two mirrored units.

Additional Information: This includes crews staffing a single center-desk station. Some control rooms are designed with the control boards of two units laid out symmetrically, side-by-side, so that one is a complete or nearly complete reversal of the other. Operators who work both units have to deal with two opposite patterns of controls and displays, and must reorient their expectations completely when they switch from unit to unit. This requirement violates the principle of positive transfer of training and is highly unfavorable for task performance reliability. The potential for confusion is greater when the reversal is incomplete (e.g., control boards mirror imaged, but annunciator panels arranged identically in both units).

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.7

3.7.2.5.7 Accentuate Differences

ES-0304-1381-12805

Guideline: The distinction between the mirrored units should be heightened as much as possible so that there will be no confusion about where one unit ends and the other begins.

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Additional Information: In addition to using labeling, distinctiveness can be increased by using a different color scheme for the elements of each unit, including carpeting, desks, and other work station equipment, as well as the board surface areas.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.7

3.7.2.6 Emergency Equipment

3.7.2.6.1 Types of Equipment

ES-0304-1381-12807

Guideline: Protective equipment should include protective clothing and breathing apparatus.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.2 Anthropometry

ES-0304-1381-12809

Guideline: Protective clothing and breathing equipment should be compatible with users' body sizes and tasks to provide adequate tactile sensitivity and ability to see, reach, move, communicate, and hear.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.3 Periodic Checks

ES-0304-1381-12811

Guideline: Protective equipment should be periodically checked to determine if it is in good condition.

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HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.4 Quantity

ES-0304-1381-12813

Guideline: There should be protective equipment available in sufficient quantities and sizes for the required number of users.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.5 Marking

ES-0304-1381-12815

Guideline: Protective clothing sizes should be clearly identifiable.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.6 Expendables

ES-0304-1381-12817

Guideline: There should be an adequate supply of personal protection equipment expendables, such as filters.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

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3.7.2.6.7 Accessibility

ES-0304-1381-12819

Guideline: All protective equipment should be easily and readily accessible.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.8 Training

ES-0304-1381-12821

Guideline: Personnel should be well practiced in donning protective equipment.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.9 Procedures

ES-0304-1381-12823

Guideline: Instructions for donning, doffing, and controlling personal protective equipment should be provided.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.10 Periodic Checks

ES-0304-1381-12825

Guideline: All equipment should be periodically checked to determine if it is in good condition.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

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Reference: NUREG-0700-12.1.1.8

3.7.2.6.11 Accessibility

ES-0304-1381-12827

Guideline: All equipment should be easily and readily accessible.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.12 Training

ES-0304-1381-12829

Guideline: Personnel should be trained in the use of all emergency equipment.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.13 Procedures

ES-0304-1381-12831

Guideline: There should be a written, administratively approved procedure for each type of emergency or combination of emergencies.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.14 Automatic Warning System

ES-0304-1381-12833

Guideline: There should be an automatic fire warning system for control room fires.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

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Reference: NUREG-0700-12.1.1.8

3.7.2.6.15 Proper Storage

ES-0304-1381-12835

Guideline: Provision should be made for the orderly storage in the control room of emergency equipment that is needed by control room personnel.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.16 Storage Locations

ES-0304-1381-12837

Guideline: The storage location(s) may be away from the main operating area but should be accessible, clearly marked, and known to all personnel.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.8

3.7.2.6.17 Automatic Action

ES-0304-1381-12929

Guideline: A control room emergency lighting system should be automatically activated and immediately available upon failure of the normal control room lighting system.

Additional Information: This system should be independent of any other plant lighting system that is available in the control room.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.4

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3.7.2.6.18 Operability

ES-0304-1381-12931

Guideline: Failure of the normal control room lighting system should not degrade operability of the emergency lighting system.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.4

3.7.2.6.19 Emergency Lighting Levels

ES-0304-1381-12933

Guideline: The control room emergency illumination system should be designed to provide a minimum illumination level of 10 footcandles at all work stations in the main operating area.

Additional Information: Higher levels of illumination are preferred if the room's surfaces are of low reflectivity or the occupants of the room are over 40 years of age.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.4

3.7.2.7 Environmental

3.7.2.7.1 Comfort Zone

ES-0304-1381-12867

Guideline: The climate control system should maintain temperatures of 68-75°F in winter and 73-79°F in summer and relative humidity levels between 30% and 60%.

Additional Information: The temperature ranges given are based on the ASHRAE summer and winter comfort zones as specified in ASHRAE 55-1992. In the summer comfort zone, workers wearing light clothing will be comfortable; in the winter comfort zone, workers wearing heavy indoor clothing (e.g., sweaters) will be comfortable. The range of relative humidity given is based on ASHRAE 62 and is narrower than that currently specified in ASHRAE 55. The comfort zones assume sedentary work; personnel performing 'light work' (e.g., actively monitoring spatially distributed

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equipment, or retrieving procedures or manuals) will be comfortable at lower temperatures. Air movement rates less than 50 ft/min are also assumed.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.1

3.7.2.7.2 Temperature Differential

ES-0304-1381-12869

Guideline: Air temperature at floor level and at head level should not differ by more than 10°F.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.1

3.7.2.7.3 Air Quantity

ES-0304-1381-12871

Guideline: The ventilation system should be capable of introducing fresh air into the control room at a rate of at least 20 cubic feet per minute per occupant.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.2

3.7.2.7.4 Air Velocity

ES-0304-1381-12873

Guideline: Air velocities in the main operating area should not exceed 45 feet per minute measured at head level and should not produce a noticeable draft.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.2

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3.7.2.7.5 Illumination Levels

ES-0304-1381-12875

Guideline: The illumination levels should be consistent with those listed in Table 3-12

Additional Information: The values in the table are preferred levels based on conservative assumptions about the reflectance of the task background, the age of the operator, and the criticality of the task being performed. Lower illuminances may be justified for more favorable visual conditions or where the need to perform critical tasks can be ruled out.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

Table 3-12. Nominal illumination levels for various tasks and work areas

Work Area or Type of Task	Task Illuminance, footcandles
Panels, primary operating area	50
Auxiliary panels	50
Scale indicator reading	50
Seated operator stations	100
Reading:	
- handwritten (pencil)	100
- printed or typed	50
- VDU	10
Writing and data recording	100
Maintenance and wiring areas	50
Emergency operating lighting	10
(Source: adapted from NUREG/CR-5680, Tables 6.2 and 6.3)	

3.7.2.7.6 Uniformity

ES-0304-1381-12895

Guideline: The level of illumination should not vary greatly over a given work station.

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HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

3.7.2.7.7 Supplemental Light

ES-0304-1381-12897

Guideline: Supplemental lighting should be provided for personnel performing specialized visual tasks in areas where fixed illumination is not adequate.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

3.7.2.7.8 Task Area Luminance Ratios

ES-0304-1381-12899

Guideline: To ensure effective visual performance, the task area luminance ratios in Table 3-13 should not be exceeded.

Additional Information: To determine task lighting requirements, it is necessary to consider the levels of lighting that surround a task. Great disparities between task and background lighting can lead to adaptation problems.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

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Table 3-13. Maximum task area luminance ratios

Areas	Luminance Ratio
Task area versus adjacent darker surroundings	3:1
Task area versus adjacent lighter surroundings	1:3
Task area versus more remote darker surfaces	10:1
Task area versus more remote lighter surfaces	1:10
Luminaires versus surfaces adjacent to them	20:1
Anywhere within normal field of view	40:1

3.7.2.7.9 Shadows

ES-0304-1381-12910

Guideline: To reduce fatigue and eyestrain, shadows should be avoided.

Additional Information: Ambient illumination should be provided via indirect or diffuse lighting. Labels, instructions, and other written information should not be in shadowed positions.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

3.7.2.7.10 Glare

ES-0304-1381-12912

Guideline: Glare should not interfere with the readability of displays, labels, or indicators.

Additional Information: Glare increases the probability that an individual will misread a display or will fail to notice displayed information. Glare can also produce discomfort. Direct sources of glare include light emitted from luminaires, indicators, and displays. Indirect sources of glare include reflected light from all surfaces, e.g., paint, metal, and glass. The surface of a VDU screen should reduce reflections. Positioning of VDUs relative to light source affects glare as can use of a shield or filter on the VDU or light source. If glare reduction or contrast enhancement techniques are used, they should not violate the requirements of luminance, contrast, and resolution as stated in this document.

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HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

3.7.2.7.11 Reflectance

ES-0304-1381-12914

Guideline: Reflectance should conform to the recommendations shown in Table 3-14.

Additional Information: The amount of light reflected from a surface depends on its color; typical reflectance values for various colors are given in Table 3-15. Surfaces adjacent to a VDU should have a dull matte finish to reduce glare. The luminance range of surfaces immediately adjacent to VDUs should be between 10 percent and 100 percent of screen background luminance.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

3.7.2.7.12 Color

ES-0304-1381-12916

Guideline: Surface colors should be recognizable under both normal and emergency lighting conditions.

Additional Information: Some types of lamps (e.g., mercury or sodium lamps) have very poor color rendering properties. Such lamps should not be used for normal or emergency lighting if the ability to distinguish among colors may be important.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

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3.7.2.7.13 Ambient Illumination and VDUs

ES-0304-1381-12918

Guideline: The ambient illumination in the VDU area that is necessary for other visual functions (e.g., setting controls, reading instruments) should not degrade the visibility of signals on the VDU.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

Table 3-14. Recommended workplace reflectance levels

Surface	Reflectances Preferred	Reflectances Permissible
Ceiling[a]	80%	60-95%
Upper Wall	50%	40-60%
Lower Wall	15-20%	
Instruments/Displays	80-100%	
Cabinets/Consoles	20-40%	
Floor	30%	15-30%
Furniture	35%	25-45%

[a] Recommended reflectances are for finish only. Overall average reflectance of acoustic materials may be somewhat lower. The upper walls (one to two feet below the ceiling) may be painted with the same paint as is used on the ceiling.

3.7.2.7.14 Use of Colored Ambient Illumination

ES-0304-1381-12923

Guideline: Colored ambient illumination should not be used if color coding is used in the workplace.

Additional Information: Colored lighting will interfere with color-coded VDU displays and other color coding. Some types of lamps (e.g., mercury or sodium lamps) have very poor color rendering properties. Such lamps should not be used for normal or emergency lighting if the ability to distinguish among colors may be important.

HSI Design Criteria

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3.7.2.7.15 Illuminance of Areas Immediately Surrounding VDUs

ES-0304-1381-12925

Guideline: There should be no light source (direct or reflected) in the immediate surrounding area of the VDU that is of greater luminance than the VDU.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.3

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Table 3-15. Surface color reflectance values

Color		Reflectance
White		85
Light::		
	Cream	75
	Gray	75
	Yellow	75
	Buff	70
	Green	65
	Blue	55
Medium:		
	Yellow	65
	Buff	63
	Gray	55
	Green	52
	Blue	35
Dark:		
	Gray	30
	Red	13
	Brown	10
	Blue	8
	Green	7
Wood Finish:		
	Maple	42
	Satinwood	34
	English Oak	17
	Walnut	16
	Mahogany	12

3.7.2.7.16 Storage Locations

ES-0304-1381-12839

Guideline: There should be a suitable, out-of-the-way, but secure place in which control room personnel may keep their coats and other personal belongings.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.9

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3.7.2.7.17 Storage Suitability

ES-0304-1381-12841

Guideline: If lockers are provided, they should be large enough to hold the items that might reasonably be expected to require storage.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.9

3.7.2.7.18 Decor

ES-0304-1381-12843

Guideline: Decor should create a pleasant working environment in the control room.

Additional Information: Features to be considered include:

- Color coordination
- Use of color and lighting to create a cheerful atmosphere (without introducing glare and brightness to a degree that causes eye fatigue or an overly intense atmosphere)
- Visual relief from arrays of instrumentation
- Comfortable seating
- Carpeting to lessen the fatigue of standing and walking.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.10

3.7.2.7.19 Restroom and Eating Facilities

ES-0304-1381-12845

Guideline: A restroom and kitchen or eating area should be provided within (preferably) or near the control room isolation boundary.

Additional Information: Since formal breaks are not scheduled in most control rooms, it is important that personnel have access to these facilities without delay. It is preferable that they be used only by control room personnel. Provision should be made for

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communication if facilities are out of voice contact, so that an operator taking a break can be contacted as necessary by personnel in the control room.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.10

3.7.2.7.20 Rest Area/Lounge

ES-0304-1381-12847

Guideline: Consideration should be given to providing a rest area (possibly in conjunction with the eating area) conducive to relaxation and revitalization, especially where shifts are long.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.10

3.7.2.8 Shared Information

3.7.2.8.1 Shared Information and Control Functions

ES-0304-1381-12849

Guideline: The HSI design should maximize the ability of users to share information and control functions among crew members if users are required to share the responsibilities for monitoring and control.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.11

3.7.2.8.2 Indication of Shared Control Capability

ES-0304-1381-12851

Guideline: If a control function is shared among users but only one user can operate it at a time, then a clear, unambiguous indication should be provided identifying which user has the control capability.

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HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.11

3.7.2.8.3 Indication of Override of Shared Control Capability

ES-0304-1381-12853

Guideline: A clear, unambiguous indication should be provided prior to overriding the use of a shared control.

Additional Information: An override capability allows one user to take the control capability of a shared control from another user. If such an override capability exists, then a clear indication should be provided prior to each override so that users are aware of the pending change.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.11

3.7.2.8.4 Shared Display Devices

ES-0304-1381-12855

Guideline: When a display device is viewed by more than one person, its use should be regulated.

Additional Information: The system should not permit one user to remove a display that is still needed by another user, or to present a display that may interfere with another user's activities.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.11

3.7.2.8.5 User-Configured Displays

ES-0304-1381-12857

Guideline: When a display device can be configured by more than one user, the system should support the coordinated use of the displays.

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Additional Information: Users may modify display pages to address particular task needs or personal preferences. For example, a user may be able to select plant variables to be included in or excluded from the display page, define coding for displayed items, and define axes and scales for plots. When multiple users can manipulate the same displays, coordination may be needed to ensure that they are aware of the current content. In addition, mechanisms are needed to ensure that displays created by one user are not changed or eliminated by other users. Possible solutions include password protection, special directories for storing these displays, and administrative procedures.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.11

3.7.2.8.6 Soft Controls with Multiple Access

ES-0304-1381-12859

Guideline: The system should make each user aware of control inputs made by others, and ensure that the control actions of one user are not unknowingly reversing another user's actions.

Additional Information: Some input interfaces for controlling plant variables can be accessed from multiple locations in the HSI. Some process plants with computer-based HSIs address this problem by assigning control capabilities for a plant variable to a particular control console. Users at other consoles can observe the control setting but cannot initiate changes.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.11

3.7.2.8.7 Consistent System Response

ES-0304-1381-12861

Guideline: The system's interpretation of a user input should not change as a result of an upgrade.

Additional Information: For example, a given keystroke should not produce a benign action in one version of the system software and a destructive action, such as erasing data, in a subsequent version.

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HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.12

3.7.2.8.8 Existing Skills Preserved

ES-0304-1381-12863

Guideline: Changes to HSI hardware or software should not force users to have to unlearn existing skills.

Additional Information: It is better for an upgrade to require the user to learn additional skills rather than expect the user to change existing ones. Thus, changes in the information presented by the system (e.g., messages, graphic symbols) are less difficult to adapt to if they do not require users to modify their skills or strategies. For example, changes limited to physical appearance do not typically seriously disrupt users' performance, whereas changes in the operation of the system almost certainly will. However, sometimes the appearance of a system is strongly linked to user skills. For example, the layout of tools on the palette of a drawing program should not be changed in subsequent versions. Users who rely on spatial memory for retrieving tools from the palette will find that this skill leads them to select the wrong tool.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.1.12

3.7.2.8.9 Salient Changes

ES-0304-1381-12865

Guideline: If changes must be made to the HSI, they should be salient.

Additional Information: Drawing the user's attention to characteristics that have changed can help them to adapt their skills. For example, injecting a single new word into a message is not recommended. Adding the word 'not' to a question, such as "Do you want to save these settings?" will change the meaning of the message. However, it may not be detected by the user until an error occurs. Many actions become automatic as users become skilled in using the interface. If HSI changes are obvious, users may be able to block their automatic responses and develop new ones.

HSI Design Criteria

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Reference: NUREG-0700-12.1.1.12

3.7.2.9 Acoustics

3.7.2.9.1 Overall Design

ES-0304-1381-12935

Guideline: The acoustic design of the control room should ensure that verbal communications among personnel are not impaired; auditory signals are readily detected; and auditory distraction, irritation, and fatigue are minimized.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.5

3.7.2.9.2 Background Noise

ES-0304-1381-12937

Guideline: Background noise should not impair verbal communication between any two points in the main operating area.

Additional Information: Verbal communications should be intelligible using normal or slightly raised voice levels. Figure 3-33 shows the voice levels needed for spoken communication over specified distances in the presence of different levels of background noise. Intelligibility of speech in noise is affected by the frequency spectra of the noise and of the speakers' voices and by the speakers' hearing sensitivity.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.5

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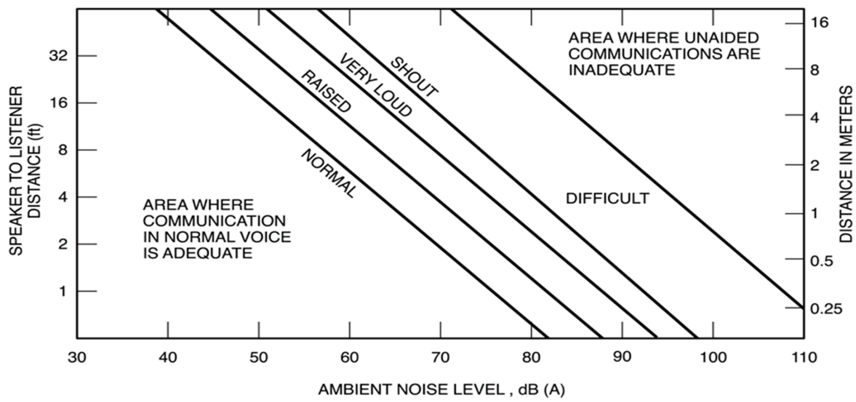

Figure 3-33. Voice level as a function of distance and ambient noise level

3.7.2.9.3 Background Noise Level

ES-0304-1381-12941

Guideline: Background noise levels should not exceed 65 dB(A).

Additional Information: Operators eight feet apart will have to speak loudly to be heard in the presence of a 65 dB(A) background noise. Therefore, if workstations, display panels, or control interfaces are widely separated in the control room, the background noise limit should be reduced.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.5

3.7.2.9.4 Further Reductions

ES-0304-1381-12943

Guideline: Where communications between the main operating area and other control room locations are necessary, and voice transmission systems are not provided, further reductions in background noise should be implemented.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.5

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3.7.2.9.5 Noise Distractions

ES-0304-1381-12945

Guideline: Noise distractions generated either inside or outside the control room should be minimized.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.5

3.7.2.9.6 Reverberation Time and Sound Absorption

ES-0304-1381-12947

Guideline: The acoustical treatment of the control room should limit reverberation time to 1 second or less.

HSI Design Criteria

NuScale control room configuration guidance will incorporate this design standard.

Reference: NUREG-0700-12.1.2.5

3.7.3 Local Control Stations Requirements and Guidelines

3.7.3.1 Labeling of Equipment

ES-0304-1381-12949

Guideline: Labels should appear on all components and systems with which personnel may interact.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.1 Replacement of Labels

ES-0304-1381-12951

Guideline: When labels are affixed, earlier markings (such as labels applied during construction or acceptance, or informal labels) should be removed.

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HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.2 Viewing Direction

ES-0304-1381-12953

Guideline: When equipment may be approached from more than one direction, labels should be placed on surfaces so that they are visible from each direction.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.3 Label Visibility

ES-0304-1381-12955

Guideline: Identifying labels should be placed so that they are readily visible at typical viewing distances and orientations.

Additional Information: Labels should be placed so as to be visible to plant personnel of both short and tall stature. Recommended character sizes are given in ES-0304-1381-13038.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.4 Locator Labels

ES-0304-1381-12957

Guideline: Readily visible markings should be placed nearby to indicate the location and identity of components that are partially blocked from view.

Additional Information: The location of overhead valves can be indicated by labels on floors or walls directly below them.

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HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.5 Label Orientation

ES-0304-1381-12959

Guideline: Labels should be designed and mounted so that text is oriented horizontally for ease of reading.

Additional Information: Requiring operators to manipulate and re-orient the label is inconvenient (especially when their hands are full), and may lead to misreading.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.6 Label Positioning

ES-0304-1381-12961

Guideline: Labels should be attached or positioned so as to unambiguously indicate the item being identified.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.7 Redundant Labels

ES-0304-1381-12963

Guideline: When labels are placed on the doors of equipment cabinets, redundant labels should be placed inside so that they are visible when the door is open.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

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3.7.3.1.8 Label Placement Conventions

ES-0304-1381-12965

Guideline: Specific conventions for label placement should be employed for each type of equipment (e.g., valves, motors).

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.9 Label Mounting

ES-0304-1381-12967

Guideline: Tags should be attached to components so as not to cause damage or interfere with operation.

Additional Information: Valve labels should not be connected to handwheels or operating chains. The wire used to attach a label to a valve should be passed through the yoke in a manner that will not damage the stem. For chain-operated valves, the label should be wired to a small piece of plastic pipe through which the operating chain passes freely.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.10 Label Replacement after Maintenance

ES-0304-1381-12969

Guideline: Maintenance procedures should require personnel to check that labels are in place after components are reassembled or replaced.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

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3.7.3.1.11 Means of Label Attachment

ES-0304-1381-12971

Guideline: Labels and tags should be securely attached in a manner appropriate to the equipment and environmental conditions.

Additional Information: The method chosen to attach a label should take into account the possibility of exposure to heat, corrosive substances, oil, or solvents.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.1

3.7.3.1.12 Label Material

ES-0304-1381-12973

Guideline: The material from which labels and tags are made should be appropriate to the equipment and environmental conditions.

Additional Information: The material chosen should take into account the possibility of exposure to heat, corrosive substances, oil, or solvents. A single label material may not be appropriate in all environments. If different label material is required at different locations in the plant, an effort should be made to keep the content and format of the labels constant.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.2

3.7.3.1.13 Label Contrast

ES-0304-1381-12975

Guideline: Lettering and background colors should provide high contrast and high legibility.

Additional Information: Dark letters on a light background are preferred. Table 3-10 provides examples of color combinations and their relative legibility. Stamped metal tags (brass, stainless steel, and color anodized aluminum) often are illegible under less-than-optimal conditions.

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HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.2

3.7.3.1.14 Character Height

ES-0304-1381-12977

Guideline: Characters used on labels should be sized to take into account viewing distances and illumination conditions.

Additional Information: The character height recommendations in Guideline ES-0304-1381-12249 should be observed. Character heights required for various viewing distances are given in Table 3-16. Under less- than-optimal viewing conditions, the preferred values should be used as minimums. The preferred values should also be used for critical markings associated with safety-related systems.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.2

3.7.3.1.15 Stenciled Labels

ES-0304-1381-12979

Guideline: Stenciled labels should not be used.

Additional Information: The gaps in stenciled characters render them less legible than other forms of labeling.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.2

3.7.3.1.16 Label Reflectance

ES-0304-1381-12981

Guideline: Surfaces of labels should have a non-reflective (i.e., matte) finish.

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Additional Information: Reflective materials may be added to labels to aid locating equipment when normal lighting is lost. Such labels should be designed so that legibility is not impaired under normal lighting conditions; e.g., a reflective border may be placed around the contents of the label.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.2

Table 3-16. Minimum and preferred character heights for various viewing distances

Viewing Distance	Minimum Character Height		Preferred Character Height	
	inches[1]	points[2]	inches[3]	points[2]
28 inches	0.112	8	0.168	12
3 feet	0.144	10	0.216	16
4 feet	0.192	14	0.288	21
5 feet	0.240	17	0.360	26
6 feet	0.288	21	0.432	30
10 feet	0.480	35	0.720	50
20 feet	0.960	70	1.440	100
30 feet	1.440	100	2.160	150
40 feet	1.920	140	2.880	200
50 feet	2.400	175	3.600	250

1 minimum character height (15 minutes of arc) = distance multiplied by .004

2 character heights in points (1 point = 1/72 inch) are approximate

3 preferred character height (20 minutes of arc) = distance multiplied by .006

3.7.3.2 Label Content

3.7.3.2.1 Label Information

ES-0304-1381-13035

Guideline: Labels should contain concise, descriptive noun names along with alphanumeric system and component identification codes.

Additional Information: Labels should provide sufficient descriptive information to allow the least experienced operator to recognize the equipment. The following additional

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items may be considered for inclusion on labels: unit/train/channel designations, power supply information, operational characteristics, and flow direction.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.3

3.7.3.2.2 Labeling Conventions

ES-0304-1381-13037

Guideline: Labeling conventions should be employed to ensure consistency of plant labeling with drawings and procedures.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.3

3.7.3.2.3 Standard Label Format

ES-0304-1381-13039

Guideline: The format of presentation (e.g., order, position) of information should be consistent on all labels.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.3

3.7.3.2.4 Abbreviations

ES-0304-1381-13041

Guideline: Abbreviations used on labels should be standardized and easily recognized.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.1.3

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3.7.3.2.5 Design of Gauges

ES-0304-1381-13043

Guideline: The design of gauges and meters should conform to the relevant portions of Section 3.1.2.25, Meters.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.2.1

3.7.3.2.6 Alignment Marks

ES-0304-1381-13047

Guideline: Alignment marks should be used to indicate open and closed status of important manual valves.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.2.3

3.7.3.2.7 Visibility of Position Indication

ES-0304-1381-13049

Guideline: The location and size of the alignment marks should reflect the normal viewing distance, location, and ambient lighting.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.2.3

3.7.3.2.8 Indication of Full Open/Closed Positions

ES-0304-1381-13051

Guideline: Alignment marks should show both the valve's fully open and fully closed positions.

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HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.2.3

3.7.3.2.9 Design of Position Indication

ES-0304-1381-13053

Guideline: Alignment marks should be located to minimize parallax error.

Additional Information: Parallax refers to the apparent change in the relative positions of objects depending on the position of the viewer. Error will be minimized if the distance between the indicator and the marks against which it is to be read is small, and if the indicator is located so that it can be viewed "straight-on," i.e., with the observer's LOS perpendicular to the plane of the alignment marks.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.2.3

3.7.3.2.10 Indication of Direction of Rotation

ES-0304-1381-13055

Guideline: The direction of rotation for opening and closing of a valve control wheel should be indicated in cases where the direction is not obvious.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.2.3

3.7.3.2.11 Precision of Indication

ES-0304-1381-13057

Guideline: Alignment marks should be precise enough that the observers can tell when a valve is fully opened or closed.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

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Reference: NUREG-0700-12.2.2.3

3.7.3.2.12 Alternate Means of Local Position Indication

ES-0304-1381-13059

Guideline: Indicators that are activated by valve limit controls should be used when alignment marks would not be appropriate.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.2.3

3.7.3.2.13 Design of Controls

ES-0304-1381-13061

Guideline: The design and operation of controls should conform to the guidelines in Section 3.3, Input/Output Systems and Devices.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.3.1

3.7.3.2.14 Inadvertent Activation

ES-0304-1381-13063

Guideline: Controls should be protected against inadvertent actuation.

Additional Information: See Guideline ES-0304-1381-10233. The danger of inadvertent actuation of controls may be greater outside the control room due to ongoing construction, maintenance, calibration, and outage-related activities. Controls can be affected by personnel or equipment moving by, radio transmissions, or vibration.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.3.1

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3.7.3.2.15 Suitability for Use

ES-0304-1381-13065

Guideline: The operation of controls should be compatible with the use of protective clothing, if it may be required.

Additional Information: The likelihood of operators requiring protection (e.g., against heat or radiation) is greater outside the control room.

HSI Design Criteria

NuScale will take into account the use of protective clothing where applicable.

Reference: NUREG-0700-12.2.3.1

3.7.3.2.16 Operating Labels

ES-0304-1381-13067

Guideline: Handwheels should be provided with double-ended arrows showing the direction of operations and labeled at each end to indicate the functional result (i.e., open and close).

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.3.2

3.7.3.2.17 Turning Aids

ES-0304-1381-13069

Guideline: Knurling, indentation, high-friction covering, or a combination of these should be built into the handwheel to allow the application of the required torque.

HSI Design Criteria

NuScale LCS labeling guidance will incorporate this design standard.

Reference: NUREG-0700-12.2.3.2

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3.7.3.3 Paging System

3.7.3.3.1 Range of Coverage of Loudspeakers

ES-0304-1381-13071

Guideline: Loudspeaker coverage should be such that members of the work force can be alerted under all plant conditions.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.1

3.7.3.3.2 Coverage Areas of Loudspeakers

ES-0304-1381-13073

Guideline: Loudspeaker coverage should be provided in all areas where the work force may be.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.1

3.7.3.3.3 Locations and Amplitudes of Loudspeakers

ES-0304-1381-13075

Guideline: Speakers should be placed within a space so that their number, location, and volume provide an intelligible signal to all workers therein.

Additional Information: Room size and configuration, and ambient noise levels should be taken into account.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.1

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3.7.3.3.4 Echoes

ES-0304-1381-13077

Guideline: Loudspeaker systems should not echo.

Additional Information: Sufficient numbers of loudspeakers should be provided in containment and other large volumes to avoid excessive echoing. Maximum speaker range in these reverberant spaces should not exceed 50 feet.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.1

3.7.3.3.5 Locations of Paging Stations

ES-0304-1381-13079

Guideline: Page stations should be located so that time required for access by personnel does not exceed 30 seconds.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.2

3.7.3.3.6 Shielding of Paging Stations

ES-0304-1381-13081

Guideline: Sound shielding should be provided where ambient noise levels exceed 90 dB(A).

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.2

3.7.3.3.7 Control of Paging System

ES-0304-1381-13083

Guideline: Design features or administrative controls should limit unauthorized or excessive use of the paging system.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.2

3.7.3.3.8 Variable Amplitude Speakers

ES-0304-1381-13085

Guideline: A means of varying speaker amplitude should be provided when ambient noise levels may vary by more than 20 dB.

Additional Information: Features should be provided to allow the volume setting to be monitored. Administrative controls should be established to ensure that speaker amplitude is restored after having been reduced, e.g., during an outage.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.2

3.7.3.3.9 High Noise Environments

ES-0304-1381-13087

Guideline: Communications equipment should conform to speech based requirements relevant to high noise environments.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.3

3.7.3.3.10 Portable Alerting Devices

ES-0304-1381-13089

Guideline: Personal paging devices should be provided and should be suitable for high-noise or remote areas.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.3

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3.7.3.3.11 Channel Capacity Requirements

ES-0304-1381-13091

Guideline: A minimum of five communications channels should be provided to avoid excessive waiting for a free channel.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.4

3.7.3.3.12 Dedicated Emergency Circuits

ES-0304-1381-13093

Guideline: Dedicated lines should be provided for frequent or emergency communications.

Additional Information: Sound-powered lines are a cost-effective method of providing this capability.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.4

3.7.3.3.13 Signal Characteristics

ES-0304-1381-13095

Guideline: The signal transmission characteristics of the system should support good intelligibility.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.4

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3.7.3.3.14 Emergency System Access Locations

ES-0304-1381-13097

Guideline: Emergency system stations should be located so that time and effort required for access by personnel is not excessive and so that stations are in areas of relative quiet.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.4

3.7.3.3.15 Portable Communication Devices

ES-0304-1381-13099

Guideline: Portable systems should be available to supplement installed systems.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.4

3.7.3.3.16 Radio Coverage

ES-0304-1381-13101

Guideline: Surveys should be conducted to identify areas in which radio communication is not possible, e.g., "dead spots" or areas near sensitive equipment.

Additional Information: Other means of communication should be readily available in areas where radio use is prohibited.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.4

3.7.3.3.17 Radio Repeaters

ES-0304-1381-13103

Guideline: Radio repeaters should be installed to eliminate "dead spots" if radio communication is relied upon.

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HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.4

3.7.3.3.18 Use with Special Garments

ES-0304-1381-13105

Guideline: Communication capability should be provided for personnel wearing protective clothing.

HSI Design Criteria

The NuScale Communications System (G030) will meet the standards addressed here.

Reference: NUREG-0700-12.2.4.4

3.7.3.4 Environmental

3.7.3.4.1 Heat Stress

ES-0304-1381-13115

Guideline: The level of physical activity and required protective clothing, as well as temperature and humidity, should be considered when assessing the danger of heat exposure.

Additional Information: Important considerations are the amount of metabolic heat being generated by the worker and the restriction of evaporative heat loss associated with protective clothing. Workers' abilities to withstand heat will also differ based on their physical conditioning and degree of acclimatization.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.1

3.7.3.4.2 Engineering Controls

ES-0304-1381-13117

Guideline: Engineering controls should be applied where heat may impair the effectiveness or threaten the wellbeing of workers.

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Additional Information: Examples of engineering controls include: shielding or insulating sources of radiant heat, eliminating steam leaks, increasing ventilation, and providing assists to reduce the strenuousness of the task. Temperature ranges intended to minimize performance decrements and potential harm to workers as a result of excessive heat are given in Table 3-17. The temperature ranges in the table are ceiling values; i.e., they assume that protective practices (such as acclimatization, training, and a cool place to rest) are in place.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.1

3.7.3.4.3 Work Practices

ES-0304-1381-13119

Guideline: Work practices should be adopted to minimize risk due to heat exposure that cannot be eliminated by engineering controls.

Additional Information: Recommended work practices recommended include training in the recognition and treatment of heat illnesses, water and salt replacement, acclimation, and work/rest cycles (stay times). Illustrations of how temperature (wet-bulb globe temperature, WBGT), metabolism, and clothing relate to stay times are found in Table 3-18. The times in the table are ceiling values; i.e., they assume that protective practices (such as acclimatization, training, and a cool place to rest) are in place.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.1

3.7.3.4.4 Water Availability

ES-0304-1381-13121

Guideline: Water should be readily available in areas where the potential for heat stress exists.

Additional Information: Unusual measures may be necessary to provide drink or cooling to workers in restricted areas.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

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Reference: NUREG-0700-12.2.5.1

Table 3-17. Ranges of WBGT for different ranges of stay times

Stay Time	Work Clothes			Cotton Coveralls			Double Cottons			Cottons plus Plastics		
	Metabolism			Metabolism			Metabolism			Metabolism		
	Low	Mod	High	Low	Mod	High	Low	Mod	High	Low	Mod	High
0-15	50-52 (122-126)	42-50 (108-122)	38-42 (100-108)	48-50 (118-122)	41-49 (106-120)	37-41 (99-106)	46-48 (115-118)	38-46 (100-115)	34-38 (93-100)	44-46 (111-115)	36-44 (97-111)	32-36 (90-97)
15-30	44-50 (111-122)	36-42 (97-108)	32-38 (90-100)	42-48 (108-118)	35-41 (95-106)	31-37 (89-99)	40-46 (104-115)	32-38 (90-100)	28-34 (82-93)	38-44 (100-111)	30-36 (86-97)	26-32 (79-90)
20-45	42-48 (108-118)	34-38 (93-100)	31-34 (89-93)	40-46 (104-115)	33-37 (91-99)	30-33 (86-91)	38-44 (100-111)	30-34 (86-93)	27-30 (81-86)	36-42 (97-108)	28-32 (82-90)	25-28 (77-82)
30-60	40-44 (104-111)	33-36 (91-97)	30-32 (86-90)	38-42 (100-108)	32-35 (90-95)	29-31 (84-89)	36-40 (97-104)	29-32 (84-90)	26-28 (79-82)	34-38 (93-100)	27-30 (81-86)	24-26 (75-79)
45-90	38-42 (100-108)	32-34 (90-93)	29-31 (84-89)	36-40 (97-104)	31-33 (89-91)	28-30 (82-86)	34-38 (93-100)	28-30 (82-86)	25-27 (77-81)	32-36 (90-97)	26-28 (79-82)	23-25 (73-77)
60-120	36-40 (97-104)	30-33 (86-91)	28-30 (82-86)	34-38 (93-100)	29-32 (84-90)	27-29 (81-84)	32-36 (90-97)	26-29 (79-84)	24-26 (75-79)	30-34 (86-93)	24-27 (75-81)	22-24 (72-75)
90-3h	34-38 (93-100)	29-32 (84-90)	27-31 (81-89)	32-36 (90-97)	28-31 (82-89)	26-30 (79-86)	30--34 (86-93)	25-28 (77-82)	23-27 (73-81)	28-32 (82-90)	23-26 (73-79)	21-25 (70-77)
2h-4h	32-36 (90-97)	28-30 (82-86)	26-28 (79-82)	30-34 (86-93)	27-29 (81-84)	25-27 (77-81)	28-32 (82-90)	24-26 (75-79)	22-24 (72-75)	26-30 (79-86)	22-24 (72-75)	20-22 (68-72)

Table 3-18. Stay times for different WBGTs

Wet-Bulb Globe Temp		Work Clothes			Cotton Coveralls			Double Cottons			Cottons plus Plastics		
		Metabolism			Metabolism			Metabolism			Metabolism		
C	F	Low	Mod	High	Low	Mod	High	Low	Mod	High	Low	Mod	High
50	122	15-30	0-10		5-15	0-5		5-15					
48	118	20-45	5-15		15-30	5-10		10-20			5-15		
46	115	20-45	5-20		20-45	5-15		15-30	0-10		15-20		
44	111	30-60	10-25		20-45	5-20		20-45	5-15		15-30	0-10	
42	108	45-90	15-30	5-10	30-60	10-25		20-45	5-20		20-45	5-15	
40	104	60-90	15-45	10-20	45-90	15-40	5-10	30-60	10-25		20-45	5-20	
38	100	90-120	20-45	15-30	60-90	15-45	10-25	45-90	15-30	5-10	30-60	10-25	
36	97	2h-4h	30-60	15-40	90-120	25-45	15-30	60-90	15-45	10-20	45-90	15-30	5-10
34	93	3h-8h	45-90	20-45	2h-4h	30-60	15-45	90-120	20-45	15-30	60-90	15-45	10-20
32	90	NL	90-120	30-60	3h-8h	60-100	25-50	2h-4h	30-60	15-40	90-120	20-45	15-30
30	86	NL	2h-4h	60-120	NL	1h-2h	30-90	3h-8h	45-90	20-45	2h-4h	30-60	15-40
28	82	NL	NL	2h-4h	NL	1h-4h	lh-3h	NL	90-120	30-60	3h-8h	45-90	20-45
26	79	NL	NL	4h-8h	NL	NL	3h-8h	NL	2h-4h	60-120	NL	90-120	30-60
24	75	NL	NL	NL	NL	NL	NL	NL	NL	2h-4h	NL	2h-4h	60-120
22	72	NL	NL	NL	NL	NL	NL	NL	NL	4h-8h	NL	NL	2h-4h
20	68	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	4h-8h
<20	<68	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL

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3.7.3.4.5 Outdoor Equipment

ES-0304-1381-13630

Guideline: Equipment located outdoors should be sheltered from the elements as much as possible.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.2

3.7.3.4.6 Wind Chill

ES-0304-1381-13632

Guideline: When considering the effects of cold on performance, the effect of air velocity should be taken into account.

Additional Information: Table 3-19 illustrates the wind chill effect; effective temperatures are shown for different combinations of air temperature and wind speed.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.2

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Table 3-19. Wind chill

Wind Speed (mph)	Actual Air Temperature (°F)									
	50	40	30	20	10	0	-10	-20	-30	-40
Calm	50	40	30	20	10	0	-10	-20	-30	-40
5	48	36	27	17	-5	-5	-15	-25	-35	-46
10	40	29	18	5	-8	-20	-30	43	-55	-68
15	35	23	10	-5	-18	-29	-42	-55	-70	-83
20	32	18	4	-10	-23	-34	-50	-64	-79	-94
25	30	15	-1	-15	-28	-38	-55	-72	-88	-105
30	28	13	-5	-18	-33	-44	-60	-76	-92	-109
35	27	11	-6	-20	-35	-48	-65	-80	-96	-113
40	26	10	-7	-21	-37	-52	-68	-83	-100	-117
45	25	9	-8	-22	-39	-54	-70	-86	-103	-120
50	25	8	-9	-23	-40	-55	-72	-88	-105	-123

3.7.3.4.7 Effects of Cold on Performance

ES-0304-1381-13914

Guideline: The potential for exposure to cold to affect task performance should be evaluated.

Additional Information: Table 3-20shows, for various tasks, the no-effect levels for the various impacts of cold on performance (i.e., temperatures below which performance decrements may occur).

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.2

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Table 3-20. Temperatures above which no cold effects occur

	Air Temperature	Hand Skin Temperature
General Discomfort	69 °F	75 °F
Effects of Cold on the Hands		
Skin Sensitivity		75 °F
Numbness	54 °F	68 °F
Pain		61 °F
Finger Discrimination		37 °F
Grip Strength	14 °F	
Task Performance		
Fine Manual Tasks	64 °F	55 °F
Tracking	55 °F	
Gross Manual Tasks	54 °F	59 °F

3.7.3.4.8 Engineering Controls

ES-0304-1381-13938

Guideline: Engineering controls should be applied where cold may impair the effectiveness or threaten the wellbeing of workers.

Additional Information: Engineering controls increase the amount of heat received by the worker or insulate the worker from the cold; examples include providing space heaters or wind breaks, and insulating tool handles or valve handwheels. In addition, equipment handles and latches and panel switches and pushbuttons should be operable with gloved hands if located in areas where workers may be exposed to cold.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.2

3.7.3.4.9 Work Practices

ES-0304-1381-13940

Guideline: Work practices should be adopted to minimize risk due to cold exposure that cannot be eliminated by engineering controls.

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Additional Information: Examples of administrative controls include scheduling outdoor maintenance for warmer seasons or times of day, assigning more worker to a job to reduce the duration of the exposure to cold, and allowing workers to take a break in warm areas when needed.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.2

3.7.3.4.10 Protective Clothing

ES-0304-1381-13942

Guideline: Insulated clothing, hats and gloves should be provided to workers who are exposed to cold.

Additional Information: The need to remove gloves to perform certain tasks should be taken into account, and engineering and administrative controls should be applied accordingly.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.2

3.7.3.4.11 Quieting the Work Process

ES-0304-1381-13944

Guideline: Steps should be taken to reduce noise at its source.

Additional Information: The preferred approach for mitigating the effects of noise is to reduce the vibration that is causing the noise by isolating or dampening the vibration with machine mountings. The speed of the operating machinery can be altered, thereby changing the frequency of the noise. The resonance of the vibrating objects can be reduced.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.3

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3.7.3.4.12 Limiting Noise Transmission

ES-0304-1381-13946

Guideline: Steps should be taken to limit the transmission of noise.

Additional Information: Noise can be reduced by increasing the distance of the noise source from the worker. This technique is less effective for low frequencies. Sound-attenuating barriers or enclosures should be used when workers are required to work near equipment that, despite quieting measures, produces high levels of noise. Sound-absorbing materials can absorb 70% of the noise that strikes them. These materials are effective for both low and high frequencies.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.3

3.7.3.4.13 Limiting Noise Exposure

ES-0304-1381-13948

Guideline: Steps should be taken to protect workers from noise.

Additional Information: Administrative controls should limit the amount of time that workers spend in noisy locations.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.3

3.7.3.4.14 Hearing Protection

ES-0304-1381-13950

Guideline: Ear protection devices should be available and required to be worn in areas where noise levels are 85 dB or more.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.3

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3.7.3.4.15 Sound Attenuating Enclosures

ES-0304-1381-13952

Guideline: When workers may be required to remain in high noise areas for extended periods of time, appropriate sound attenuating enclosures should be provided.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.3

3.7.3.4.16 Auditory Capabilities of Users

ES-0304-1381-13954

Guideline: The hearing sensitivity of the work force should be monitored.

Additional Information: The needs of those workers with hearing degradation should be taken into account.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.3

3.7.3.4.17 Communications and Hearing Protection

ES-0304-1381-13956

Guideline: Communication equipment in high noise areas should be compatible with ear protection devices.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.3

3.7.3.4.18 Illumination Levels

ES-0304-1381-13958

Guideline: The illumination levels should conform to those listed in Table 3-21.

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Additional Information: The values in the table are based on conservative assumptions about the reflectance of the task background, the age of the worker, and the criticality of the task being performed. Lower illuminances may be justified for more favorable visual conditions or where the need to perform critical tasks can be ruled out. For tasks similar to those performed in the control room (e.g., reading instruments, calibration, reading procedures), the lighting recommendations in Section 3.7.2.7, Illumination, should be consulted.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.4

Table 3-21. Range of recommended illuminances for inspection/assembly activities

Area/activity	Footcandles
Inspection/assembly	
Simple	50
Difficult	200
Rough Bench or Machine Work	50
In-plant areas	
Turbine Building	50
Auxiliary Building	20
Laboratory	100
Storage Room	20
ESF Equipment	50
Diesel Generator Building	50
Fuel Handling Building	50
Reactor Building	50
Stairways and Corridors	10

3.7.3.4.19 Portable Lighting

ES-0304-1381-14005

Guideline: Easily used, portable lighting devices should be readily available nearby when permanent lighting (normal or emergency) may be inadequate.

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Additional Information: A supply of fresh batteries should be stored near portable lighting devices.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.4

3.7.3.4.20 Permanent Means of Access

ES-0304-1381-14007

Guideline: Permanent means of access to equipment requiring recurrent or emergency operation should be provided when it is beyond the normal standing reach of workers.

Additional Information: Examples of access provisions include work platforms and ladders.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.5

3.7.3.4.21 Temporary Means of Access

ES-0304-1381-14009

Guideline: Temporary or movable access platforms to equipment should be available when the equipment is located beyond the normal standing reach of workers and permanent access provision is not feasible.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.5

3.7.3.4.22 Appropriate Means of Access

ES-0304-1381-14011

Guideline: Catwalks, ladders, and other suitable means should be provided for workers to reach equipment.

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Additional Information: Workers should not be required to walk along pipes or to use components as "stepping stones" in order to reach equipment.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.5

3.7.3.4.23 Sufficient Clearance

ES-0304-1381-14013

Guideline: Sufficient clearance should be provided in the vicinity of equipment in contaminated or high temperature areas to allow workers easy access despite the use of protective garments and associated gear.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.5

3.7.3.4.24 Impediments to Access

ES-0304-1381-14015

Guideline: Access to equipment to be operated should not be impeded by structural elements.

Additional Information: Structural elements added to the plant (e.g., seismic reinforcements) should not restrict access to equipment.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.5

3.7.3.4.25 Vibration Levels

ES-0304-1381-14017

Guideline: The effects of vibration on visual and manual performance should be evaluated using Figure 3-34.

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Additional Information: Engineering controls should be applied to reduce vibration. If vibration levels still exceed those in the unshaded areas of Figure 3-34, a study should be performed to demonstrate that human performance is within acceptable limits. In the top graph, the shaded area represents conditions that will cause an error of 5% or more in number reading. In the bottom graph, the shaded area represents conditions that will cause a tracking error of 10% or more.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.6

3.7.3.4.26 Reducing Vibration

ES-0304-1381-14019

Guideline: Steps should be taken to reduce vibration at its source.

Additional Information: The preferred approach for reducing the vibration is to isolate or dampen the vibration with machine mountings.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.6

3.7.3.4.27 Limiting Transmission of Vibration

ES-0304-1381-14021

Guideline: Steps should be taken to limit the transmission of vibrations to workers.

Additional Information: Workers can be isolated from vibration in shock-mounted, energy-absorbing platforms.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.6

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3.7.3.4.28 Reducing the Effects of Vibration

ES-0304-1381-14023

Guideline: User interfaces should be designed to reduce the disruptive effects of vibration.

Additional Information: Modifications that minimize the effects of vibration on task performance include installing larger dials that can be read despite vibration or providing a means for workers to stabilize their limbs.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.6

3.7.3.4.29 Limiting Exposure to Vibration

ES-0304-1381-14025

Guideline: Steps should be taken to protect workers from excessive vibration.

Additional Information: Administrative controls should limit the amount of time that workers are exposed to high levels of vibration. These controls would primarily address effects on comfort and worker safety.

HSI Design Criteria

NuScale overall plant design will ensure this standard is addressed.

Reference: NUREG-0700-12.2.5.6

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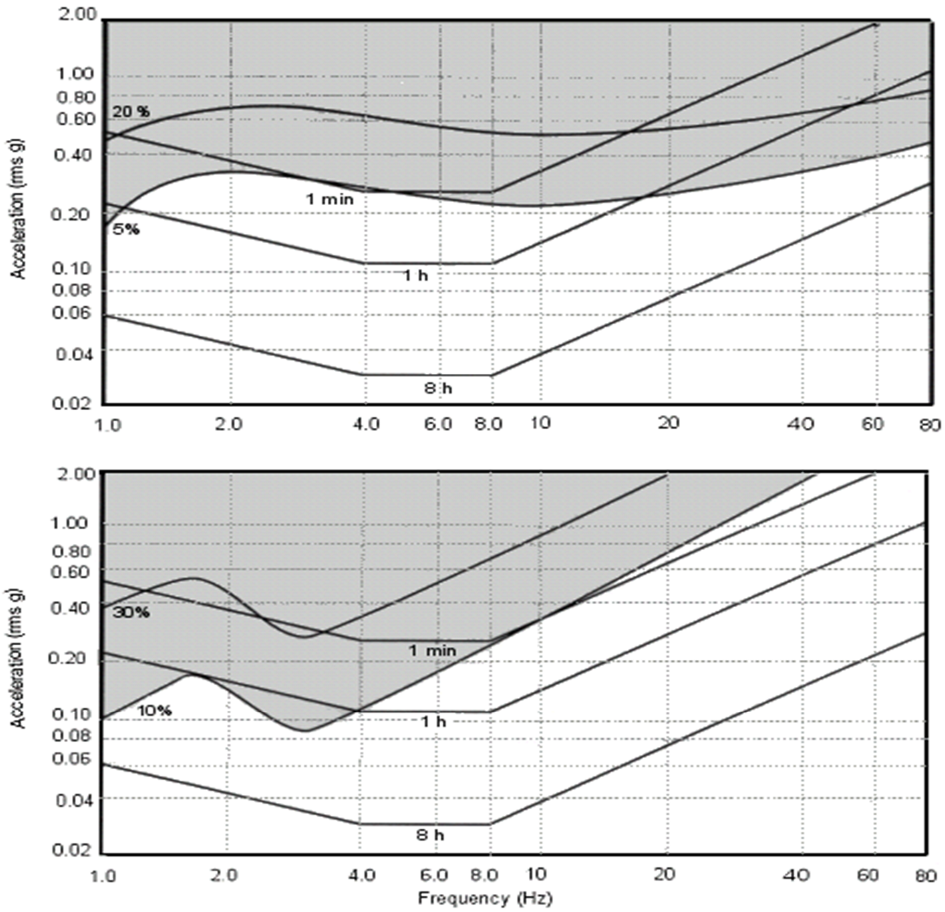

Figure 3-34. Vibration level graphs used for accuracy and manual tracking guidance

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3.8 Hardware

3.8.1 Input Controls

Controls are the devices through which personnel interact with the HSI and the plant, including computer- input devices and conventional controls. Each is described below. General design and coding principles that apply to all controls are given in 3.1. Soft controls are treated as an HSI system because they have display, interactions, and control components.

3.8.1.1 Definitions

Computer Based Input Devices

Input devices are devices used to provide input to computer-based systems. The following input devices are frequently used in computer-based systems:

Alaphanumeric Keyboards

These are keypads containing alphabetic and numeric characters. The user presses these keys to form commands or to enter data.

Function Keys

This refers to the physical keys of a keyboard or keypad that are used to initiate a particular, dedicated function.

Trackballs, Joysticks and Mice

These are indirect pointing devices in the sense that their movement at one location causes the cursor to move at a separate location – the display screen. A trackball is a device that allows the user to control the cursor's movement in any direction by rotating a ball. A joystick is a stick-type device that can provide continuous control of the cursor in any direction on a display screen. A mouse is a device whose movements across a flat surface are converted into analogous movements of the cursor across the screen.

Touchscreens, Light Pens and Graphics Tablets

These are direct pointing devices in that they allow the user to select information directly from a display screen. A touch screen is a device whereby user can communicate with the computer by touching a screen. A light pen is a pencil- or pen-like device that interacts with the computer system through the display device screen by either emitting or sensing light. A graphics tablet (also called a digitizing tablet) is a device that converts an image into digital code by drawing or tracing with a pen-like or puck-like instrument. The instrument is moved across the tablet, generating a series of X-Y coordinates.

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Speech Input Devices

These devices allow the user to provide input in spoken form, which a computer then interprets as data or commands. A speech input system typically consists of a microphone (e.g., stationary or mounted to a headset), components for transmission (e.g., a cable or a wireless media), and a processing unit.

Conventional Control Device

Conventional controls are hardwired devices for providing control input. Each control typically has a single dedicated location in a control panel. Conventional controls usually have either discrete settings or a continuous range for adjustment. Those with discrete settings typically have one of two types of operation – momentary and latching. Momentary control returns to its original setting when released. A

latching control stays in position until operated again. The following are examples of conventional control devices:

Pushbutton Controls

These are buttons that generate a signal when they are pressed with the finger or hand. Their shape (e.g., round or square), size, and texture may vary. Legend pushbuttons are illuminated by internal lamps; their faces may contain alphanumeric text.

Rotary Controls

These controls are operated with a rotary motion. They include knobs, dials, J-handle controls, key- operated controls, continuous adjustment controls, and rotary selector controls.

Other Controls

<u>Thumbwheels</u>

These controls are wheels that are turned by running the thumb or finger across their surface.

<u>Slide switches</u>

These controls are operated by sliding a knob linearly in the horizontal or vertical direction.

<u>Toggle switches</u>

These are stemmed switches that the user can move to discrete settings.

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Rocker switches

These switches have nearly flat faces and can be moved by the user to discrete settings.

3.8.1.2 Requirements and Guidelines

General

3.8.1.2.1 Appropriate Use of Input Devices

ES-0304-1381-10226

Guideline: Input and control devices provided for interacting with the HSI should be appropriate for the user's task requirements.

Additional Information: Control/input devices and conditions for their appropriate use are listed in Table 3-22

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

Table 3-22. Control and input devices for human-computer interaction

Control/Input Device	Conditions for Appropriate Use
Cursor Control Keys	Moving cursor in X and Y dimensions
Touch Screen	Moving/holding arm to screen for long periods of time is not required Screen does not have small poke points relative to size of finger tip A low level of resolution is required for positioning Task will not be disrupted by hand temporarily blocking screen Periodic cleaning of screen is provided
Light Pen	High positioning precision is not required Holding arm to screen for long periods of time is not required
Mouse	Adequate space is available for mouse movement over a pad or desktop A low to medium level of resolution is required for positioning Periodic cleaning is provided
Isotonic Joystick (Displacement)	Positioning accuracy is more important that positioning speed
Trackball	Rapid cursor positioning is desirable Limited space is available for installing an input device
Graphics Tablet	A low to medium level of resolution is required
Isometric Joystick (Force)	Precise or continuous control of two or more related dimensions is required

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3.8.1.2.2 Input Device Stability

ES-0304-1381-10230

Guideline: Input and control devices should be stable during normal usage, i.e., they should not slip or rock, unless such actions are a part of the controller operation.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.3 Feedback

ES-0304-1381-10232

Guideline: Visual, tactile auditory feedback should be provided to indicate that the system has received a control input.

Additional Information: This is especially important when the control surface does not depress or move (such as with a force joystick or touchscreen), thereby providing little tactile feedback to the user.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.4 Accidental Input or Actuation Prevention

ES-0304-1381-10234

Guideline: The system should be located and designed to prevent the accidental manipulation of control and input devices that could result in changes to the status of the system functions, components, or data.

Additional Information: Controls may be recessed, shielded, or otherwise surrounded by physical barriers. The control should be entirely contained within the envelope described by the recess or barrier. Controls may be covered or guarded with movable (e.g., hinged) barriers. Safety or lock wires should not be used. When a movable control guard is in the open position, it should not interfere with the operation of the guarded control or other adjacent controls. Conventional controls may be provided with interlocks. The interlocking controls may require: (1) extra movement (e.g., a side movement out of a

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detent position or a pull-to-engage clutch), or (2) prior operation of a related or locking control.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.5 Location

ES-0304-1381-10236

Guideline: Controls should be operable from the location where the user is most likely to need to interact with the system.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.6 Speed

ES-0304-1381-10238

Guideline: Controls should provide rapid positioning of cursors or selection of choices.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.7 Accuracy

ES-0304-1381-10240

Guideline: The accuracy of the control device or method should be commensurate with the functions to be served.

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HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.8 Displacement

ES-0304-1381-10242

Guideline: Control design should allow the user freedom of movement to perform other duties.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.9 Range and Precision

ES-0304-1381-10244

Guideline: Control should provide the sufficient range and precision required by the task.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.10 Economy

ES-0304-1381-10246

Guideline: Each control or input device should be necessary, use minimal space, and be the simplest effective control for the task concerned.

Additional Information: There should be a good reason to require a control for the function concerned. Duplication of controls should not occur, except for a specific reason. The precision and range of a control should not greatly exceed the need.

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HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.11 Human Suitability

ES-0304-1381-10248

Guideline: Controls and input devices should be suitable for use in a control room environment.

Additional Information: Controls and input devices should be suited to the anthropometric and ergonometric characteristics of the expected user population. Each should be recognizable in terms of its function and should be of the type normally anticipated for the operation concerned. This means conforming to user expectations, matching to other devices having similar functions, and generally conforming to conventional practice.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.12 Compatibility with Emergency Gear

ES-0304-1381-10250

Guideline: If used while wearing protective equipment (e.g., oxygen masks and protective gloves), controls and input devices should be easy to identify and activate, or use.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

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3.8.1.2.13 Durability

ES-0304-1381-10252

Guideline: Controls and input devices should be sufficiently rugged to withstand normal and emergency use.

Additional Information: Each device should retain its appearance, "feel," and functional characteristics during its service life. Broken, chipped, or crumbled control surfaces should not ordinarily occur. Control knobs or handles should not rotate, slip, or move loosely on their shafts. No internal wear or breakage should occur which alters the "feel" or other sensory feedback of a control. Controls should not develop internal looseness, binding, or backlash.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.14 Control Activation

ES-0304-1381-10254

Guideline: Controls and input devices should require distinct or sustained effort for activation.

Additional Information: Conventional controls should be provided with resistance (e.g., friction or spring- loading). Activation of computer-displayed controls should require a separate action, distinct from pointing.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.15 Sequential Activation

ES-0304-1381-10256

Guideline: When a strict sequential activation is necessary, controls should be provided with locks to prevent the controls from passing through a position.

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Additional Information: Movement to the next position should require a new control action.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

3.8.1.2.16 Population Stereotypes

ES-0304-1381-10258

Guideline: Control movements should conform to population stereotypes (see **Figure 3-35**).

Additional Information: The following are control movement stereotypes for the U.S. population: (1) On, start, run, open; Up, right, forward, clockwise, pull; (2) Off, stop, close; Down, left, backward, counterclockwise, push; (3) Right; Clockwise, right; (4) Left; Counterclockwise, left; (5) Raise; Up; (6) Lower; Down; (7) Increase; Forward, up, right, clockwise; (8) Decrease; Backward, down, left, counterclockwise.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.1

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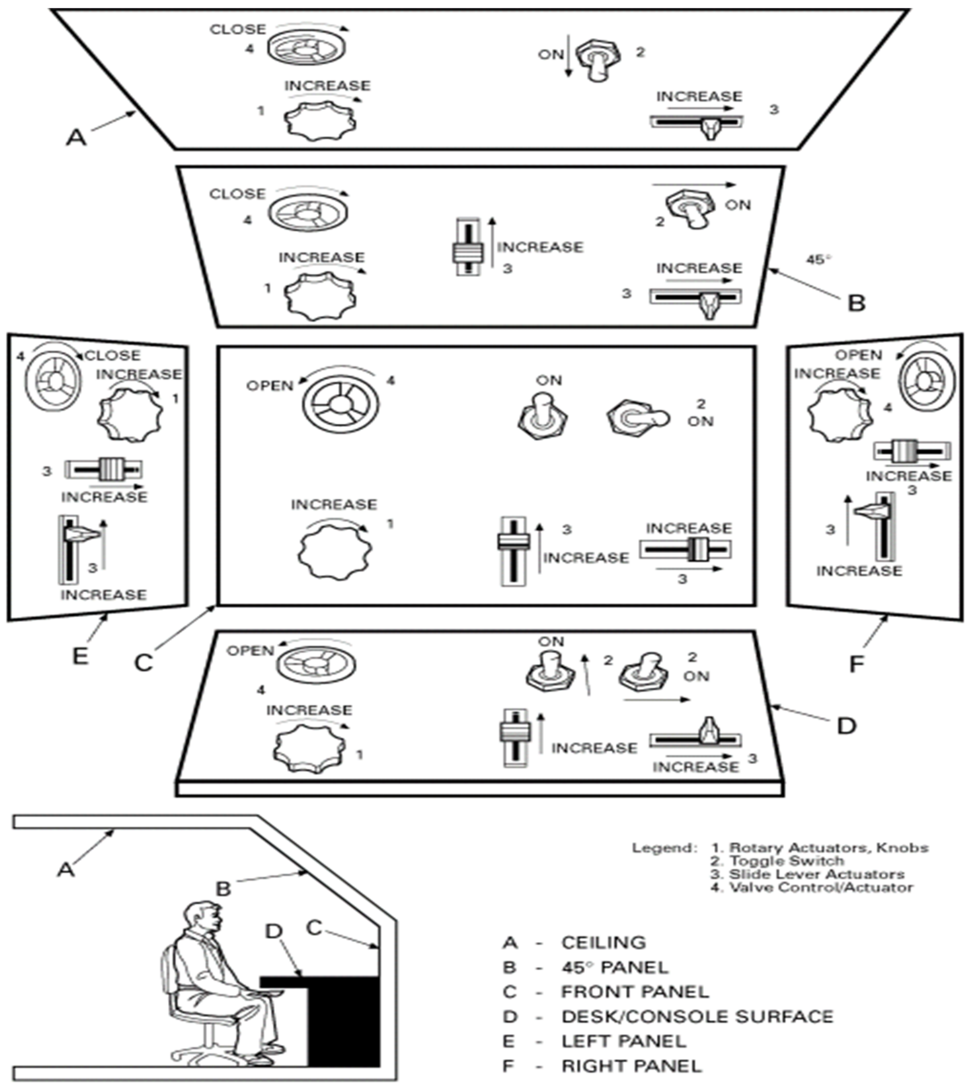

Figure 3-35. Control operation stereotypes for the U.S. population

Coding of Controls

3.8.1.2.17 Consistency

ES-0304-1381-10262

Guideline: The coding system should be uniform throughout the control room.

Additional Information: Table 3-23 is provided as a general guideline for control coding evaluation.

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HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.2

3.8.1.2.18 Size Coding Levels

ES-0304-1381-10264

Guideline: No more than three different sizes of controls should be used for discrimination by absolute size.

Additional Information: When knob diameter is used as a coding parameter, differences between diameters should be at least 0.5 inch. When knob thickness is a coding parameter, differences between thicknesses should be at least 0.4 inch.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.2

3.8.1.2.19 Size Coding Uniformity

ES-0304-1381-10266

Guideline: Controls used for performing the same function on different items of equipment should be the same size.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.2

3.8.1.2.20 Shape Coding

ES-0304-1381-10268

Guideline: When possible, controls should be differentiated by shape.

Additional Information: The shapes of conventional controls should be identifiable both visually and tactually to facilitate "blind" manipulation. When shape coding is used: (1)

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The coded feature should not interfere with ease of control manipulation; (2) Shapes should be identifiable by the hand regardless of the position and orientation of the control knob or handle; (3) Shapes should be tactually identifiable when gloves are worn; (4) A sufficient number of identifiable shapes should be provided to cover the expected number of controls that require tactual identification; (5) Shape-coded knobs and handles should be positively and non- reversibly attached to their shafts to preclude incorrect attachment when replacement is required; and (6) Shapes should be associated with or resemble control function, and not alternate functions.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.2

3.8.1.2.21 Color Coding Contrast

ES-0304-1381-10270

Guideline: The color of the control should contrast with the panel background.

Additional Information: See Table 3-23. Guidelines for color coding are given in Appendix B.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.2

3.8.1.2.22 Color Coding Between Control and Display

ES-0304-1381-10272

Guideline: When color coding is used to relate a control to its corresponding display, the same color should be used for both the control and the display.

Additional Information: Color coding should follow the recommendations found in Appendix B.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

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Reference: NUREG-0700-3.1.2

3.8.1.2.23 Location Coding by Function

ES-0304-1381-10274

Guideline: Controls should be located so as to be easily related to functions and functional groupings.

Additional Information: See Guideline ES-0304-1381-12303.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.2

3.8.1.2.24 Location Coding Across Panels

ES-0304-1381-10276

Guideline: Controls with similar functions should be in the same location from panel to panel.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.1.2

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Table 3-23. Advantages and disadvantages of various types of coding

Advantages	Type of Coding					
	Location	Shape	Size	Mode of Operation	Labeling	Color
Improves visual identification	X	X	X		X	X
Improves nonvisual identification (tactual and kinesthetic)	X	X	X	X		
Helps standardization	X	X	X	X	X	X
Aids identification under low levels of illumination and colored lighting	X	X	X	X	(when trans-illuminated)	(when trans-illuminated)
May aid in identifying control position (settings)		X		X	X	
Requires little (if any) training; is not subject to forgetting					X	

Disadvantages	Type of coding					
	Location	Shape	Size	Mode of Operation	Labeling	Color
May require extra space	X	X	X	X	X	
Affects manipulation of the use of the control (ease of use)	X	X	X	X		
Limited in number of available coding categories	X	X	X	X		X
May be less effective if operator wears gloves		X	X	X		
Controls must be viewed (i.e., must be within visual areas and with adequate illumination present)					X	X

Push Buttons

3.8.1.2.25 Position

ES-0304-1381-10416

Guideline: Pushbuttons in a row or matrix should be positioned in a logical order, or in an order related to the procedural sequence.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.1

3.8.1.2.26 Indication of Activation

ES-0304-1381-10418

Guideline: To ensure that the user knows that a pushbutton has been pressed far enough for activation, a positive indication should be provided.

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Additional Information: This indication can be in the form of a snap feel, an audible click, or an integral light.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.1

3.8.1.2.27 Pushbutton Surface

ES-0304-1381-10420

Guideline: The surface of a pushbutton should offer slip resistance or be concave.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.1

3.8.1.2.28 Dimensions of Round Pushbuttons

ES-0304-1381-10422

Guideline: Round pushbuttons should conform to the dimensions given in Figure 3-36.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.2

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	Diameter (D)			Displacement (A)	
	Fingertip Operation	Thumb Operation	Palm Operation	Fingertip Operation	Thumb or Palm
Minimum	0.4 (10)*	0.75 (19)	1.6 (40)	.08 (2)	0.12 (3)
Maximum	1.0 (25)	1.0 (25)	2.8 (70)	.25 (6)	1.5 (38)

Dimensions are given in inches and (millimeters).
* Minimum diameter for guarded or recessed pushbuttons should be 0.75 inch (19mm).

Figure 3-36. Recommended dimensions for unguarded and non-recessed pushbuttons

3.8.1.2.29 Resistance of Round Pushbuttons

ES-0304-1381-10426

Guideline: Resistance should be 10 to 40 ounces (2.8 to 11.1 N) for fingertip operation and 10 to 80 ounces (2.8 to 22.2 N) for thumb or palm operation.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.2

3.8.1.2.30 Discriminability

ES-0304-1381-10428

Guideline: Legend pushbuttons should be readily distinguishable from legend lights.

Additional Information: This may be achieved by distinctive shape, labeling, location, or other techniques.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.3

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3.8.1.2.31 Legend

ES-0304-1381-10430

Guideline: The legend should be readable under all environmental conditions.

Additional Information: The legend should be readable under ambient light conditions, with or without internal illumination. The illuminated condition should be clearly recognizable under the highest predicted ambient light condition and should be at least 10 percent brighter than the surrounding panel. Legend lettering and contrast should conform to recommendations for legend lights (see also Guidelines ES-0304-1381-8822 and ES-0304-1381-8223). The legend message should be specific, unambiguous, and concise. The legend message should contain no more than three lines of lettering.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.3

3.8.1.2.32 Lamp Reliability

ES-0304-1381-10432

Guideline: A lamp test or dual lamp/dual filament capability should be provided if the mean time between failures is less than 100,000 hours.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.3

3.8.1.2.33 Easy Replacement of Covers

ES-0304-1381-10434

Guideline: Lamps within the pushbutton should be replaceable from the front of the panel.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

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Reference: NUREG-0700-3.3.1.3

3.8.1.2.34 Safe Replacement of Lamps

ES-0304-1381-10436

Guideline: Legend pushbuttons should not short out during lamp replacement or be susceptible to inadvertent activation during the process of lamp removal or replacement.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.3

3.8.1.2.35 Correct Replacement of Covers

ES-0304-1381-10438

Guideline: Legend covers should be keyed to prevent the possibility of interchanging the covers.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.3

3.8.1.2.36 Barriers

ES-0304-1381-10440

Guideline: Barriers should be used when legend pushbuttons are contiguous.

Additional Information: Barriers should have rounded edges.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.3

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3.8.1.2.37 Dimensions of Legend Pushbuttons

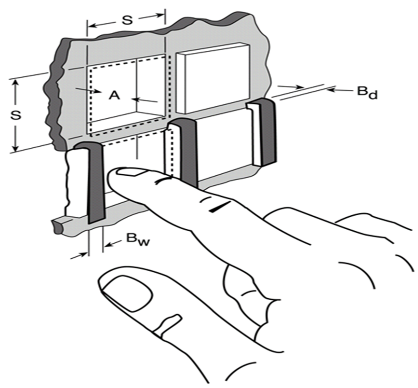
ES-0304-1381-10442

Guideline: Legend pushbuttons should conform to the dimensions shown in Figure 3-37.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.1.3



	Size (S)	Displacement (A)	Barriers Width (Bw)	Depth (Bd)
Minimum	0.75 (19)*	0.125 (3) **	0.125 (3)	0.188 (5)
Maximum	1.50 (38)	0.250 (6)	0.250 (6)	0.250 (6)

Dimensions are given in inches and (millimeters).
* 0.65 inches (15 mm) where switch is not depressed beyond the panel surface.
** 0.2 inches (5 mm) for switches having positive indication of activation.

Figure 3-37. Recommended dimensions for legend pushbuttons

3.8.1.2.38 Resistance of Legend Pushbuttons

ES-0304-1381-10446

Guideline: Resistance should be 10 to 60 ounces (2.8 to 16.7 N).

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

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Reference: NUREG-0700-3.3.1.3

Rotary Switches

3.8.1.2.39 Direction of Activation

ES-0304-1381-10448

Guideline: Rotary control settings should increase in value with a clockwise rotation.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.1

3.8.1.2.40 Rotary Control Shape Coding

ES-0304-1381-10450

Guideline: Shape coding should be employed if rotary controls used for widely different functions are placed on the same panel.

Additional Information: General guidelines for coding controls (including shape coding) are given in Appendix C.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.1

3.8.1.2.41 Coding Specifications

ES-0304-1381-10452

Guideline: Shape-coded rotary controls should be visually and tactually identifiable.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.1

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3.8.1.2.42 Rotating Knob Shape Options

ES-0304-1381-10454

Guideline: Rotating knob controls for different types of control actions should be distinguishable by sight and touch and not easily confused with each other.

Additional Information: Figure 3-38 gives examples of suitable knob designs developed for three major classes of knobs, each class intended for a different purpose: multiple rotation, fractional rotation, and detent positioning. General guidelines for coding controls (including shape coding) are given in Appendix C.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.1

3.8.1.2.43 Rotary Action Control Applications

ES-0304-1381-10456

Guideline: Rotary action controls should be used in situations where linear or pushbutton controls would be subject to inadvertent activation and fixed protective structures are impractical or inappropriate.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.1

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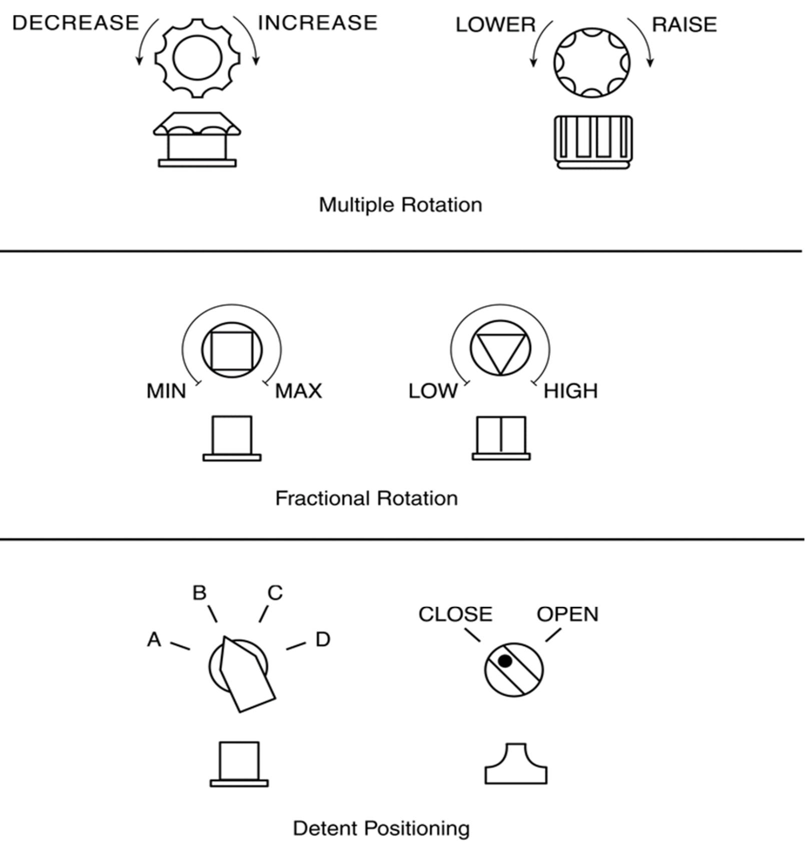

Figure 3-38. Shape-coded rotary controls

3.8.1.2.44 Dimensions of J-Handles

ES-0304-1381-10460

Guideline: High torque J-handles should conform to the dimensions shown in Figure 3-39.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.2

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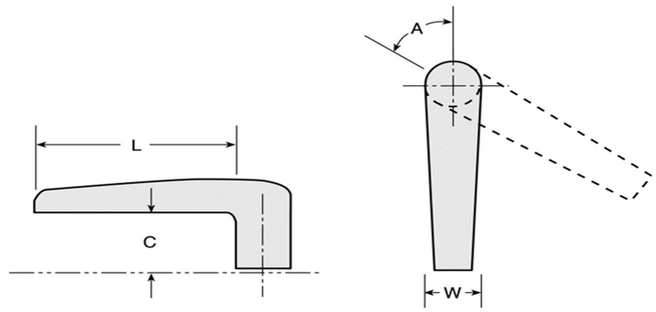

	Length (L)	Clearance (C)	Width (W)	Displacement (A)
Minimum	3.75 (95)	1.25 (32)	0.65 (16)	± 24°
Maximum	6.0 (150)	2.0 (50)	1.0 (25)	± 60°

Dimensions are given in inches and (millimeters).

Figure 3-39. High-torque J-handle dimensions

3.8.1.2.45 Resistance of J-Handles

ES-0304-1381-10464

Guideline: Resistance should be 6 to 12 inch-pounds (0.7 to .14 N-m).

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.2

3.8.1.2.46 Low-Torque Designs

ES-0304-1381-10466

Guideline: When using smaller scale J-handles, the handle portion usually has a flattened or flared tip for finger placement, and the clearance between handle and panel surface can be less.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.2

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3.8.1.2.47 Use

ES-0304-1381-10468

Guideline: Key-operated controls should be used when system requirements dictate that the function being controlled should be secured against activation by unauthorized personnel.

Additional Information: If key-operated controls cannot be justified in terms of security, they are probably not necessary and should not be used. Key-operated switches should not be used solely as a means of shape coding.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.3

3.8.1.2.48 Teeth: Single Row

ES-0304-1381-10470

Guideline: Keys with a single row of teeth should be inserted into the lock with the teeth pointing up or forward.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.3

3.8.1.2.49 Teeth: Double Row

ES-0304-1381-10472

Guideline: Keys with teeth on both edges should fit the lock with either side up or forward.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.3

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3.8.1.2.50 Off Orientation

ES-0304-1381-10474

Guideline: Locks should be oriented so that the OFF or SAFE state is in effect when the key is in the vertical position.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.3

3.8.1.2.51 Key Removal

ES-0304-1381-10476

Guideline: Users should not normally be able to remove the key from the lock unless the switch is turned to the OFF or SAFE position.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.3

3.8.1.2.52 Labeling

ES-0304-1381-10478

Guideline: Control positions should be labeled.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.3

3.8.1.2.53 Actuation of Key Switch

ES-0304-1381-10480

Guideline: Actuation of an item by a key operated switch should be accomplished by turning the key clockwise from the vertical OFF (i.e., upright) position.

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Reference: NUREG-0700-3.3.2.3

3.8.1.2.54 Dimensions of Key-Operated Controls

ES-0304-1381-10482

Guideline: Key-operated control dimensions should conform to the dimensions shown in **Figure 3-40**.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.3

3.8.1.2.55 Resistance of Key-Operated Controls

ES-0304-1381-10484

Guideline: The resistance of key-operated controls should be 1 to 6 inch-pounds (0.11 to 0.68 N-m).

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.3

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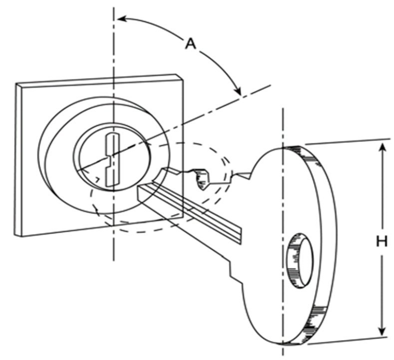

	Displacement (A)	Height (H)
Minimum	60	0.5 (13)
Maximum	90	3.0 (75)

Dimensions are given in inches and (milli meters).

Figure 3-40. Key-operated control dimensions

3.8.1.2.56 Knobs

ES-0304-1381-10488

Guideline: Knobs for continuous adjustment controls should be round in shape, with knurled or serrated edges.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.4

3.8.1.2.57 Position Indication

ES-0304-1381-10490

Guideline: When an indication of position is desirable, it should allow the user to easily recognize the position.

Additional Information: The pointer configurations shown in bottom of Figure 3-38 may be used. Where more accuracy is required, a line should be engraved (and filled with contrasting pigment) both on top and down the side of the pointer, as shown on the knob at the bottom of the figure.

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HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.4

3.8.1.2.58 Knob Dimensions

ES-0304-1381-10492

Guideline: Fingertip grasp knobs should be between 0.5 and 1 inch (13 and 25 mm) in height and between 0.375 and 4 inches (10 and 100 mm) in diameter. Thumb and forefinger encircled knobs should be between 1 and 3 inches (25 and 75 mm) in diameter.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.4

3.8.1.2.59 Knob Torque

ES-0304-1381-10494

Guideline: Knob torque should be within the range of 4.5 to 6.0 inch-ounces (32 to 42 mN-m).

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.4

3.8.1.2.60 Dimensions of Knobs with Skirts

ES-0304-1381-10496

Guideline: Knobs with skirts should conform to the dimensions shown in Figure 3-41.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

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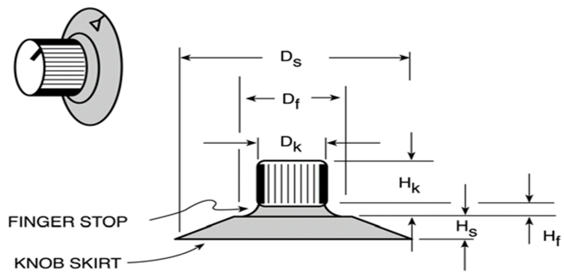
Reference: NUREG-0700-3.3.2.4



	Knob (k)	F-Stop (f)	Skirt (s)
Diameter (D)	0.75 (19)	1.25 (32)	2.0 (50)
	Combined		
Height (H)	0.75 (19)		0.25 (6)

Dimensions are given in inches and (millimeters).

Figure 3-41. Recommended dimensions for rotary controls with finger stops and skirts

3.8.1.2.61 Selection

ES-0304-1381-10500

Guideline: Rotary selector controls should be used when three or more detented positions are required, and may also be used for two-detented position operation.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.5

3.8.1.2.62 Positioning

ES-0304-1381-10502

Guideline: Detents should be provided at each control position to ensure proper positioning of a discrete rotary control.

Additional Information: It should not be possible to position a control between detented positions. To minimize the possibility of placing a rotary selector in an unused position, stops should be provided at the limits of the control range. A maximum of 24 positions should be used on a rotary selector control.

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HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.5

3.8.1.2.63 Readability

ES-0304-1381-10504

Guideline: Rotary controls should have a moving pointer and fixed position settings to maximize readability.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.5

3.8.1.2.64 Position Indication

ES-0304-1381-10506

Guideline: Position indication should be provided.

Additional Information: Desirable alternatives are: (1) illuminated indicator lights, (2) a line engraved both on the top of the knob and down the side, or (3) a pointer shape. It should not be possible to confuse the position of the knob in reference to position markers on the panel. To minimize the problem of parallax, pointers on knobs should be mounted close to the settings to which they point.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.5

3.8.1.2.65 Dimensions of Rotary Selector Controls

ES-0304-1381-10508

Guideline: Rotary selector controls should conform to the dimensions shown in Figure 3-42.

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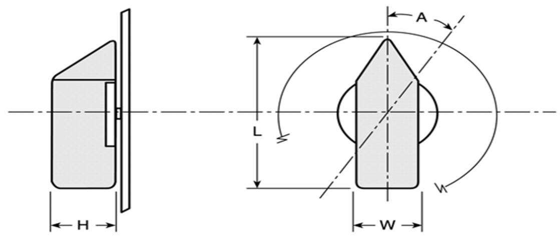
HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.5



	Length (L)	Width (W)	Depth (H)	Displacement (A)	Displacement (A)*
Minimum	1.0 (25)		0.625 (16)	15°	30°
Maximum	4.0 (100)	1.0 (25)	3.0 (75)	40°	90°

Dimensions are given in inches and (millimeters).
* When special engineering requirements (such as protective clothing) or when tactually ('blind*) positioned controls demand large separation.

Figure 3-42. Recommended dimensions for rotary selector switches

3.8.1.2.66 Resistance of Rotary Selector Controls

ES-0304-1381-10512

Guideline: Resistance should be 1 to 6 inch-pounds (0.11 to 0.68 N-m).

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.5

3.8.1.2.67 Momentary Contact Rotary Selector Controls

ES-0304-1381-10514

Guideline: Knobs for spring-loaded momentary contact rotary selector controls should be large enough to be easily held against the spring torque, without fatigue, for as long as necessary to accomplish the control action.

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HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.2.5

3.8.1.2.68 Visibility

ES-0304-1381-10516

Guideline: To minimize error, thumbwheel readouts should be visible from the thumbwheel operating position.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.1

3.8.1.2.69 Coding

ES-0304-1381-10518

Guideline: If the thumbwheel is used as an input device, the OFF, zero, or normal position should be coded to facilitate visual recognition of status.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.1

3.8.1.2.70 Dimensions of Continuous Adjustment Thumbwheels

ES-0304-1381-10520

Guideline: At least 1 inch of circumference of a continuous adjustment thumbwheel should be exposed to permit easy manipulation.

Additional Information: A continuous adjustment thumbwheel controls moves smoothly, i.e., its motion is not 'stepped' like that of a discrete thumbwheel control.

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HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.1

3.8.1.2.71 Resistance of Continuous Adjustment Thumbwheels

ES-0304-1381-10522

Guideline: The resistance of a continuous adjustment thumbwheel should be between 3 and 6 ounces.

Additional Information: A continuous adjustment thumbwheel controls moves smoothly, i.e., its motion is not 'stepped' like that of a discrete thumbwheel control.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.1

3.8.1.2.72 Dimensions of Discrete Thumbwheel Controls

ES-0304-1381-10524

Guideline: Discrete thumbwheel controls should conform to the dimensions shown in Figure 3-43.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.1

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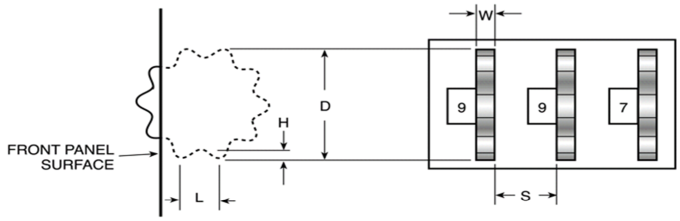

	Diameter (D)	Trough (L)	Width (W)	Depth (H)	Separation (S)
Minimum	1.125 (30)	0.45 (11)	0.125 (3)	0.125 (3)	0.4 (10)
Maximum	3.0 (75)	.75 (19)		.25 (6)	

Dimensions are given in inches and (millimeters).

Figure 3-43. Recommended dimensions for discrete thumbwheel controls

3.8.1.2.73 Resistance of Discrete Thumbwheel Controls

ES-0304-1381-10528

Guideline: The resistance of discrete thumbwheel controls should be 6 to 20 ounces (1.7 to 5.6 N).

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.1

Slide, Rocker and Toggle Switches

3.8.1.2.74 Slide Switch Surface

ES-0304-1381-10530

Guideline: The surface of slide switches should be serrated or knurled.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.2

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3.8.1.2.75 Slide Switch Detents

ES-0304-1381-10532

Guideline: Detents should be provided for each slide switch setting.

Additional Information: Resistance should gradually increase, then drop when the switch snaps into position. The switch should not be capable of stopping between positions.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.2

3.8.1.2.76 Slide Switch Accidental Actuation

ES-0304-1381-10534

Guideline: Channel guards or other preventive features should be provided when accidental actuation would have undesirable consequences.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.2

3.8.1.2.77 Slide Switch Orientation

ES-0304-1381-10536

Guideline: Slide switches should be vertically oriented.

Additional Information: Horizontal orientation or activation slide switches should be employed only for compatibility with the controlled function or equipment location.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.2

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3.8.1.2.78 Slide Switch Positive Indication

ES-0304-1381-10538

Guideline: Slide switches involving more than two positions should be designed to provide positive indication of the control setting, preferably a pointer located on the left side of the slide handle.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.2

3.8.1.2.79 Slide Switch Dimensions

ES-0304-1381-10540

Guideline: Slide switches should conform to the dimensions shown in Figure 3-44.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.2

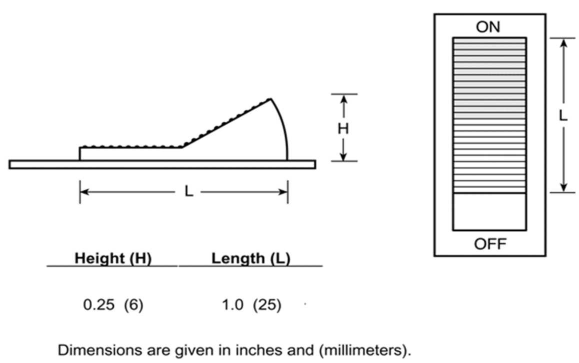

Figure 3-44. Recommended dimensions for slide switches

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3.8.1.2.80 Toggle Switch Positioning

ES-0304-1381-10544

Guideline: To minimize the possibility of inadvertent activation or setting between control positions, toggle switches should have an elastic resistance that increases as the control is moved and drops as the switch snaps into position.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.3

3.8.1.2.81 Toggle Switch Feedback

ES-0304-1381-10546

Guideline: Toggle switches should emit an audible click, or provide some other source of feedback on activation.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.3

3.8.1.2.82 Toggle Switch Dimensions

ES-0304-1381-10548

Guideline: Toggle switches should conform to the dimensions shown in Figure 3-45.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.3

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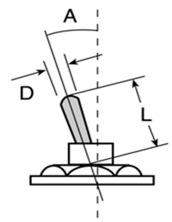

	Arm Length (L)			Displacement (A)	
	Bare Finger	Gloved Finger	Tip Diameter (D)	Two Position	Three Position
Minimum	0.5 (13)	1.5 (38)	0.125 (3)	30°	17°
Maximum	2.0 (50)	2.0 (50)	1.0 (25)	80°	40°
Desired	—		—	—	25°

Dimensions are given in inches and (millimeters).

Figure 3-45. Recommended dimensions for toggle switches

3.8.1.2.83 Toggle Switch Resistance

ES-0304-1381-10552

Guideline: Resistance should be 10 to 16 ounces (2.8 to 4.4 N) for small switches and 10 to 40 ounces (2.8 to 11.1 N) for large switches.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.3

3.8.1.2.84 Rocker Switch Orientation

ES-0304-1381-10554

Guideline: Rocker switches should ordinarily be oriented vertically.

Additional Information: Activation of the upper part should control the ON or INCREASE function. Horizontal orientation should be used only when required by the location of the controlled function or equipment.

HSI Design Criteria

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Reference: NUREG-0700-3.3.3.4

3.8.1.2.85 Rocker Switch Indication of Activation

ES-0304-1381-10556

Guideline: Activation should be indicated by a snap feel, an audible click, or an integral light.

Additional Information: In the ON position, the top of the switch should be flush with the panel surface.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.4

3.8.1.2.86 Rocker Switch Resistance

ES-0304-1381-10558

Guideline: Control resistance should gradually increase, then drop to zero when the control snaps into position.

Additional Information: This resistance should preclude the switch being placed between positions.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.4

3.8.1.2.87 Rocker Switch Inadvertent Activation

ES-0304-1381-10560

Guideline: If it controls a critical function, the rocker switch should be protected by channel guards or other means to prevent inadvertent activation.

HSI Design Criteria

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Reference: NUREG-0700-3.3.3.4

3.8.1.2.88 Rocker Switch Dimensions

ES-0304-1381-10562

Guideline: Rocker switches should conform to the dimensions shown in Figure 3-46.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.4

3.8.1.2.89 Rocker Switch Resistance

ES-0304-1381-10564

Guideline: Resistance should be 10 to 40 ounces (2.8 to 11.1 N).

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

Reference: NUREG-0700-3.3.3.4

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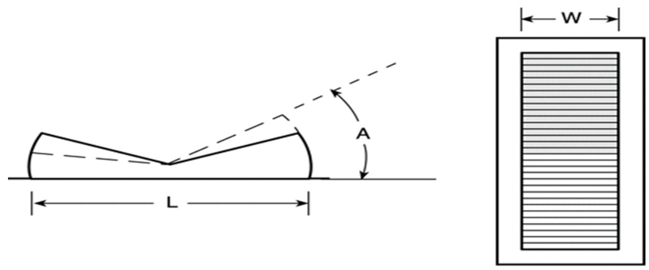

	Width (W)	Length (L)
Minimum	0.25 (6)	0.50 (13)
Maximum	1.5 (38)	0.75 (19)

	Displacement (A)	
	Two-Position	Three-Position
Minimum	30°	18°
Optimum		25°

Figure 3-46. Recommended dimensions for rocker switches

3.8.2 Soft Controls

The basic function of soft control systems is to provide operators with control interfaces that are mediated by software rather than by direct physical connections. Soft controls can be used to control plant equipment, such as a pump, or the HSI itself, such as display selection. The unique characteristics of soft control systems that make them different from conventional controls, e.g., hardware knobs and buttons, are described below.

Spatial dedication vs virtual location – A conventional control typically has a unique location in the CR and is used to control a specific aspect of the plant or HSI. By contrast, a soft control for the same function is typically not spatially dedicated and may exist in multiple locations, e.g., it may be accessed from more than one display device, and from multiple pages within a display device. Thus, soft controls often lack the degree of spatial dedication that is characteristic of conventional controls.

Serial versus parallel presentation – Conventional controls are presented in parallel; i.e., all controls exist in their spatially dedicated location at the same time. Operators visually scan the controls to determine their status. Computer-based HSI components usually contain more displays and controls than can be viewed at one time via its display devices. Because the total set of displays cannot be viewed at once, the user views portions of it one after another, similar to a person looking into a room through a keyhole in a door. This 'keyhole effect' limits the number of soft controls that can be viewed or used at one time, thus forcing serial rather than parallel access.

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Present versus available – Conventional controls are spatially dedicated and as such are continuously present in the control room. Soft controls may either be designed to be continuously present like conventional controls, or they may have to be retrieved from a display system. Hence, soft controls may be considered available but not necessarily present. In addition, the availability of soft controls can be restricted to specific conditions. For example, some soft controls, such as those used for configuring digital control systems, may have protective features (e.g., password protection) that limit their availability to specific personnel or situations.

Physical decoupling of input and display interfaces – Typically, conventional controls are located close to their associated display. That is, operators perform the input actions and monitor feedback at the same location (e.g., when turning a rotary dial, the operator observes its motion and reads the new setting from its perimeter). For soft controls, there may be a looser physical coupling between the location of control action and the presentation of feedback. That is, the operator may take a control action in one place and read the setting elsewhere. For example, when using a pointing interface, the user may manipulate a mouse on a console top to move a cursor across a display screen to select an icon. The results of this action may be displayed in yet another location, such as a window indicating that some equipment has been turned off or on. In this case, the operator must monitor three locations to complete a single control action: the mouse, the icon, and the window. This physical decoupling of the input device (e.g., the mouse) and the displays that present feedback may result in monitoring demands that differ from conventional controls.

Plant control versus interface management control – Actions that control the HSI (i.e., cause displays to be presented) can be distinguished from actions that control the plant. Both types of actions may be performed using the same or different input and display devices. For example, an operator may use a mouse and VDU to access a display and then use the same mouse and VDU to operate a piece of plant equipment (e.g., a pump) from that display. In this case, the mouse and VDU are used to operate both the HSI and the plant.

Multiple modes – While a conventional control typically performs a single control function, a soft control may perform a range of control functions, each representing a different mode (e.g., mode 1 for performing function A, and mode 2 for performing function B). The behavior of these functions is defined by the software. Options for control actions are usually communicated to the operator via displays. When the operator carries out a control action, the software converts the results into a signal for the control system. Hence, a specific action, such as pressing a button, can produce different results depending on such factors as the particular display page currently accessed, the status of the control system, and the status of the plant.

Complex control functions – Because the operator's actions are interpreted by software, many operations may be initiated via a single action using a soft control. For example, a sequence of operations required to start plant equipment may be linked to a single “Start” command. While conventional control systems also offer this capability

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(e.g., via relays), software-defined functions can result in more complex linkages among operations.

Interface flexibility – Computer-based technology can allow the user interface of soft controls to be adaptable to changing needs or conditions of use. For example, the operator may be able to arrange the presentation of the control and its associated information based on a current need or personal preference. Alternatively, the control and information may be automatically arranged based on the current situation.

3.8.2.1 Definitions

Information Display

Information display considerations important to operator performance using soft control systems include the means for selecting the components to be controlled, the display areas where input is entered, and the formats used for entering data. Each of these is described below. The general display characteristics of soft controls should also be reviewed using Section 3.1, Information Presentation.

Selection Displays

These are displays used when choosing the variables or plant components to be controlled. Two commonly used formats are the mimic and the list.

Input Fields

These are display areas used for providing input (e.g., entering a new control setpoint). Input fields may appear on an adjacent display device, as a window placed on top of a selection display, or as a data entry field inside a control selection display.

Input Formats

These are formats used for entering data. Important characteristics include the representation of formats commonly used with soft control systems (e.g., discrete-adjustment interfaces, soft sliders, and arrow buttons).

Display Devices

The display devices on which soft control systems are presented may be either functionally dedicated or general purpose. A functionally dedicated display device is used for a specific function or set of functions (e.g., a display device used only to interact with a particular plant system, such as feedwater control). A general-purpose display device may be used to interact with a broad range of plant systems. This distinction affects where a soft control may be accessed in the HSI and, possibly, the degree of interaction required to access it. For example, if a soft control can be accessed from a set of general-purpose display devices, then it may be accessed from multiple locations in the control room, but a high degree of interface management may be required to

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retrieve it from the other displays in the network. Conversely, a display device dedicated to a small set of plant variables may require very little interface management to access the desired soft control. A variety of VDU hardware may be used to present soft controls.

User-System Interaction

Interactions with soft controls include selecting a plant variable or component to be controlled, providing the control input, and monitoring the system's response. Each is described below. In addition, system response characteristics are also described.

Selecting Plant Variables or Components

A separate step is often required to select the specific plant variable or component that is to be controlled by a soft control. Selection methods may require the user to make a choice from a set of options or to identify a choice from memory. The following interaction methods are commonly used to present the operator with a set of options.

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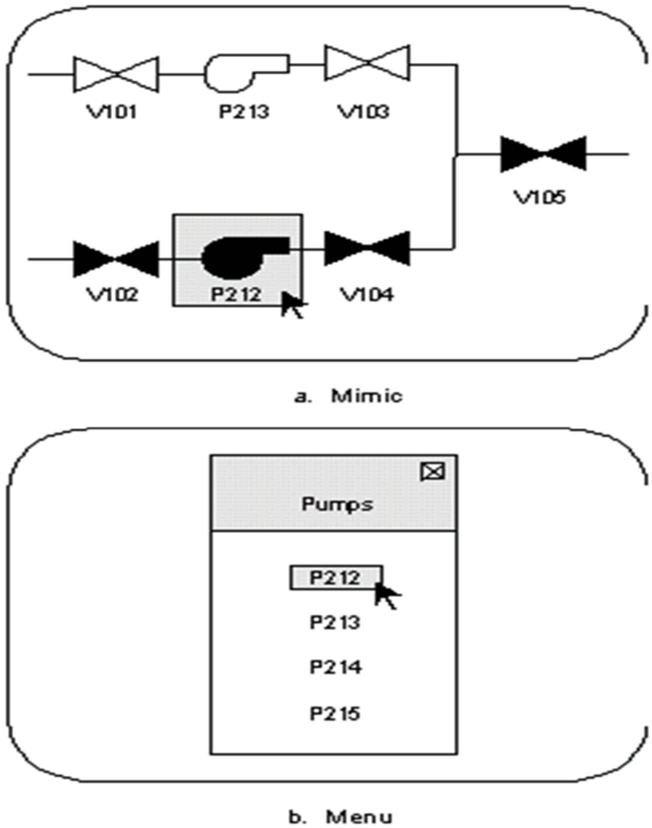

Figure 3-47. Two typical displays for selecting variables or components

Mimic display – Typically, plant components are represented by symbols, and the flow paths (e.g., for mass or energy) are represented by lines. Operators may select a component from a mimic display by using a pointing device. Alternatively, the operator may use a keyboard to enter the identification code for the specific component. The top part of Figure 3-47 depicts a component being selected from a mimic display through the use of a cursor.

Menu display – This is a display format that shows a list of alternatives. Selection may be made using a pointing device, function key, or by using a keyboard to enter an identification code. The bottom part of Figure 3-47 depicts a component being selected from a menu display through the use of a cursor.

Dedicated button – This is a button whose activation will cause a particular control or display to be retrieved. It may be dedicated to particular soft control. A dedicated button may be a physical 'hard' button located on a keyboard of console or a 'soft' button presented on a computer-based display device.

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The following interaction methods generally require the user to identify a choice from memory: command language, natural language, query language, and question and answer dialogues. These methods may be augmented with online forms and other aids to help the operator compose entries. Input is typically provided via alphanumeric keyboards. However, other input mediums, such as voice, are also possible.

Providing Control Inputs

Providing control inputs often requires at least two steps: accessing the input field and providing control inputs. Input fields are areas of the display where users enter values for the control system. These areas may be part of the display used to select the plant component or variable, they may be displayed as a window on that display, or they may be displayed on a separate device. When the input field is integrated into the display, the user provides input directly, e.g., an operator may open or close a valve by clicking on its icon. No additional adjustment of the display screen may be necessary because no new input window is introduced. An example is shown in Figure 3-48. When the input field is window, selection of a component or variable causes a window to appear to accept input. For example, an operator may select a component from a mimic display by clicking on it with a mouse. This causes an input window to be positioned in the display. The display may have a space dedicated to the input window or the window may be superimposed on the display and overlap or obstruct part of it. An example is shown in Figure 3-49. When the input field appears on the screen of a separate display device, the interaction is similar. For example, an operator may select a component from a mimic display by clicking on it with a mouse. This causes the input field to appear on an adjacent display device, allowing the input field to appear without obstructing the user's view of the selection display. An example is shown in Figure 3-50.

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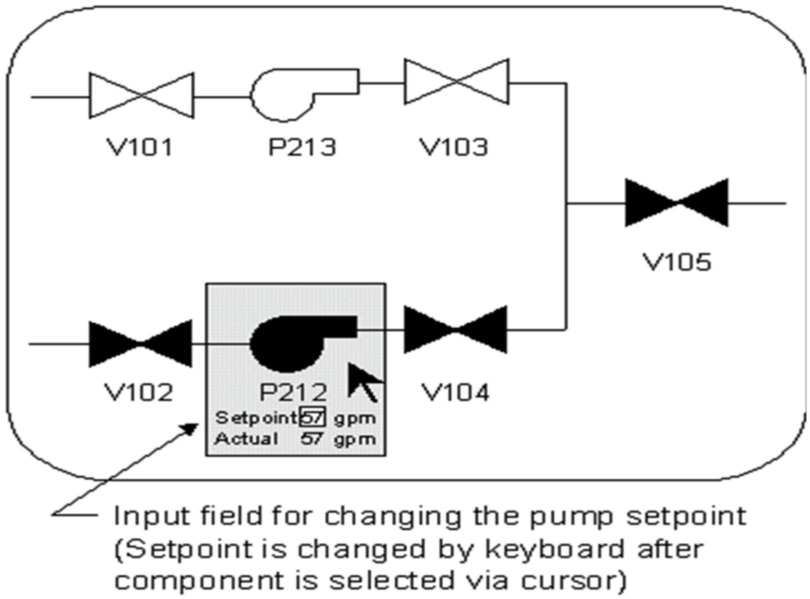

Figure 3-48. Soft control input field is integral with selection display

The input field configurations in Figure 3-49 and Figure 3-50 are more commonly used in process control applications than the integral configuration shown in Figure 3-48. This is because they provide more space for displaying setpoints and other related values.

Once an input field has been accessed, three categories of inputs can be provided to affect the state of the plant: command inputs, discrete values, and continuous values. Each is described below.

A command is an instruction to a computer or system requesting it to perform an action. For example, commands may be given to obtain, transfer, process, store, retrieve, delete, or display information about plant status. Commands may also be used to control the plant (e.g., as an instruction to an automatic control system to perform a function, such as shutting down a piece of equipment).

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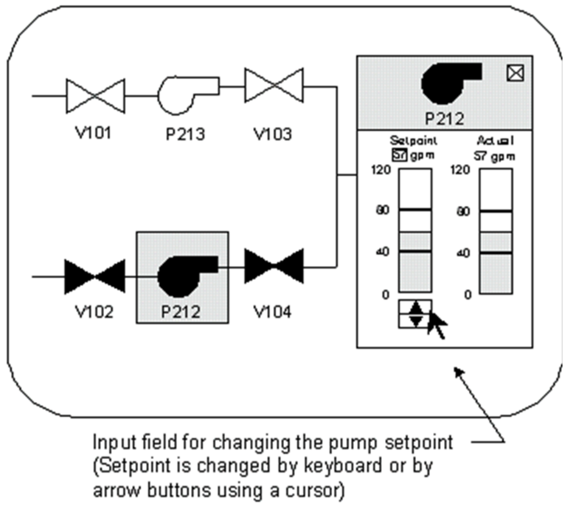

Figure 3-49. Soft control input field is a window within the selection display

A discrete variable has a defined set of individual values. The input action involves selecting one of them. Many control actions involve making a selection from a discrete set of states. For example, plant breakers and valves may be changed from the open to the closed state.

Automatic controllers have discrete control modes (e.g., manual, automatic, and cascade). In addition, controls used for interface management may have discrete settings. For example, buttons may be pushed to access particular displays. Input formats used for providing discrete-variable inputs may be referred to as discrete-adjustment interfaces; they have individual settings that can usually be accessed with fairly gross movements. Their operation is similar to physical controls that provide discrete adjustment, such as push buttons and switches.

A continuous variable has a continuous set of values within a defined range. Many control actions involve providing a value from a continuous range, e.g., when changing a control setpoint, the operator increases or decreases the setting of a controller within a defined range. When using physical control devices, continuous variables are often set using continuous-adjustment controls. The desired value is accessed using some type of slewing motion requiring a gross movement followed by a fine adjustment. With soft controls, continuous variables may be adjusted in a variety of ways. Three common means are described below.

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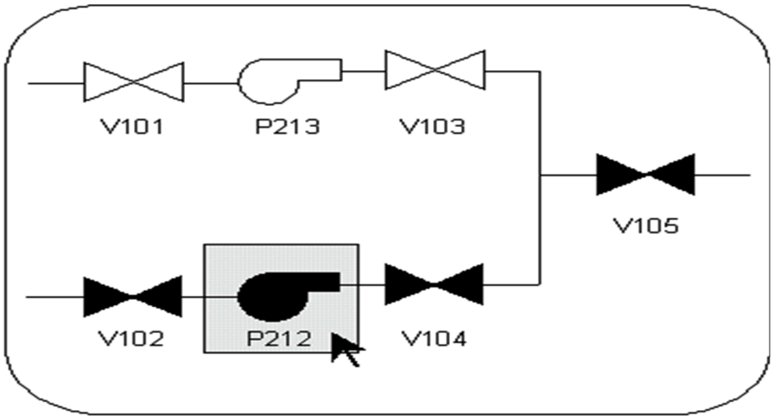
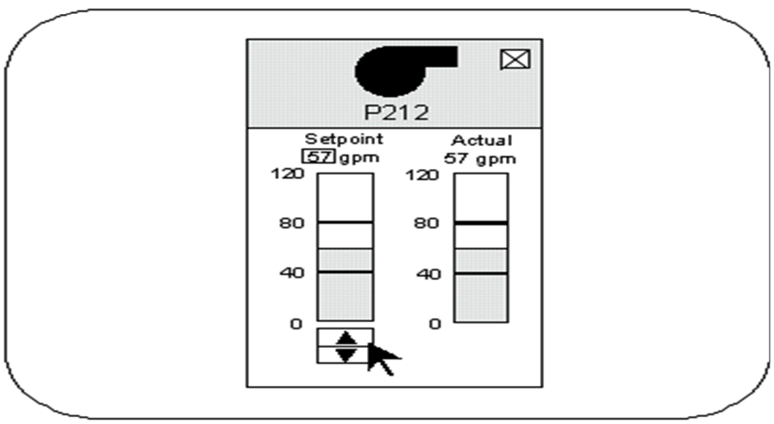


Selection Display



Input Field Display

Figure 3-50. Soft control input field and selection display are on separate VDU's

First, incremental input devices may allow continuous-adjustment such that the position of the device corresponds to the magnitude of the input value. These are similar to continuous-adjustment control devices, such as dials, levers, and sliders. For example, the magnitude of input provided by a dial corresponds to the degree to which it is rotated. A large change in a value requires a large degree of rotation of the dial from its current position. An example is the soft slider (i.e., a slider presented on a computer-based display device), which resembles a bar chart with a pointer directed toward the current value. Input is accomplished by sliding the pointer via a mouse or touch screen interface along the length of the bar chart scale to the desired value.

Second, incremental input devices may accept discrete inputs that change the variable by a specific amount. One example is a pair of buttons pointing in opposite directions that are used to increase and decrease a value sequentially. Arrow buttons may be implemented on a display screen or on a keyboard. Soft buttons are typically presented

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on the display screen and operated via a pointing device, such as a mouse or touch screen. Hard buttons may be physical keys mounted on a keyboard or panel that are used in conjunction with a display screen. With each press of the increase button, the variable increases by a specific amount. If the button is held down, the variable will increase in proportion to the length of time that the button is depressed.

A common design practice is to have the input value change by the smallest unit of precision presented by the soft control device for each press of the arrow button. For example, if the soft control presents a variable to one decimal place, then one press of the arrow button will change the value by one tenth (e.g., increase the value from 10.1 to 10.2). If the variable is presented in integer values, then one button press will change the current value to the next integer (e.g., increase the value from 11 to 12). If a variable has a wide range, executing a large change in the value may require pressing the button many times or holding it down for a long time. Some soft controls feature a second set of arrow buttons that can change the input value by a larger amount for each button press. For example, single arrow buttons [>] may be used for making small changes and double arrow [>>] buttons for making large ones. The size of the increment provided by the double arrow buttons may be configured by the control system engineer for each soft control. The standard values provided by the vendor for the double arrow buttons are 2%, 3%, 5%, or 10% of the range of the instrument. Other values may be programmed.

In some computer-based control systems, the size of the increment provided by incremental input devices may change as a function of plant or system state. For example, a single press may produce a large change during plant startup but a small change when the plant is in its normal operating range.

Finally, keyboards and number pads may be used to enter values in digital form using a set of key actuations, e.g., the value '100.7.'

Several formats may be combined in a single soft control.

Monitoring Control Feedback

Control feedback refers to indications provided to the user that show whether the user's entry was accepted by the system, whether the system is responding to the input, and whether the input is having the desired effect. Each is described below.

System Acceptance Feedback

System acceptance refers to feedback that indicates whether the user correctly performed the input action. For example, when an operator provides an input, an indication is given to show whether the user interface was manipulated properly. Feedback may entail visual cues, such as computer-based buttons that change color when selected, and auditory cues, such as a click accompanying a selection. The system should also provide feedback indicating whether the user's entry was acceptable. For example, if the user enters a value that is outside of acceptable range or selects an unacceptable command, the system should alert the user by visual cues (e.g., changes

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in symbols to indicate that the user entry is not acceptable or that the selected option is not available), warning messages (e.g., a description of the problem), or auditory tones (e.g., a tone that directs the user's attention to the problem). The soft control should also display the user's entry in a way that allows the user to review it and determine whether it is correct. A variety of text and graphical approaches can be used. For example, when the operator enters a control setpoint, the value may be presented in text format by displaying the digits via the user interface. The setpoint may also be represented graphically. One commonly used format is the bar chart. The bar is usually depicted against a reference scale with its length or height corresponding to the magnitude of the input value. Text and graphic feedback may be combined. For example, the input value may be depicted in both digital and bar chart formats.

System Response Feedback

System response feedback indicates whether the user's entry, which was accepted by the system, is being acted upon. For example, an operator may use a soft control to operate a pump by entering a new (higher) control setpoint for pump speed. After providing acceptance feedback indicating that the new setpoint was within the acceptable range, the soft control should provide system response feedback indicating whether the pump is responding to the new setpoint. That is, the operator should be able to determine whether the speed of the pump is increasing toward the setpoint value. To provide this type of feedback, the soft control should be coordinated with plant displays that indicate system status.

Goal Achievement Feedback

Goal achievement refers to feedback that indicates whether the input is achieving its intended goal (e.g., moving the plant toward a safer state). For plant control actions, such as adjusting the flow rate of a feedwater pump, it is necessary that the operator determine that the intended goal (e.g., increased steam generator level) is achieved. To provide this type of feedback, the soft control should be coordinated with plant displays that indicate system and plant status. For example, mimic displays can support the operator in selecting plant components, monitoring the system's response, and monitoring goal achievement. When selection displays and input fields are implemented in other ways, such as via menus and tables, respectively, the higher-level goals affected by the control action may not be readily visible.

System Response Time

Total system response time may be described as the time between the submission of an input to the soft control system and the various types of feedback. For soft controls, system response time may affect the ability of operators to control the plant. Four response time factors are described below.

Display retrieval time is the time required for the HSI to present a new display following the onset of a command. For soft controls, this includes the time required to retrieve: (1) a selection display, and (2) the input field with which operators provide input. Slow

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response time for retrieving displays can delay the operators' access to important information.

Display update time is the interval with which plant variables shown in the soft control or associated displays are updated with new data. If the update rate is slow relative to the behavior of the plant, then a soft control or display could present data that is not representative of the current state of the plant.

Sampling rate and interval for inputs is the number of scans of an input field per unit of time. The sampling interval is the amount of time between samples. Computer-based display systems typically scan the input fields for new input from the operator. If the sampling interval is large, then a long delay could exist between when an input is entered and when it is received by the control system.

Plant response time is the interval between the time at which an input is received by the control system and the plant achieves the desired state. It may have two components: (1) response time for the plant system (i.e., the time required for plant equipment to respond, such as an electrical breaker closing) and (2) response time for the plant process (i.e., the time required for the plant process to achieve the desired goal state, such as reaching a target temperature value). These response times can be fast or slow. If the response is slow then the operator may have difficulty determining whether an input value was too high or too low. As a result, the process value may overshoot or undershoot the target value. If the response time is fast, the operator may lack sufficient time to recognize and respond to input errors.

These response times, combined with operator response time, determine the overall response of the human-machine system. For example, the total time required to access a particular display is the sum of the time required for the operator to select the display and the HSI to respond (display retrieval time). The total time required for achieve a desired change in plant state is equal to the sum of the time required for the operator to enter the input value, the HSI to sample the input value, the plant to respond to the input, and the HSI to represent the change in a display.

Controls

Soft controls are implemented using a broad range of input devices, including those presented in Section 3.3.2.2; thus, no unique guidance is provided for soft control input devices. In addition, conventional, hardwired control devices may also be used if their operation is interpreted by software (e.g., to access multiple plant variables). For example, a physical pushbutton located next to a display screen could perform several different functions depending upon the information presented in the display screen.

Backup Capabilities

If the failure or loss of availability of the soft control system may affect operator tasks that are important to plant safety, then backup systems should be addressed. For

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example, a separate set of conventional controls may be provided as an emergency backup for controls that are important to plant safety.

Integration with other HSI Elements

The consistency and compatibility of the soft control system with the rest of the HSI can affect operator performance. Thus, important review considerations include the degree to which the control devices and displays of the soft control system are compatible with other controls and displays of the HSI.

3.8.2.2 Requirements and Guidelines

General

3.8.2.2.1 Coordinating Soft Control Use Among Operators

ES-0304-1381-11170

Requirement: If a soft control can be accessed from more than one location in the HSI, protective measures should ensure its coordinated use among multiple users.

Additional Information: The HSI should be designed to allow operators to maintain awareness of each other's use of the soft control so their actions do not interfere. For example, two operators should not be able to operate the same soft control simultaneously from different places without being aware of each other's actions. Coordination problems may be minimized by assigning the control capability for a soft control to a particular individual or workstation (e.g., while the settings of a soft control can be viewed from multiple display devices, it can only be operated from one device). Alternately, coordination may be supported by features that restrict access to soft controls one user at a time, and group-view displays that allow operators to observe each other's actions.

HSI Design Criteria

The behaviors and actions of the NuScale Plant operators will be well defined to eliminate dual responses and/or actions.

Software interlocks and status indications embedded into the HSI's will provide the information to the user needed to perform their role and understand the current roles of the other operators of the plant.

Reference: NUREG-0700-7.1

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3.8.2.2.2 Operation with Protective Clothing

ES-0304-1381-11172

Requirement: Soft controls should be designed to accommodate any protective clothing that personnel may be required to wear.

Additional Information: In some plant locations, environmental conditions necessitate wearing protective clothing that can limit the ability of personnel to manipulate soft controls. For example, gloves may reduce manual dexterity and tactile sensitivity, degrading the ability of personnel to operate soft controls quickly and accurately. As another example, eye protection, such as goggles, may become foggy or distort vision and, thus, interfere personnel's ability to view computer-based display devices.

HSI Design Criteria

Soft Control touch locations will be of common size with a minimal size (.6" x .6") requirements to specifically addressing this concern.

Reference: NUREG-0700-7.1

3.8.2.2.3 Representing Relationships Between Control System Components

ES-0304-1381-11174

Guideline: The display capabilities of soft controls should allow users to quickly assess the status of individual components of a control system and their relationships with other components.

Additional Information: Due to the limited size of the display devices used with soft controls, not all components of a control system may be visible to the operator at once. However, they should allow the operator to rapidly view relationships between functionally related components. For example, if a controller is part of a hierarchical control system, the operator should be able to see higher-level controllers that provide control inputs and lower-level ones that receive inputs. Rapid assessment of the control system's status should be supported by such features as displays that depict these relationships, and retrieval mechanisms that give rapid access to detailed information on individual control system components.

HSI Design Criteria

The display capabilities of NuScale soft controls will allow users to quickly assess the status of individual components of a control system and their relationships with other components through the use of color and in some cases icon position.

Reference: NUREG-0700-7.2.1

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3.8.2.2.4 Making Options Distinct

ES-0304-1381-11176

Guideline: The interface should be designed so that users can, at a glance, distinguish options by such characteristics as context, visually distinct formats, and separation.

Additional Information: Slips involve errors in performing well-practiced, unconscious actions. Description errors, a type of slip, involve performing the wrong set of well-practiced actions for the situation. They occur when the information that activates or triggers the action is either ambiguous or undetected. Many control input actions involve the selection of options, such as choosing between alternative commands or selecting a plant component to perform a control action upon it. Description errors that result in selecting a similar but incorrect option may be prevented by organizing options to supply context (such as by functional organization), making options visually distinct, and separating options that users may confuse. Options may be separated by placing them on different display pages or different display devices.

HSI Design Criteria

The display capabilities of NuScale soft controls will allow users to quickly assess the status of individual components of a control system and their relationships with other components through the use of color and in some cases icon position.

Reference: NUREG-0700-7.2.1

3.8.2.2.5 Selection Displays

3.8.2.2.6 Visually Distinct Selection Displays

ES-0304-1381-11178

Guideline: Displays used for selecting components and variables should be visually distinct to support choice of the correct display.

Additional Information: A selection display shows a set of components or variables that may be chosen for a control action. One common format is the mimic, in which components are arranged as a schematic diagram. Excessive reuse of layouts and display elements in mimic displays may cause them to look alike and so may contribute to operators searching the wrong selection display for the component that they wish to manipulate. Selection displays should be laid out and labeled so operators readily recognize and distinguish them.

HSI Design Criteria

NuScale will use mimics and clear naming conventions for display pages.

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Reference: NUREG-0700-7.2.2

3.8.2.2.7 Visually Distinct Components

ES-0304-1381-11180

Guideline: The representation of components and variables within selection displays should be visually distinct to support their correct selection.

Additional Information: Using a standard set of symbols and layout conventions in displays is important in reducing the mental workload associated with finding and interpreting information. However, these factors may also cause components to look alike and may contribute to operators selecting the wrong component. The symbols and graphical icons used to represent different types of components should be designed to be readily recognized and distinguished. In addition, they should be clearly labeled for correct identification.

HSI Design Criteria

The display capabilities of NuScale soft controls will allow users to quickly assess the status of individual components of a control system and their relationships with other components through the use of color and in some cases icon position.

Reference: NUREG-0700-7.2.2

3.8.2.2.8 Identification of Loops on Multiple-Loop Controllers

ES-0304-1381-11182

Guideline: The loops of multiple-loop controls should be distinctly marked to prevent the selection or use of the wrong loop.

Additional Information: A multiple-loop controller is a digital controller that can control multiple variables via independent channels, one per control loop. Each channel acts as a separate control device. For example, a single controller may be capable of controlling 10 different variables, each on a separate control loop. Operators access these loops through the user interface of the controller device. However, because there may be few cues to identify the loops, operators may fail to correctly recognize the loop accessed and may control the wrong variable.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.2

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Input Fields

3.8.2.2.9 Cues for Matching Input Fields to Selection Displays

ES-0304-1381-11184

Guideline: A user looking at the field for providing a control input should be able to determine which plant component or variable is being controlled.

Additional Information: The design of a soft control should provide a salient link between the input field and the corresponding variable or component. Starting at the input field, the operator should be able to quickly trace the component or variable back to its representation in the display that was used to select it. Three methods that might be used are graphic coding, landmarks, and animation. Graphic codes, such as borders, symbols, and colors, may be applied to both the representation of the component in the display from which it was selected and to the input field, making a strong visual association between them. For example, if the selection display has a mimic format, the input field may contain the symbol for the selected component. It also may contain symbols for the components that precede and follow it in the flow path. Animation may be used when an input field is opened and closed. The input field could appear as if it were 'popping out' of an option selected from a display, and 'go back' into the option when the field is closed.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.3

3.8.2.2.10 Labeling of Input Fields

ES-0304-1381-11186

Guideline: The input field should be labeled with sufficient information to uniquely identify its corresponding component.

Additional Information: Labeling should include a unique identification code for the component, matching its representation in the selection display. It may also describe the component (e.g., valve, pump, breaker) and identify those components that immediately precede and follow it in the system.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

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Reference: NUREG-0700-7.2.3

3.8.2.2.11 Coordination of Soft Controls with Process Displays

ES-0304-1381-11188

Guideline: Displays should be readily accessible from the input field so the user can readily verify that the control actions have had the intended effect on plant systems and processes.

HSI Design Criteria

Coordination of input fields with plant process displays should verify that control actions have had the expected effects on plant systems and processes.

Reference: NUREG-0700-7.2.3

Input Formats

3.8.2.2.12 Appropriate Use of Discrete-Adjustment Interfaces

ES-0304-1381-11190

Guideline: Discrete-adjustment interfaces should be used for selecting among a set of individual settings or values.

Additional Information: Discrete-adjustment interfaces are computer-based formats with individual settings that can be accessed by fairly gross movements; their operation is similar to discrete-adjustment controls, such as push buttons. By contrast, continuous-adjustment interfaces are computer-based formats that have continuous ranges usually accessed using some type of slewing motion, requiring a gross movement followed by a fine adjustment; their operation is similar to that of continuous-adjustment controls, such as rotary dials or sliders. Discrete-adjustment interfaces are preferred when the user must select one option from a limited number of choices, or when precision requirements are such that a limited number of settings can represent the entire continuum of values. The most common discrete- adjustment interfaces used with soft controls are individual buttons and radio buttons (a group of buttons representing a set of related options). However, other formats also are possible, such as rotary selector dials operated via cursor or gestural interfaces. Some computer interfaces have a continuous-adjustment control, such as a slider or scroll bar, for looking at a group of individual options. Because choosing a specific setting with a continuous-adjustment control can be awkward, there should also be a discrete- adjustment control, such as a set of arrow buttons.

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HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.13 Labeling Selection Options in Discrete-Adjustment Interfaces

ES-0304-1381-11192

Guideline: The selection options in discrete input formats should be clearly labeled.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.14 Feedback for Discrete-Adjustment Interface with Multiple Settings

ES-0304-1381-11194

Guideline: Discrete-adjustment interfaces should indicate which setting was selected.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.15 Feedback for Discrete-Adjustment Interface with Continuous Operation

ES-0304-1381-11196

Guideline: If a discrete-adjustment interface has continuous operation, it should provide continuous feedback on the current state.

Additional Information: A continuous-operation control continues to produce an effect until the user provides the next input, or until a predefined action sequence is stopped by a termination criterion. An example is a button that changes to the activated state when pressed and remains in that state until it is pressed again. An example of continuous feedback in a soft control is a checkbox format in which an 'X' appears in the box to indicate that an option has been selected, and disappears only after the option is de-selected.

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HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.16 Appropriate Use of Continuous-Adjustment Interfaces

ES-0304-1381-11198

Guideline: Continuous-adjustment interfaces should be used when precise adjustments along a continuum are needed or when many discrete settings are present.

Additional Information: Continuous-adjustment interfaces, such as soft sliders, provide continuous adjustment and are, therefore, suited to selecting a setting from a continuum. Because these interfaces often require a gross slewing movement followed by fine adjustment, setting them correctly may require more time and attention than discrete input formats. Therefore, they should not be used in place of a discrete-adjustment interface for selecting from a small set of options.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.17 Appropriate Use of Soft Sliders

ES-0304-1381-11200

Guideline: A soft slider should be considered as an input device when the range of possible values and the ratio of a value to that range need to be displayed.

Additional Information: A soft slider (also called a slider bar or a scroll bar) is an input format used to directly manipulate a variable over a set range of values. Soft sliders are typically maneuvered via pointing interfaces, such as a touch screen or mouse. They may require careful hand-eye coordination to ensure that the pointing device does not leave the linear path of the slider nor overshoot or undershoot the intended target. If the user's tasks do not permit careful hand-eye coordination, then other interfaces, such as arrow keys, should be used. The slider sometimes is combined with arrow buttons.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

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Reference: NUREG-0700-7.2.4

3.8.2.2.18 Indicating the Range of Values on Soft Sliders

ES-0304-1381-11202

Guideline: The range of values should be indicated on horizontal sliders with the low value on the left and the high value on the right, and on vertical sliders with the low value on the bottom and the high value on the top.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.19 Displaying the Digital Value on Soft Sliders

ES-0304-1381-11204

Guideline: The numerical value to which a soft slider is set should be presented in digits on the soft slider.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.20 Dimensions of Soft Sliders

ES-0304-1381-11206

Guideline: The physical dimensions of the soft slider should allow the user to read the current and target positions and position the slider with the required precision, accuracy, and response time.

Additional Information: The length of the slider is determined, in part, by the range of values depicted, the increments between individual values, the degree of precision required for reading the slider's position, and the user's expected viewing distance. The accuracy with which the slider may be positioned may be affected by characteristics of the input device (e.g., mouse devices may allow more accurate positioning than a touch interface due to the size and irregular shape of the finger). A very short slider may be difficult to read or position precisely. A very long slider may produce slow response times

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due to the long distance that must be traveled and the need to keep the pointing device on its linear path.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.21 Depicting Critical Ranges on Soft Sliders

ES-0304-1381-11208

Guideline: When part of the range of values depicted by a soft slider represents critical information, such as alarm limits, those values should be coded to facilitate recognition.

Additional Information: Graphical codes may be applied to distinguish the normal operating range, alarm limits, and other abnormal operating ranges.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.22 Appropriate Use of Arrow Buttons

ES-0304-1381-11210

Guideline: A set of arrow buttons should be considered as the input device when it is desirable to incrementally increase or decrease a variable from its previous value.

Additional Information: Arrow buttons change values sequentially as each increase or decrease button is pressed. In addition, values may change continuously if a button is held down. These inputs provide feedback about the magnitude of the change (i.e., the magnitude increases with the number of presses or the time that a button is held down). Such feedback may reduce the likelihood of producing large errors or increase the likelihood of detecting them. Some soft controls have two sets of arrow buttons, one for small and one for large incremental changes. Arrow buttons are sometimes combined with a slider in a soft control.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

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Reference: NUREG-0700-7.2.4

3.8.2.2.23 Indicating Current Value for Arrow Buttons

ES-0304-1381-11212

Guideline: Arrow buttons should have a display indicating the current value of the variable being controlled.

Additional Information: The current value should be shown in a format consistent with the type of variable being controlled. Numerical values should be presented as digits, and textual values (e.g., Low, Medium, and High) as words.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.24 Uniform Changes in Values Via Arrow Buttons

ES-0304-1381-11214

Guideline: Each press of an arrow button should change the current value uniformly.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.25 Feedback Regarding Arrow Button Actuation

ES-0304-1381-11216

Guideline: Arrow buttons should provide salient feedback when they are actuated.

Additional Information: Feedback should be sustained when the button is held down and momentary when the button is momentarily pressed.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

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Reference: NUREG-0700-7.2.4

3.8.2.2.26 Apparent Operation of Arrow Buttons

ES-0304-1381-11218

Guideline: Labeling and other coding should be used when the operation of the arrow buttons is not apparent.

Additional Information: For example, when arrow buttons are used to change a date display, it may be unclear whether actuating a button will incrementally change the days (and change the month when the last day is reached), or whether the month and day values are changed separately after being selected by the user. The arrow buttons should be labeled or coded to indicate their effects.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

3.8.2.2.27 Reference Values For Continuous Variable Inputs

ES-0304-1381-11220

Guideline: Reference values should be provided to help the user judge the appropriateness of values when entering continuous variable inputs.

Additional Information: Reference values commonly used in process control applications include the variable's range, alarm limits, and the current value. Reference values may be presented as digits or graphs.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.4

Display Devices

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3.8.2.2.28 Adequate Display Area

ES-0304-1381-11222

Guideline: Adequate display space should be provided so that short-term monitoring and control tasks do not interfere with longer-term tasks.

Additional Information: Making control actions available via a general-purpose display device may require other plant information to be removed from the user's view. Sufficient general-purpose display devices should be provided so that short-term control actions can be undertaken without interfering with long-term ones (e.g., they can be performed on separate devices). Alternatively, control actions can be supported by dedicated special devices.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.2.5

Soft Control General Information

3.8.2.2.29 Minimizing Soft Control Modes

ES-0304-1381-11224

Guideline: The excessive use of modes in soft controls should be avoided.

Additional Information: Modes occur in soft controls when a display or input device is designed for more than one function. For example, a soft control that is used for manipulating multiple variables may have a separate mode for each one (e.g., individual modes for variables A, B, and C). In addition, there may be multiple modes for a single variable, each allowing it to be controlled in a different way (e.g., variable A may have separate modes for manual control, automatic control, and testing). Mode errors occur when the user believes the device is in one mode when it is in another and, as a result, performs an inappropriate input action. The likelihood of mode errors can be lessened by reducing the number of modes; if multiple modes do not exist, then mode errors cannot occur.

HSI Design Criteria

NuScale will not employee the use of modes in the design of soft controls.

Reference: NUREG-0700-7.3.1

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3.8.2.2.30 Distinctive Indication of Soft Control Modes

ES-0304-1381-11226

Guideline: When multiple modes exist, they should be distinctively marked so the user can determine the current mode at a glance.

Additional Information: Distinct labels may be used to indicate the currently active mode.

HSI Design Criteria

NuScale will not employee the use of modes in the design of soft controls.

Reference: NUREG-0700-7.3.1

3.8.2.2.31 Coordination of Destructive and Safety-Significant Commands Across Modes

ES-0304-1381-11228

Guideline: A command that produces a benign action in one mode should not cause a different action with serious negative consequences in another mode.

Additional Information: A command is an instruction provided by a user requesting a computer system to perform a particular action. Actions that are destructive (e.g., delete file) or have serious safety consequences should have unique commands. For example, the function key 'F2' should not have a benign action, such as listing a directory, in one mode but a destructive action, such as deleting a file or operating important plant equipment, in another mode.

HSI Design Criteria

NuScale will not employee the use of modes in the design of soft controls.

Reference: NUREG-0700-7.3.1

3.8.2.2.32 Unique Commands for Destructive and Safety-Significant Commands

ES-0304-1381-11230

Guideline: Unique commands associated with actions that have important consequences should not be easily confused with other commands used in the same or different modes.

Additional Information: Reserving special commands for special actions can prevent mode errors because, if the command is entered while the device is in the wrong mode, it will not be accepted by the system. A unique or reserved command should not be so similar to other commands that a valid entry may result from incorrectly entering another

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command. For example, if the command 'CNTL X' is reserved for a special action, then similar commands, such as 'ALT X' and 'Shift X,' should not be valid, even in other modes. The combination of a mode error and the incorrect entry of the command may execute an unintended action.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.3.1

3.8.2.2.33 Discrimination of Interface Management Actions and Process Control Actions

ES-0304-1381-11232

Guideline: The design of the user interface should clearly distinguish between interface management actions and process control actions.

Additional Information: Actions required for interface management tasks and plant control tasks should look different. This may be accomplished by providing different interfaces, different coding for interfaces, and, possibly, different input devices.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.3.1

3.8.2.2.34 Reducing the Likelihood of Unintended Actuation

ES-0304-1381-11234

Requirement: For actions that can have significant negative consequences, the user interface should be designed to reduce the likelihood of unintended actuation by requiring deliberate action for their execution.

Additional Information: Deliberate actions should be required for inputs having serious potential consequences. Actions that require physical effort in the form of multiple steps or higher actuation forces may be less likely to occur accidentally as the result of a random motion of the user. In addition, actions that require greater attention, such as multiple steps and checks, may reduce the likelihood that the user will revert to the type of 'automatic' activity that could cause a slip. However, control actions that require multiple steps also should be designed to reduce the likelihood of other errors (i.e., the failure to complete a set of steps in the correct order).

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HSI Design Criteria

All soft touch areas that perform functions (control of a components or the start of a procedure) that are deemed appropriate will have a multiple touch requirement that forces the user to "repeat" the action as a means to validate the users intention.

Reference: NUREG-0700-7.3.1

3.8.2.2.35 Feedback For Selected Actions Before Execution

ES-0304-1381-11236

Guideline: The HSI should give the user feedback indicating the action that was selected and allow the action to be canceled before it is executed.

Additional Information: The goal of this recommendation is to avoid unintended manipulation of plant equipment or unintended interface management actions. Feedback about the selected option is important because a broad range of actions may be accessed through a soft control device, including manipulation of various plant components and of the user interface. The close proximity and similarity of input options within the display area may result in users selecting the wrong ones. Users should be able to cancel or modify an action if they determine that its execution would be undesirable.

HSI Design Criteria

NuScale will clearly indicate any soft control function(s) to avoid the incorrect selection of an operation.

Reference: NUREG-0700-7.3.1

3.8.2.2.36 Use of Error-Mitigation Approaches

ES-0304-1381-11238

Guideline: Error-mitigation approaches should not be the sole means for achieving error tolerance, but should be used in conjunction with other means for error prevention and system-assisted error detection.

Additional Information: Error-mitigation mechanisms limit the effects of incorrect inputs after they have been entered into the control system. Two strategies include reducing the rate of the system's response and deferring it. Both are intended to provide time for detecting and correcting input errors and for reversing them. Error mitigation should not be considered a substitute for error prevention and detection.

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HSI Design Criteria

NuScale will enforce the two touch approach for error mitigation.

Reference: NUREG-0700-7.3.1

3.8.2.2.37 Undo Features

ES-0304-1381-11240

Guideline: If undo features are provided they should be consistently available.

Additional Information: Undo features minimize the effects of users' errors by allowing them to undo or reverse previous actions. Users tend to rely upon undo features and incorporate them into their work. Failures of undo features may have worse consequences than if they were not provided in the first place. For example, operators may be more willing to delete files if they think they can recover them.

HSI Design Criteria

NuScale will not provide an undo feature.

Reference: NUREG-0700-7.3.1

Soft Control Sequential Information

3.8.2.2.38 Indicating the Status of Sequential Actions

ES-0304-1381-11242

Guideline: Computer-based HSIs should support users in rapidly assessing the status of sequential actions in progress.

Additional Information: An action sequence is a set of operations that must be performed in a specific order. Errors involving misordering the components of an action sequence include skipped, reversed, and repeated steps. Soft controls may be more prone to this type of slip than conventional controls because they introduce additional operations for accessing controls and displays and providing inputs that also often have sequential constraints on their execution. In addition, many control operations must be performed in particular sequences. For example, when configuring a fluid system, it may be necessary to establish the flow path, control mode, and setpoint of a flow controller in a specific sequence of operations (e.g., A, B, C, D, and E). One form of error occurs when a user skips a step thinking that it was completed. For example, a user may perform operations A, B, and C and after some delay or interruption, may perform operation E thinking that D already was finished. The repetitiveness of the task is a factor in this type of error. If a user has performed a set of operations repeatedly on several identical controllers, the memory of performing a particular operation on the other controllers may

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increase the likelihood of the user incorrectly concluding that the operation was completed on the present controller. Thus, the sequentiality of soft controls can interact with repetitive, sequential tasks to increase the probability of errors involving misordering the components of the action sequence. The display design of computer- based HSIs should support users in identifying tasks that are in progress; ideally, they should be designed so that the status of related operations (e.g., A, B, C, D, and E) can be checked at a glance from a single display.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.2

3.8.2.2.39 Drawing Attention to Points Where Similar Sequences Diverge

ES-0304-1381-11244

Guideline: The design of the HSI should draw the user's attention to points where operational sequences that have multiple steps in common begin to diverge from each other.

Additional Information: A capture error occurs when an infrequently performed action requires a sequence of operations that overlaps with the sequence required for a frequently performed action. In attempting the infrequent action, the frequent one is performed instead. For example, a user intends to perform task 1, consisting of operations A, B, C, and D, but instead executes the more frequently performed task 2, (composed of operations A, B, C, and E). Capture errors often occur at the point of divergence of the frequently and infrequently performed sequences. HSI design efforts may be directed at that critical point to bring it to the user's attention. For example, if the control system knows the user's intention (e.g., by requiring an indication of the overall intention), it could highlight the proper path at the choice point, or initiate a warning if the wrong one is taken. Another approach is to draw the user's attention to important choice points (i.e., points where the sequence of operations differs from the sequences of similar tasks) by coding, labeling, and caution messages. Yet another way is to incorporate features drawing attention to the operational significance of alternative paths and supporting an understanding of which path has been taken.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.2

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3.8.2.2.40 Interruption of Transaction Sequences

ES-0304-1381-11246

Guideline: The HSI should allow the user to interrupt or terminate a current transaction sequence.

Additional Information: A transaction sequence is a series of steps undertaken to accomplish a larger task. For example, the task of changing a control setpoint may involve multiple steps for selecting the variable and entering the new value. If different types of interruptions or terminations exist, then each should have a separate control option and a distinct name. Table 3-24 lists interruption and termination types.

HSI Design Criteria

NuScale will allow any sequence to be interrupted or canceled.

Reference: NUREG-0700-7.3.2

Table 3-24. Different types of interruptions or terminations for transaction sequences

Back or Go Back	A nondestructive option that returns the display to the last previous transaction.
Cancel	An option that erases changes just made by the user and restores the current display to its previous state.
End, Exit, or Stop	An option that concludes a repetitive transaction sequence.
Pause and Continue	Options that interrupt and later resume a transaction sequence without any changes to either the data entries or the logic of the interrupted transaction.
Restart or Revert	An option that cancels entries made in a transaction sequence and returns the user to the beginning. If a restart will result in the loss of data or changes, a confirming action is required of the user.
Review	A nondestructive option that returns to the first display in a transaction sequence, permitting the user to review a sequence of entries and make necessary changes.
Suspend	An option that permits the user to preserve the current state of a transaction while leaving the system and permits resumption of the transaction later.

3.8.2.2.41 Interrupted Sequence Prompt

ES-0304-1381-11250

Guideline: The HSI should support the user in maintaining awareness or recalling tasks that were interrupted or suspended by giving a reminder.

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Additional Information: A loss-of-activation error occurs when an intended action is not carried out due to a failure of memory (i.e., the intention has partially or completely decayed from memory). One way of preventing loss of activation is to have an on-screen message reminding the user of the suspended task. If necessary, the system should prompt the user with information on how to resume it. A second approach is to provide more display screens or implement a window-based display system to keep tasks that are in progress visible, as they would be in spatially dedicated conventional control rooms.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.2

3.8.2.2.42 Resumption of Interrupted Sequences

ES-0304-1381-11252

Guideline: A minimum number of actions should be required to resume a control-action sequence that was temporarily suspended.

Additional Information: When a user has interrupted a sequence of operations, a minimum number of actions should be required to resume it. The user should not be required to restart the sequence from the beginning. One way of supporting the user in finding a display containing a suspended task is to have a 'previous display' feature that accesses a sequence of previous displays. A second approach is an interaction history feature that lists previously accessed displays and provides access to them. A third method is to include a 'bookmark' feature allowing users to designate displays containing tasks that are in progress. Thereafter, few actions or none should be required to resume the task.

HSI Design Criteria

NuScale employees a two touch action philosophy.

Reference: NUREG-0700-7.3.2

Verification, Interlocks and Error Detection

3.8.2.2.43 Separate Action For Verification Steps

ES-0304-1381-11254

Guideline: Verification steps should be separate from input actions.

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Additional Information: Verification steps are usually steps added to the input action. For example, the user selects an option and then presses the Enter key to verify it. Verification steps reduce the likelihood of input errors by increasing the effort (i.e., the number of steps) and drawing users' attention to the input operation. However, they can lose their effectiveness if users can perform them unconsciously as part of the input action.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.3

3.8.2.2.44 Confirmation of Goals

ES-0304-1381-11256

Guideline: When feasible, confirmation steps should draw attention to the goal of the action, not just to the action.

Additional Information: Confirmation steps require the user to respond to a warning or advisory message. For example, the user may respond to the question, 'Are you sure you want to do this?' by pressing 'Yes' or 'No.' Like verification steps, confirmation steps attempt to reduce input errors by increasing the effort (i.e., the number of steps) and drawing users' attention to the input operation. A problem with confirmation steps is that they are often ill timed, occurring just after the user initiated the action and is still fully content with the choice. If the user requests an action but specifies the wrong object to be acted upon (e.g., the user requests a file deletion but specifies the wrong file), the system's request for confirmation is not likely to help the user detect the error. At this point, the user is apt to focus on confirming the action (e.g., deletion) rather than the object (e.g., which file). The potential benefits of confirmation steps should be weighed by comparing their effects on the user's response time (e.g., potential delays) to the potential consequences associated with the errors that are being guarded against.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.3

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3.8.2.2.45 Use of Interlocks, Lockouts, and Lockins

ES-0304-1381-11258

Guideline: Interlocks, lockouts, and lockins should be provided to restrict personnel actions that may affect plant safety.

Additional Information: An interlock is a feature that requires user actions to proceed in a specific sequence. A lockout prevents personnel from providing input that may generate a negative effect. Statically defined lockouts may restrict inputs to a specific, predefined range or set of values. Context- sensitive lockouts may restrict input values based on the current situation. A lockin keeps an ongoing operation active by preventing personnel from terminating it prematurely. Personnel actions that may affect plant safety include control actions and manipulating stored data important to safe plant operation.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.4

3.8.2.2.46 Override of Interlocks, Lockouts, and Lockins

ES-0304-1381-11260

Guideline: The design of interlocks, lockouts, and lockins should not limit the users' authority unless there is a clear safety reason.

Additional Information: Error-prevention measures (e.g., interlocks, lockouts, and lockins) that cannot be overridden by the user may be detrimental to safety. Sometimes a normally undesirable tactic may be the only thing a user can do to solve a problem.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.4

3.8.2.2.47 Visibility of Interlocks, Lockouts, and Lockins

ES-0304-1381-11262

Guideline: Interlocks, lockouts, and lockins should be designed to indicate which actions are being blocked and what conditions activated the block.

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Additional Information: A lockout blocks inputs that it considers unacceptable or not achievable. When this occurs, the user should be able to determine why an input was blocked and what inputs are acceptable, especially for context-sensitive validation in which complicated rules may be used for assessing the acceptability of an input value. An interlock should inform the user of the condition(s) that activated it and the conditions that must be satisfied to release it. Lockin features should show the user what action is being 'locked in' (i.e., the action that is being caused to operate without interruptions) and how it can be canceled.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.4

3.8.2.2.48 Automatic Logging of the Activation of Interlocks, Lockouts, and Lockins

ES-0304-1381-11264

Requirement: The activation of an interlock, lockout, or lockin should be automatically logged.

HSI Design Criteria

The NuScale Plant will automatically log the lockout actions initiated by a user as well as provide visual indication on the HSI's as to the current lockout status of any components affected by the action.

Reference: NUREG-0700-7.3.4

3.8.2.2.49 No Automatic Actuation of Blocked Actions

ES-0304-1381-11266

Guideline: An interlock, lockout, or lockin should not initiate an action that was previously blocked merely because the status of the triggering condition has changed.

Additional Information: If operation B was blocked because condition A was not satisfied, the system should not automatically start operation B when condition A is met. Instead, a separate action should be required (e.g., the user should be required to take a specific action to allow operation B to resume).

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

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Reference: NUREG-0700-7.3.4

3.8.2.2.50 Warning Message Content

ES-0304-1381-11268

Guideline: Warning messages should draw users' attention to the goal of the action, not just to the action.

Additional Information: Actions may be described in many levels of detail. Often error messages are not effective because they are directed toward the wrong level of detail, so that the description of what is wrong may not match the user's understanding of what was done. An alternative is to allow the user to interrogate the warning. For example, the initial warning could be given at a very high level, corresponding to the system's understanding of the user's intent but then could allow the user to obtain information at lower, more detailed levels, such as describing how the action was performed and why it was inappropriate for the goal.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.5

3.8.2.2.51 Automatic, Self-Correct Features for Interface Management Action

ES-0304-1381-11270

Guideline: Automatic, self-correcting features should only be used for interface management actions, such as retrieving displays.

Additional Information: Automatic, self-correcting features detect and automatically correct errors that users make when providing inputs; for example, a 'Delete' command that is incorrectly entered as 'DLE' will be automatically changed to its correct form 'DEL' and then executed. These systems can interfere with user's activities if their error-detection facilities are overgeneralized (i.e., they interpret correct entries as being errors), since the system may substitute an incorrect response for the correct one provided by the user, thereby affecting plant operation and safety. Additional mental burdens may be imposed on the user to learn, remember, and anticipate the types of correct inputs that these systems will interpret as errors. Therefore, automated, self-correcting features should not be employed for plant-control actions. Instead, other approaches should be used, such as warnings and confirmation steps.

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HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.5

3.8.2.2.52 Undo Capabilities for Self-Correct Features

ES-0304-1381-11272

Guideline: Automatic, self-correcting features should only be used if they include good 'Undo' capabilities, so that inappropriate changes made by the system can be reversed by the user.

HSI Design Criteria

NuScale will not employee any self-correcting features.

Reference: NUREG-0700-7.3.5

3.8.2.2.53 Use of Inspection and Transfer Steps

ES-0304-1381-11274

Guideline: Inspection and transfer steps should be considered if inputs are complex, or if incorrect inputs can seriously affect safety.

Additional Information: Inspection and transfer steps are intermediate steps included in a sequence of operations to create additional opportunities for detecting and correcting faulty inputs. Rather than entering data directly into the control system, the data may be sent to a holding file for review and approval. Thereafter, a command may be entered to transfer the data from the holding file into the active portion of the control system.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.5

Variables, Inputs, Data and Response

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3.8.2.2.54 Identification of Plant Variables and Components

ES-0304-1381-11276

Guideline: The HSI should support the identification of plant variables and components based on recognition rather than relying strictly upon recall.

Additional Information: The HSI should present the options available to users for selecting plant variables and components. For example, they may be shown via menus or mimic displays to facilitate recognition. Where there are multiple variables, their selection should not be based strictly upon the ability of operators to recall components' identification codes.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.6

3.8.2.2.55 Simple Input Actions for Selection

ES-0304-1381-11278

Guideline: The user should be able to select a component or variable from a display by using simple input actions.

Additional Information: Multi-step or complex input operations, such as transcribing identification codes, should be avoided. The demands of making a selection should be minimized so as not to compete with cognitive resources needed for assessing plant conditions and planning responses. However, in some cases, such as for controls that are very important to plant safety, more complex actions may be required to reduce the likelihood of accidental actuation.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.6

3.8.2.2.56 Minimize Action-Sequence Errors for Selecting Plant Variables

ES-0304-1381-11280

Guideline: If a sequence of actions is required to select a component or variable, the HSI should be designed to prevent misordered action-sequence errors.

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Additional Information: When a soft control is used to manipulate multiple plant components or variables, the user may need to select one, perform the control action, and then deselect it before controlling the next. Errors involving misordering the components of an action sequence may occur. If the user fails to deselect the last component or variable (i.e., the one that was previously controlled), the control action may be performed on the wrong one. The HSI may minimize the likelihood of misordered action-sequence errors by minimizing the number of selection steps, reducing sequential constraints on selection steps, and providing feedback for identifying out-of-sequence steps.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.6

3.8.2.2.57 Minimize the Number of Retrieval Steps for Controls that are Used Together

ES-0304-1381-11282

Guideline: When a group of controls must be used together, their retrieval should require a minimal number of actions.

Additional Information: Excessive selection steps can prevent prompt access to controls and can cause misordered action-sequence errors. One approach to reducing the number of selection actions is to present, on the same display, controls that are used together.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.6

3.8.2.2.58 No Activation When Display Is Inoperable

ES-0304-1381-11284

Requirement: Users should not be able to activate a soft control if it's display is not working.

Additional Information: A reported problem with touch screens is that sometimes their buttons may remain active even though the video image is not visible. Thus, a user could touch a blank screen and provide a valid input. Such problems may be avoided by

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requiring multiple actions, such as separate selection and activation steps, for inputs that may have serious consequences (e.g., affect the operation of plant equipment).

HSI Design Criteria

All soft touch areas that perform functions (control of a components or the start of a procedure) that are deemed appropriate will have a multiple touch requirement that forces the user to "repeat" the action as a means to validate the users intention.

Reference: NUREG-0700-7.3.7

3.8.2.2.59 Automatic Reset of Multi-Variable Controls

ES-0304-1381-11286

Guideline: If an input device controls more than one variable, the user should not have to reset the device to match the value of the new variable before executing a control action.

Additional Information: When switching between variables, the control should automatically display the current value of that variable and position the input device consistent with that value. The user should not be required to adjust the input device to match the current value of a new variable. For example, if variable A is currently set at a value of 100 and variable B at 10, when selecting the latter, the user should not be required to adjust the input device to the 10 position before executing a control action.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.7

3.8.2.2.60 Numerical Input Values

ES-0304-1381-11288

Guideline: The HSI should provide feedback to support the user in verifying the correctness of numerical values entered.

Additional Information: At a minimum, the value should be depicted as digital readout. However, additional feedback can further aid users in detecting input errors. For example, for control setpoints, reference values can convey the implications of the new value for plant operations and, thus, support the user in identifying a value that is too large or too small. Reference values include the actual value of the process variable, the current setpoint value, the normal operating limits, and the alarm limits. Graphical feedback might include a bar chart depicting the input value (i.e., the bar's length

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corresponds to the magnitude of the entered value). The reference values and the graphical representation may be combined.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.7

3.8.2.2.61 Minimize the Use of Irreversible Actions

ES-0304-1381-11290

Guideline: The design of the HSI should minimize the use of irreversible actions for handling stored data.

Additional Information: The design of HSI should seek to eliminate irreversible actions in handling stored data. The user should be able to reverse an action with an 'Undo' capability. If an action cannot be designed to be reversible, the user interface should be designed to reduce the likelihood of unintended actuation.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.8

3.8.2.2.62 Deferring Execution of Operations that are Destructive to Stored Information

ES-0304-1381-11292

Guideline: Whenever practical, irreversible operations that destroy stored information should be deferred and require a separate action for their execution rather than being carried out immediately.

Additional Information: Operations that are destructive to stored information include modification and deletion of files. One way of making actions reversible is to defer their execution, giving the user an opportunity to reconsider and reverse the action. An example is the command to delete a file. Many computers place the files in a storage location where, depending upon the computer, it may be deleted automatically in the future, or remain indefinitely until the user issues a separate command. This feature allows the user to easily recover the file. Such reversible delete features may be beneficial in NPPs for recovering trend information or other data important for the safe operation of the plant.

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HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.8

3.8.2.2.63 Actuation Feedback

ES-0304-1381-11294

Guideline: Soft controls should provide feedback about their operating state after activation.

Additional Information: Momentary controls, which operate only during actuation (e.g., while a button is pressed) should provide feedback during operation. Continuous-operation controls, which remain operating after actuation, should provide continuous feedback.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.9

3.8.2.2.64 Notification of Automatic Mode Changes

ES-0304-1381-11296

Guideline: Systems that can change mode automatically should provide feedback to make the user aware of the current mode.

Additional Information: The HSI should inform the user of the current operating mode, mode-transition points, limits on actions, and circumstances in which users must assume control. This feedback should help the user assume control without unnecessary actions and without unnecessarily disrupting plant systems and processes.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.9

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3.8.2.2.65 Delaying System Response

ES-0304-1381-11298

Guideline: Where appropriate, systems that are sensitive to incorrect inputs should be designed to limit the rate at which these inputs can affect the process.

Additional Information: Limiting the rate at which a system responds to a user's inputs can provide opportunities for the user to detect and correct erroneous material. Methods for delaying system response include programmed limits in the control software, such as maximum ramp rates, and physical limits in plant equipment, such as orifices and dampers, to limit the rate at which processes can respond to inputs. These methods may be used when the system's slower response will not degrade plant operation or safety. These methods should be used with other methods that prevent errors and detect them.

HSI Design Criteria

NuScale will clearly indicate any sequential information to the operator needed to avoid incorrect operation of the plant.

Reference: NUREG-0700-7.3.9

3.8.3 Hand Held Devices and Laptops

3.8.3.1 Section Information Under Development

3.8.4 Display Devices

3.8.4.1 Requirements and Guidelines

3.8.4.1.1 VDU Resolution

ES-0304-1381-8700

Guideline: The display should have adequate resolution; i.e., users should be able to discriminate all display elements and codes from maximum viewing distance.

Additional Information: The Modulation Transfer Function Area (MTFA) is a measure of resolution; it should have a value of at least 5. This value may be directly developed from microphotometric measurements, or for monochrome VDU displays, it may be estimated using the formula given in Table 3-25.

HSI Design Criteria

NuScale display will have adequate resolution on all VDU's.

Reference: NUREG-0700-1.6.1, NUREG-0700-1.6.2

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Table 3-25. Calculation of Modulation Transfer Function Area

$$\mathrm{MTFA} = 10A$$

where $A = b_0 + b_1V_D + b_2W_D + b_3A_B + b_4V_DA_B + b_5W_DA_B + b_6L_MA_B + b_7V_DL_MA_B$,

where $b_0 = 1.48$ $b_1 = 0.60$ $b_2 = -1.07$ $b_3 = -1.62$
$b_4 = -0.17$ $b_5 = 0.59$ $b_6 = 0.48$ $b_7 = 0.06$

where V_D = Viewing Distance in meters (m), when $0.30\ \mathrm{m} < V_D < 1.02\ \mathrm{m}$,

W_D = the full width of the Gaussian spot at the half-amplitude point in mm, when $0.15\ \mathrm{mm} < W_D < 0.76\ \mathrm{mm}$,
$A_B = \log_{10}$ of the reflected luminance (in cd/m^2) from the display screen, when $0 < A_B < 1.7$ (= 50 cd/m^2), and
$L_M = \log_{10}$ of the peak display luminance (in cd/m^2), when 1.3 (= 20 cd/m^2) $< L_M < 2.54$ (= 343 cd/m^2).

3.8.4.1.2 VDU Contrast

ES-0304-1381-8704

Guideline: The contrast ratio of the display should be greater than 3:1; a contrast ratio of 7:1 is preferred.

Additional Information: Either display polarity – that is, dark characters on a light background – or light characters on a dark background is acceptable provided it meets the requirements for resolution (1.6.1-1) and luminance (1.6.1-7). When ambient illumination in the vicinity of the VDU is high, dark characters on a light background are preferred. Contrast ratio is calculated as follows:

CR = Lmax/Lmin where Lmax is the higher luminance of the background or of the character, and Lmin is the lower luminance of the two.

These values include the contribution from ambient light. Small characters, i.e., characters between 10 and 17 minutes of arc should have minimum luminance modulation (M) of:

M = 0.3 + 0.07 (20 - S) where S is the vertical size of the character set, in minutes of arc, and Luminance modulation is calculated M = (Lmax-Lmin)/(Lmax + Lmin).

HSI Design Criteria

NuScale display will have the correct contrast ration on all VDU’s.

Reference: NUREG-0700-1.6.1

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3.8.4.1.3 Geometric stability

ES-0304-1381-8708

Guideline: The display should maintain the illusion of a continuous image, be free of 'jitter' and 'flicker free'.

Additional Information: Variations in the geometric location of a picture element should be no more than 0.0002 inch per inch (0.0002 mm per mm) of viewing distance over a period of one second. This may be expressed as VD x 0.0002 >= $(H^2 + V^2)$^0.5 where VD is the viewing distance and H and V are the maximum excursions of picture element centers, horizontally and vertically.

The regeneration rate should be above the critical frequency for fusion so that flicker is not perceptible.

It does not matter if the raster is scanned or directly addressed.

HSI Design Criteria

All NuScale displays will fulfill this design standard.

Reference: NUREG-0700-1.6.1

3.8.4.1.4 VDU Image Linearity

ES-0304-1381-8712

Guideline: The display should be free of geometric distortion.

Additional Information: Linearity, the horizontal displacement of a symbol position relative to the symbol positions directly above and below the symbol position, should vary by not more than five percent of the symbol box height. The vertical displacement of a symbol position, relative to the symbol positions to the right and left of the symbol position, should vary by not more than five percent of the symbol box height. Nonlinearity of any column or row should be not more than two percent of the length of the column or row. Lines and columns should be parallel and orthogonal one to the other within the limits of the linearity requirement. This may be expressed as: 0.04 (Shorter edge/Longer edge) >= |Diag1/Diag2| - 1

The size of a specific symbol anywhere on the display should not vary by more than 10 percent, regardless of its location within the image area. This is expressed as follows: 2(h2 - h1)/(h2 + h1) <= 0.1 and 2(w2 - w1)/(w2 + w1) < 0.1 where h is the height of the symbol and w is the width of the symbol. When all the character positions on the screen are filled with 'H's or 'M's of the same character set, h1 is the height of the smallest character, h2 is the height of the largest character, w1 is the width of the smallest character, and w2 is the width of the largest character.

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HSI Design Criteria

All NuScale displays will fulfill this design standard.

Reference: NUREG-0700-1.6.1

3.8.4.1.5 VDU Display Luminance

ES-0304-1381-8714

Guideline: The display should have adequate luminance and all luminance's that are supposed to be the same should appear the same.

Additional Information: Either the character or its background, whichever is of higher luminance, should achieve a luminance of at least 10 ft-L (35 cd/m²) or more. The preferred display luminance is 23 to 47 ft-L (80 to 160 cd/m²).

Luminance uniformity, the variation from the center to the edge of the active area of the display, should not vary more than 50 percent of the center luminance. Unintended luminance variations, within half a degree of arc, calculated from the design viewing distance anywhere on the display, should be less than 50 percent. For an intended uniform luminance, the variation in luminance from the center of the display to the edge or any portion thereof should not vary by more than 50 percent of the center luminance. This measurement is to be made in a dark room.

HSI Design Criteria

All NuScale displays will fulfill this design standard.

Reference: NUREG-0700-1.6.1

3.8.4.1.6 Display Devices for Concurrent Tasks

ES-0304-1381-8724

Requirement: The number of display devices provided in the HSI should be sufficient to support all tasks that must be performed concurrently by each user and does not impair user performance.

Additional Information: The number of display devices should not be so high that the devices cannot fit within the recommended viewing areas of workplace design and, thus, cannot be easily monitored or operated effectively by the users. However, the number of display devices should not be so low that the interface management demands required for accessing and using displays detracts from the user's overall performance on primary tasks. Table 3-26 describes some tasks supported by display devices that should be addressed by requirements for the necessary number of display devices.

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HSI Design Criteria

The User Interface Location Guide Appendix (I) will discuss the number of screens needed by each of the locations in the MCR.

Reference: NUREG-0700-1.6.1

3.8.5 Group-View Displays

Group-view display systems allow multiple personnel to simultaneously view the same information when they are in the CR or distributed throughout the plant. The most important characteristic of a group-view display is supporting team performance and not the type of device used to implement the display.

Group-view displays have traditionally been implemented in conventional control rooms using large- screen displays that enable multiple individuals to refer to the same information and allow individuals to move about the CR while still viewing the information. They can also reduce distractions that might otherwise occur if the information is needed by multiple personnel is located at the workstation of one individual. Configurations other than large-screen display devices are also used such as small-screen display devices that are conveniently located for access by multiple individuals (i.e., walkup display devices).

Conventional CRs have specific characteristics that have evolved over many years of design that contribute to crew performance. They typically feature hardwired controls and displays (and perhaps a lesser number of computer-based controls and displays) that are installed on large control panels that are shared by the crew members. Because they have fixed locations on control panels, access typically does not require unusual display-space navigation skills. Personnel who wish to use the same control or display tend to be aware of each other's intent and actions because they must share the physical devices. In addition, supervisors and other operators can often understand much about an individual's activities (e.g., which procedure step is being performed) by observing the operator's position at the control panels, which contain spatially fixed controls and displays.

Some of these positive characteristics of conventional CRs may be lost in CRs with computer-based workstations, resulting in the following types of problems:

- Difficulty maintaining awareness of overall plant status – Narrowing of attention to local problems at the expense of overall awareness has long been a problem in NPPs. This problem may be aggravated in computer-based CRs by the fact that only a portion of the total plant information is visible at one time through the limited viewing area of an information display screen.
- Difficulty and time delay associated with accessing computer-based controls and displays – Problems may result because controls and displays must be retrieved through navigation of the computer display space.

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- Difficulty maintaining awareness of crew member actions – Operator actions performed in a computer-based workstation may be less identifiable when compared with actions performed at a conventional control panel. In addition, because a single control could have multiple locations in the computer display space, it may be possible for multiple operators to perform tasks involving the same control without being fully aware of each other's specific control actions and intentions.
- Difficulty communicating – Expressing ideas through face-to-face interactions using gestures or verbal communication is important to crew performance. This may be difficult in a computer-based CR because of physical separation/isolation. This problem may be further aggravated by the fact that operators have individual views of the display system and may not be viewing the same portion (e.g., display page) of the display system when they attempt to collaborate.

3.8.5.1 Definitions

Group-View Display Functions

The overall purpose of a group-view display system can vary from design to design. The specific purpose of the system provides a basis for identifying and assessing the relevance and appropriateness of the functional capabilities and design features of a group-view display system. Some considerations to be addressed include the intended users of the system, the physical locations to be covered, the conditions

under which the system is to be used (e.g., normal operations versus emergencies), and types of support the group-view display system is to provide to personnel.

The functionality of group-view displays can include:

- Providing an overview or high-level summary of the plant status.
- Directing operators to additional information from other portions of the HSI by providing automatic retrieval of required information or cues to the operator to assist manual retrieval.
- Supporting crew coordination and awareness of each other's activities.
- Supporting personnel communication and collaboration for tasks such as diagnosing the cause of a process failure or performing a multi-person control task that may require discussions between personnel to coordinate information, diagnose problems, and plan corrective actions. To accomplish this a group-view display should provide information that other operators can see, discuss, and use. Verbal communication and gestures, such as pointing, are important means for communicating ideas. When operators are physically present at the same display device, communication may take the form of natural talking and gesturing. However, when operators cannot be physically present at the same display device this type of communication may take the form of computer-based interaction.

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User-System Interaction

The specific characteristics of group-view displays that support user interaction may be considered in two categories: (1) support for an individual's interaction with a group-view display device and (2) support for shared use of the group-view display device among multiple individuals. Each is described below.

Features that support individual interaction allow a user to access, and possibly manipulate, information presented on the group-view display. An important consideration is whether the group-view display is a stand-alone system or coordinated with the controls and displays. The following are some examples:

- Coordinated displays – The user can select options from the group-view display and the chosen items appear on a display in the user's work area.
- Coordinated controls – The user can operate both the group-view display and a display in the user's work area via the same control device such as the same keyboard or mouse.
- Features for shared use allow multiple users to interact with the display. Features that manage users' access to the group-view display system are important for minimizing conflict. For example, if an individual changes the information content of the display to suit personal needs, the needs of the other crew members may not be met.

  Some interaction considerations that are important to an HFE design review include the following:

- User access – Sequential user access allows one user to interact with the system at a time. This may require some sort of gate-keeping function to help users “take turns.” Concurrent access allows multiple individuals to use the system at the same time.
- Control capabilities – The type of user access will affect the types of user interfaces and controls used for interacting with the system. For example, if the system is operated via cursor and has sequential user access then the cursor must be shared by the users. If the system supports concurrent use, then multiple cursors may be present on the group-view display at the same time.
- Display capabilities – Display capabilities may also be affected by the type of access. For example, if the system has a windowing capability then individual windows might be operated by different users.

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Information Display

Three alternative display device configurations applicable to the implementation of group-view displays in CRs include:

- Large-screen display devices that are usually centrally located and viewable from many areas in the CR.
- Individual, redundant display devices located throughout the CR in areas where operators often work.
- Walkup display devices, within the area defined as “at the controls” by the plant's safety analysis report and technical specifications, that are not located in an operator's immediate work area.

Controls

The types of devices used to interact with the group-view display system should be identified, including computer-based input devices, conventional controls, and soft controls.

Backup Capabilities

If the failure or loss of availability of the group-view display system may affect operator tasks that are important to plant safety, then backup systems and capabilities should be addressed.

Integration with other HSI Elements

The consistency and compatibility of the group-view display system with the rest of the HSI can affect operator performance and, therefore, should be addressed in the characterization. For example, the content (e.g., plant variables) and form (e.g., display formats, coding schemes) of information presented on the group-view display should be consistent with the other displays used by personnel in the CR. In addition, the user-system interaction methods used for the group-view display system should be consistent with methods used for other HSI resources.

3.8.5.2 Requirements and Guidelines

The NuScale Plant will use Group-view displays (GVD's) in the main control room (MCR) to provide all of the personnel high-level information about the 12 Units and the "Common Systems".

One "Overview" display page will be developed for all 12 Unit GVD's and a separate display page for the Common Systems GVD. These pages will not be changeable from any location in the main control room, thus ensuring the information on the GVD will be presented in a reliable and consistent location.

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The GVD's are considered an operator aid and as such are not part of any operators "control" station.

All NuScale Plant HSI pages will be developed following the NuScale Power HSI Style Guide and all applicable Appendices i.e. ICON libraries, navigation techniques. Following this approach ensures commonality amongst all display pages throughout the MCR.

General Guidance

3.8.5.2.1 Applicability

ES-0304-1381-11006

Guideline: Group-view displays should be used when crew performance may be enhanced by access to a common view of plant information or a means of sharing information between personnel.

Additional Information: A group-view display is one approach to presenting information and may be used to address any of the following problems:

- Difficulty maintaining awareness of overall plant status,
- Difficulty and time delay associated with accessing computer-based controls and displays,
- Difficulty maintaining awareness of crew member actions,
- Difficulty communicating.

The acceptability of a group-view display depends upon its purpose and the degree to which this purpose is accomplished. A group-view display may be considered unacceptable if it does not satisfy a recognized need or its presence detracts from personnel performance.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.1.1

3.8.5.2.2 Group-View Display Information

ES-0304-1381-11008

Guideline: Information presented in a group-view display should be relevant to the task requirements of multiple personnel and presented in a manner that is evident to its

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intended users. The group-view display should direct the user to relevant detailed information.

Additional Information: Personnel should have available in their immediate work areas the information needed to perform their tasks. A group-view display located outside of the immediate work area, such as a large-screen display or a walk-up display device, should not be the sole location for information pertaining to plant conditions. Although the arrangement of information on the group-view display may be unique, the data values and status indications presented on the group-view display should also be available from the displays in the operators' work areas.

Relevant detailed information may reside in other portions of the HSI such as lower-level display screens, other display devices, and procedures to support their specific information needs. While the group-view display presents information that is of interest to the crew, it should also assist individual operators in obtaining detailed information that is relevant to their particular needs. The group-view display should provide this function if:

- The quantity of potential supporting information is high, or
- The supporting information is distributed among multiple topics/categories, or
- The supporting information is distributed among multiple information sources (e.g., display devices, procedures).

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.1.1, NUREG-0700-6.1.2, NUREG-0700-6.1.3

3.8.5.2.3 Consistency With Other Portions of the HSI

ES-0304-1381-11010

Guideline: The design of group-view displays, including information presentation and interaction characteristics, should be consistent with the rest of the HSI.

Additional Information: Because group-view displays are to be used in conjunction with the rest of the HSI, consistency is necessary to support personnel in finding and using information. Guideline 1.1-17 states that consistent meanings should be assigned to codes, from one display to another. Generic HFE guidance should be tailored to specific HSIs and used to facilitate the standard and consistent application of HFE principles across the detailed design of the HSI. Since the group-view display is one part of the overall HSI, it should adhere to the same guidelines and standards of rest of the HSI, regarding such characteristics as modes of interaction, dialogue style, terminology,

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abbreviations, and symbols and other coding schemes. Differences should be based upon unique personnel task requirements that the group- view display is intended to support. However, obvious inconsistencies between the group-view display and the rest of the HSI, which may lead to confusion on the part of personnel, should be avoided. Examples of such inconsistencies may include presenting the same plant parameters with different units of measure or using unique coding schemes on one display device that may be confused with coding schemes used for other devices.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.1.1

3.8.5.2.4 Control of Group-View Display

ES-0304-1381-11012

Guideline: Individuals should not be permitted to make changes to the group-view display in a way that would reduce its usefulness to others.

Additional Information: Control of changes in a group-view display, such as changing variables or their ranges, may lead to misinterpretation or confusion. The use of administrative procedures is one way to control changes that may be confusing or otherwise detract from personnel performance.

HSI Design Criteria

NuScale GVD's will not have input or control capabilities.

Reference: NUREG-0700-6.1.1

3.8.5.2.5 Retrieving Information via the Group-View Display

ES-0304-1381-11014

Guideline: If individuals use the group-view display system to access additional information for their own use, this information should be presented on a separate display (e.g., an individual-view display).

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators.

Reference: NUREG-0700-6.1.1

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Overview Display

3.8.5.2.6 Providing an Overview Display

ES-0304-1381-11016

Guideline: The group-view display should provide an overview display if user performance may be supported by a display that combines and integrates diverse plant data in a way that informs personnel of important conditions and allows them to see the overall status of the plant or process.

Additional Information: Operator performance may be enhanced by an overview display if:

- The demands on personnel for gathering and integrating plant data at certain times are high due to time demands from plant dynamics and competing operator tasks,
- Data needed by personnel for assessing plant conditions are dispersed within the physical space of the panels and consoles of the control room or the virtual space of the display system,
- The process for comparing and integrating data is inherently time consuming and error prone (e.g., incorrect comparisons, omissions),
- Personnel performance would benefit from rapid access to status information.

The appropriateness of overview displays should be considered within the context of the entire HSI design. The overview display is one approach to providing personnel with rapid access to important plant information. Other approaches may also be appropriate such as individual, spatially dedicated display devices. An overview display should not be provided if personnel have adequate access to required information without it and the presence of the overview display would distract personnel or interfere with their tasks.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators.

Reference: NUREG-0700-6.1.2

3.8.5.2.7 Indicating Plant Status

ES-0304-1381-11018

Guideline: The overview display should support the personnel in obtaining an overall view of plant status, gaining awareness of major changes in plant status, and identifying minor changes in plant state that are important to the plant condition.

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Additional Information: The overview display should support the personnel in understanding of the immediate health of the plant during ongoing operations and response to plant upsets. It should also serve to orient people entering the control room, including during shift turnover. The overview display should indicate major changes in plant condition, such as the presence of alarm conditions. It should identify conditions that are changing, their rate of change, their significance to plant safety, and their implications for the future state of the plant. In addition, the overview display should support personnel in identifying minor changes in plant condition (e.g., changes that have not gone beyond an alarm setpoint) that are important to maintaining a general awareness of plant condition. These indications should keep personnel informed of (1) the normal operation of ongoing plant processes (e.g., closure of a valve may indicate the completion of some stage of an automatic fluid transfer process) and (2) the early stages of potential problems (e.g., parameters that are approaching alarm conditions).

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators.

Reference: NUREG-0700-6.1.2

3.8.5.2.8 Flexibility In Searching Information

ES-0304-1381-11020

Guideline: The overview display should provide flexibility in the types of information searches that personnel may employ to assess plant status.

Additional Information: The overview display should support the operator in making rapid overall assessments of plant condition using various types of searches, including:

- Data driven – Searching for information that describes conditions to which personnel were specifically alerted (e.g., via alarms),
- Knowledge driven – Searching for information for which operators are specifically looking (e.g., testing hypotheses about plant status),
- Incidental – Identifying of information indicative of plant conditions for which the operator was not specifically looking (e.g., discovering potential problems while traversing the various displays in the course of other information searches or activities).

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.2

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3.8.5.2.9 Support for Rapid Shift of View

ES-0304-1381-11022

Guideline: The overview display should support personnel in rapidly shifting their focus of attention when tracking an evolving event.

Additional Information: While personnel have a tendency to focus on the details of a particular problem, the overview display should direct attention to new conditions. It should support personnel in alternating their focus of attention between the details of the event and the status of the entire plant in a manner that does not disrupt ongoing lines of reasoning.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators.

Reference: NUREG-0700-6.1.2

3.8.5.2.10 Overall Assessment at a Glance

ES-0304-1381-11024

Guideline: The manner in which information is presented in the overview display should provide a characterization of the situation as a whole in a concise form that can be recognized at a glance.

Additional Information: Rapid assessment of plant conditions requires personnel to quickly extract status information from the display. Rapid assessment is determined by both the amount of information and the manner in which it is presented. That is, presentation techniques may be used to reduce demands on the user's attention while maintaining the quantity of information contained in the display. The following design techniques are particularly relevant to the design of overview displays for supporting rapid overall assessment of plant condition:

(1) Coding schemes should be used to make important information the most perceptually salient.

(2) Related concepts should be spatially grouped and information should be imbedded within graphical objects to reduce the need for shifts in attention caused by excessive eye movement. For example, organize data by plant safety function; incorporate bar charts and digital values within symbols for major plant components.

(3) The number of objects presented should be minimized to reduce demands on short term memory.

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(4) Cues that support rapid access to long-term memory stores, such as well defined object categorization schemes and pattern-matching cues, should be used to reduce demands on attention.

(5) Information processing such as filtering, suppression, and prioritization, based on considerations such as plant state and operator task requirements, should be used where the quantity of incoming information may impose excessive demands on operators.

(6) Display formats that make use of peripheral vision capabilities should only be used to facilitate non-attentive monitoring of qualitative changes of less important information and should only be implemented where they do not detract from primary task performance.

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators.

Reference: NUREG-0700-6.1.2

3.8.5.2.11 Level of Abstraction

ES-0304-1381-11026

Guideline: The information presented on the overview display should be abstracted to a level that is consistent with users' information requirements for assessing plant status.

Additional Information: The overview display is intended to support personnel in monitoring and assessing changes in plant state. Information should be selected to be consistent with the types of decisions operators must make when monitoring the plant, such as determination of challenges to plant safety, the availability of plant safety systems, and the operational status of specific systems and components.

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators.

Reference: NUREG-0700-6.1.2

3.8.5.2.12 Mimic Format

ES-0304-1381-11030

Guideline: The overview display should include a plant mimic when a mimic may enhance personnel performance by (1) communicating functional relationships between components or (2) providing a means of organizing information that aids information retrieval and plant monitoring.

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Additional Information: Mimics are a prominent feature of overview displays for advanced control rooms. However, a mimic that is intended to provide a high-level indication of plant status may not be very informative to experienced operators because operators are very familiar with the functional relationships of the depicted systems and components. It may however, provide a useful framework for organizing plant information to support the operators in locating specific information and monitoring particular portions of the plant. A mimic format may also be valuable if it is used to depict functional relationships of lower-level components and parameters for which the operators are less familiar.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators.

Reference: NUREG-0700-6.1.2

3.8.5.2.13 Display of Safety Parameters and Functions

ES-0304-1381-11032

Guideline: If plant safety parameters and functions are presented via a combination of the overview display and other display devices, then these display devices should be within easy view of each other.

Additional Information: Plant safety parameters and functions should be displayed in accordance with the guidelines in Section 3.3.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators.

Reference: NUREG-0700-6.1.2

3.8.5.2.14 Automatic Retrieval and Presentation of Information

ES-0304-1381-11036

Guideline: If information is automatically retrieved, it should be presented in a way that conveys where it came from and why it was retrieved.

Additional Information: This may be achieved using approaches such as animation in which changes in position and size of visually represented objects or concepts are used to indicate relationships.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators.

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Reference: NUREG-0700-6.1.3

3.8.5.2.15 Manual Retrieval of Information

ES-0304-1381-11038

Guideline: Support provided for manual retrieval of additional information should convey the location of both the user and the additional information in relationship to the total display space and the available pathways and mechanisms for accessing this information.

Additional Information: The following are design approaches that use perceptual context to convey relationships between the locations of data in the display space and help the user develop an understanding of the organization of the data:

- Long shot view – Provide an overview (long shot view) of the structure of the display space noting current and desired locations.
- Perceptual landmarks – Provide easily discernable features that appear in successive displays that provide a frame of reference for establishing relationships.
- Display overlap – Divide a single display that is too large to be displayed at one time on a single display device into sections with some portions repeated (overlapping) between successive views.
- Spatial representation – Assign spatial attributes to data to aid human information processing (e.g., displaying data via taxonomic trees, organizing computer files using a desktop metaphor).
- System representation – Arrange the data in a manner that provides information about the structure of the process or system to which the data relates. (Woods refers to this category as spatial cognition.)

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.3

Crew Support

3.8.5.2.16 Support for Crew Coordination

ES-0304-1381-11040

Requirement: The group-view display may be used to support crew coordination when crew performance would benefit from better awareness and coordination of actions.

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Additional Information: This group-view display function consists of assisting the operators in maintaining awareness of the intentions and actions of the other operators so that separate activities can be coordinated and operators can monitor each other's activities to correct errors or promptly lend support when needed. This assistance may take many forms including providing information about operators' locations in the display system, locations in ongoing procedures, and actions performed using computer- based controls. This function is especially important in work settings where:

- Personnel need to coordinate their activities with those of others,
- The workstation design tends to isolate operators, and
- Casual observation and conversation is not adequate for maintaining awareness of others' activities.

HSI Design Criteria

The method used to provide operators a way to determine active or passive control of display pages or procedures is discussed in Appendix E.

Reference: NUREG-0700-6.1.4

3.8.5.2.17 Openness of Tools

ES-0304-1381-11042

Guideline: Where enhanced coordination is desired between personnel, the group-view display should feature open tools for interacting with the HSI or the plant.

Additional Information: The "openness" of a tool refers to the degree to which it enables other personnel to infer useful information about the nature of the task and the specific actions being taken by observing its use by the operator. User interfaces that incorporate representations of physical and functional characteristics of the problem domain can provide observers with a context for understanding the task. For example, a group-view display may be used to allow personnel to observe a control action such as the alignment of a piping system. In this case, a mimic display, in which operators manipulate graphical objects, may provide more useful information to an observer than if the same task were performed via text commands on a keyboard. This is because the display conveys to the observer physical characteristics of the task, such as the type of valve being operated, and functional characteristics, such as the relationship of the valve to the overall piping system, which provides the observer with a better understanding of what action has been performed and its significance to the plant system.

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

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Reference: NUREG-0700-6.1.4

3.8.5.2.18 Openness of Interaction

ES-0304-1381-11044

Guideline: Where enhanced coordination is desired between personnel and communication is restricted by the design of the workstations, the group-view display may be used to facilitate open interactions.

Additional Information: Openness of interaction refers to the degree to which the interactions between team members allow others with relevant information to make contributions. The mode and style of interaction should allow others to see/hear the interaction and provide input (e.g., personnel working on other tasks are not excluded from providing helpful input). For example, if interactions are performed using computer-based communications or audio headsets, other crew members may not be able to observe the interaction and contribute. Where communication can be augmented visually, the group-view displays may be used to enhance the openness of interaction.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.4

3.8.5.2.19 Horizon of Observation

ES-0304-1381-11046

Guideline: Where enhanced coordination is desired between personnel, the group-view display should be used to allow each crew member to perceive a greater portion of the task environment.

Additional Information: Horizon of observation refers to the portion of the crew task that can be seen or heard by each individual. It is largely determined by the arrangement of the work environment (e.g., proximity of team members), the openness of interaction, and the openness of tools. By making portions of a job more observable, other team members are able to monitor for errors of intent and execution, and situations in which additional assistance may be helpful. The horizon of observation may be enhanced through the implementation of group-view displays that present information about the actions of crew members. For example, group-view displays may be used to indicate each crew member's location in the display system and the status in ongoing procedures. Group-view displays may also be used to allow personnel to monitor control actions performed by others for system anomalies or operator errors.

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HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.4

3.8.5.2.20 Supporting Communication and Coordination

ES-0304-1381-11048

Guideline: Where crew performance may be enhanced by improved coordination, the group-view display may be used to support operators in actively participating in the same task through the sharing of information, ideas, and actions.

Additional Information: This function is achieved by providing the operators with a common frame of reference and tools for communication. It contrasts with the group-view function of support crew coordination, which supports personnel in coordinating separate activities. The group-view display should provide this function when:

- There is a high need for operators to work together on the same task/problem (e.g., complex diagnoses of plant failures),
- Face-to-face interaction/collaboration is difficult due to the arrangement of the work setting and the demands of concurrent tasks, and
- The quality of communication and collaboration would be enhanced by computer-based tools.
- Collaborative problem solving – Searching, retrieving, reviewing, and annotating plant information in a collaborative manner.
- Collaborative control tasks – Allowing multiple operators to perform control actions on the same plant system at the same time.
- Data recording/form filling – Entering and recording data that requires contributions from multiple operators.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.5

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3.8.5.2.21 General Requirements for Communication/Collaboration

ES-0304-1381-11050

Guideline: If the group-view display is to be used to support communication/collaboration, it should provide a representation of the task/problem and the tools required for examining and explaining the task/problem.

Additional Information: The group-view display should provide the crew with a common understanding of the task/problem (i.e., the specific problem-solving, control, or data recording task of interest). It should provide means for crew members to express information and ideas and receive information and ideas from others regarding the task/problem.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.5

3.8.5.2.22 Coordinating Input Between Participants

ES-0304-1381-11052

Guideline: The group-view display should contain mechanisms to regulate the participants' access to the group-view display to allow information to be provided in an orderly manner.

Additional Information: Failure to provide regulating mechanisms may result in (1) conflict between users as they try to coordinate their presentations and (2) higher attention and processing demands for viewers as they attempt to identify contributors and process information from multiple presenters. In addition, mechanisms for regulating the participants' access should be compatible with social conventions of communication (e.g., preventing one person from monopolizing communication to the extent that it excludes all others) to allow effective use and maintain user acceptance. Any social mechanisms adopted by users for regulating the participants' access to the group-view display should support effective use of the system under a full range of plant conditions.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.5

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3.8.5.2.23 Minimizing Communication/Collaboration Interaction Burdens

ES-0304-1381-11054

Guideline: The methods of interaction provided by a group-view display to support communication/collaboration should be designed to minimize the demands associated with executing these interactions.

Additional Information: Computer-based interfaces may impose burdens that are different from face-to- face discussions for multi-person interactions, such as providing inputs via keyboards or pointing interfaces. These burdens should not interfere with the ability of operators to interact with each other and should not detract from the operators' primary tasks associated with controlling the plant. Overall, the burdens associated with communicating and collaborating via the group-view display should be offset by the benefits gained from interactions via this media.

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.5

3.8.5.2.24 Compatibility With Social Conventions

ES-0304-1381-11056

Guideline: The methods of interaction for communication/collaboration provided by a group-view display should be compatible with social conventions within the intended user group.

Additional Information: The design of communication/collaboration capabilities of a group-view display should be based on an understanding of social conventions within the intended user group. The communication/collaboration capabilities should be sensitive to the subtle and complex social dynamics that is inherent in group interaction. Also, the design of a groupware application may fail to support the use of subtle cues, such as facial and hand gestures, verbal signals, and non-verbal signals (e.g., pausing, clearing the throat), which people often use to moderate communication (e.g., indicate that they are about to start or stop talking). As another example, the system may provide capabilities for recording interactions between individuals, which may be considered unacceptable or undesirable by some users.

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

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Reference: NUREG-0700-6.1.5

3.8.5.2.25 Flexibility in Communication/Collaboration Methods

ES-0304-1381-11058

Guideline: The methods of interaction provided by the group-view displays to support communication/collaboration should be flexible enough to accommodate the range of personnel interactions that occur during normal and upset conditions.

Additional Information: The design basis for communication/collaboration capabilities of group-view displays should be based on analyses of actual interaction requirements for normal and upset conditions rather than on simplified or idealized of representations of these requirements (e.g., as depicted in operating procedures). Exception handling is critical for rapid, adaptable responses to abnormal and emergency conditions. For example, the roles of individuals in an operating crew may change from the typically roles of shift supervisor, reactor operator, and balance of plant operator, as personnel share responsibilities in response to specific plant conditions. A lack of flexibility in the group-view display for supporting this interaction may impair operator response or introduce additional workload, as operators try to find ways to work around the limitations of the system. This may detract from the operator's primary task of controlling the plant.

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.5

3.8.5.2.26 Identification of Participants

ES-0304-1381-11060

Guideline: A coding scheme or designation system should be used to identify participants while they manipulate information on the group-view display.

Additional Information: Operators of a NuScale Power Plant will not be performing any action via the GVD's.

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.5

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3.8.5.2.27 Maintaining Historical Record of Contributions

ES-0304-1381-11062

Guideline: The group-view display system should support the recording of information regarding the history of interactions if personnel tasks require this information.

Additional Information: Personnel may need information regarding the current version of an idea or the complete history, such as when an idea was introduced, who was the originator, who modified it, and when and how the idea was modified. This information should be made available.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators. Support display pages are available at local workstations.

Reference: NUREG-0700-6.1.5

3.8.5.2.28 Spatial Coordination of Inputs

ES-0304-1381-11064

Guideline: When transferring information between an individual-view display and the group-view display, the information should be presented in a manner consistent with the sender's expectations.

Additional Information: When transferring information from one screen to another the user should either (1) have control over where the information will appear or (2) be informed of where it will appear (e.g., information always appears in a designated location). Transferred information should be presented in a manner that reduces the user's workload associated with finding the information and adapting to its orientation on the screen.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.1.5

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3.8.5.2.29 Timing Coordination of Inputs

ES-0304-1381-11066

Guideline: When transferring information between an individual-view display and the group-view display, the information should be presented promptly and with minimal delay.

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.1.5

3.8.5.2.30 User-System Integration

3.8.5.2.31 Separate Input Devices for Displays

ES-0304-1381-11068

Guideline: When control of the large- and individual-view display devices is performed by separate input devices, their design should support coordinated use.

HSI Design Criteria

NuScale GVD’s display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.2

3.8.5.2.32 Mode Switch

ES-0304-1381-11070

Guideline: When a mode switch is provided to transfer input control between the large- and individual-view display devices, protection should be provided to prevent input from being entered into the wrong display.

HSI Design Criteria

NuScale GVD’s will not have a control switch.

Reference: NUREG-0700-6.2

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3.8.5.2.33 Cursor Motion

ES-0304-1381-11072

Guideline: If a cursor motion is used to transfer input control between the large- and individual-view display devices, then the movement between the displays should be smooth and contiguous.

HSI Design Criteria

NuScale GVD's will not have a cursor.

Reference: NUREG-0700-6.2

3.8.5.2.34 Compensating for Different Screen Sizes and Shapes

ES-0304-1381-11074

Guideline: If a cursor motion is used to transfer input control between the large- and individual-view display devices of different size and shape, then features should be incorporated to make their spatial relationships clear to the user.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.2

3.8.5.2.35 Indicating Active Display

ES-0304-1381-11076

Requirement: When using the group-view display, the user should receive a clear indication that the display is active.

HSI Design Criteria

Because the GVD will be a standalone operator aid the technique used to ensure that the information is updating (or active) is the same "Heart Beat" indication used on the operator HSI stations as discussed in ES-0304-1381-7959.

Reference: NUREG-0700-6.2

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3.8.5.2.36 Processing Information to Match User Requirements

ES-0304-1381-11078

Guideline: The information associated with selectable items of the group-view display item should be processed to match each user's task requirements when this processing would reduce distracting and unnecessary information and enhance operator performance.

HSI Design Criteria

Operators of a NuScale Power Plant will not be performing any action via the GVD's.

Reference: NUREG-0700-6.2

3.8.5.2.37 Shared Cursors

ES-0304-1381-11080

Guideline: When multiple users must share a single cursor for interaction with the group-view display, features should be provided to manage access to the cursor and indicate current ownership.

HSI Design Criteria

NuScale GVD’s will not have a cursor.

Reference: NUREG-0700-6.2

3.8.5.2.38 Multiple Individual Cursors

ES-0304-1381-11082

Guideline: When multiple users operate individual cursors for interaction with the group-view display, a coding scheme should be provided so the users can readily identify their own cursors and identify the users of the other cursors.

HSI Design Criteria

NuScale GVD’s will not have a cursor.

Reference: NUREG-0700-6.2

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3.8.5.2.39 Shared Window

ES-0304-1381-11084

Guideline: If the communication/collaboration function is performed by presenting information on a shared window of the group-view display, features should be incorporated to prevent new information from obscuring old information.

Additional Information: One approach to performing the communication/collaboration function is to allow users to create representations of ideas, problems, or tasks using an individual-view display and then present it to others using a window of the group-view display. A possible problem with this approach is the possible duplication of information as multiple users present slightly different versions of the same idea. This restricts the amount of information that can be added to the group-view display and adds potentially distracting clutter. A decluttering function is needed that prevents inputted windows from obscuring each other and eliminates older windows. If the decluttering function is performed manually, it becomes a user-system interaction task that may compete with other operator tasks. If the decluttering function is performed automatically then the users may have to expend cognitive resources to locate their input when it is automatically positioned on the group-view display and adjust to changes if the decluttering function automatically removes or repositions information that is already on the group-view display. The automatic decluttering function should use techniques such as animation to help users maintain an awareness of how the content of the group-view display has changed.

HSI Design Criteria

NuScale GVD’s will not have a shared screen.

Reference: NUREG-0700-6.2

Devices

3.8.5.2.40 Selection of Group-View Display Devices

ES-0304-1381-11086

Guideline: The selection of display hardware for group-view displays should consider such factors as the user's need for immediate access to the group-view display, user's need to view the group-view display from multiple locations in the control room, ability of users to leave their usual work areas, and the type of interaction that occurs between users when viewing the displayed information.

Additional Information: The group-view display function may be implemented using a variety of display hardware. Three alternatives that are relevant to NPP control room applications are:

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- Large-screen display – Large display devices that are usually centrally located and viewable from
- many parts of the control room.
- Individual, redundant displays – Display devices located throughout the control room in areas where operators often work.
- Walkup display – This is a smaller display device that is not located the operators' immediate work area. Operators must walk to it from their usual workstations. For example, in conventional control rooms some computer-based display devices are not located in each operator's immediate work area, but are located within a convenient walking distance. If this option is selected, the display device should be within the area defined as "at the controls" by the plant's safety analysis report and technical specifications.

HSI Design Criteria

NuScale GVD's will be selected in the same manner as all of the VDU's.

Reference: NUREG-0700-6.3.1

ES-0304-1381-19714

Guideline: Four factors that should influence the selection of the display device include:

- Need for access to the group-view display – Does the nature of the operators' tasks require them to have immediate access to the group-view display?
- Need to view the group-view display from multiple locations in the control room – Can operator performance be enhanced by viewing the group-view display information from multiple, fixed locations in the control room or while walking around the control room?
- Ability to leave usual work area to go to a walkup display – Does the nature of the operators' tasks confine them to specific locations in the control room when the group-view display may be needed?
- Type of crew interaction required – Does the use of information presented on the group-view display involve independent actions of operators, verbal communication between operators, or both verbal communication and gesturing.

HSI Design Criteria

NuScale GVD's will be selected in the same manner as all of the VDU's.

Reference: NUREG-0700-6.3.1

ES-0304-1381-19713

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Guideline: Table 3-26 shows conditions under which each of the two display devices types are desirable based on these factors. A tradeoff exists between (1) the ability to use natural gesturing and (2) the other considerations such as immediate access, viewing from multiple control room locations, and ability to remain at one's usual work area. The walk-up display allows natural verbal communication with gesturing, but requires operators to gather around it. The large-screen display and redundant, small screen displays provide immediate access from each operator's work area, but the operators may be physically separated. Thus, operators may not be able to communicate using pointing and other gestures unless this capability is provided by computer-supported tools. Evaluating the acceptability of these alternatives involves consideration of the amount of time required to complete an interaction and the quality of the interaction. For example, individual interactions using computer-based tools may require more time compared to natural interactions but the computer-based interactions may be more informative and beneficial to crew performance because ideas can be expressed with more visual detail. Finally, when comparing the relative benefits of large-screen displays to redundant smaller displays, one should consider other factors such as (1) the adequacy of space for these devices and (2) the flexibility that the large-screen display provides for viewing the group-view display from multiple locations in the control room compared to the redundant smaller displays which have more restricted viewing areas.

HSI Design Criteria

NuScale GVD’s will be selected in the same manner as all of the VDU’s.

Reference: NUREG-0700-6.3.1

Table 3-26. Appropriate use of group-view display devices

DISPLAY DEVICE	APPROPRIATE USE*
Large-screen displays and redundant, small-screen displays	Immediate access is required Operator must be able to view information from multiple locations in the CR Operator often cannot leave usual work area to go to a walkup display Crew interaction requirements (e.g., verbal, gesturing) are low, or computer- based communication is provided
Walk-up display	Immediate access is not required Operator does not need to view information from multiple locations in the CR Operator can leave work area to go to a walkup display

* Conditions when device is preferred.

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3.8.5.2.41 Maximum Viewing Distance

ES-0304-1381-11102

Guideline: The determination of the maximum viewing distance on a large-screen display should be based on an analysis of the information requirements of individuals and their locations in the work area.

Additional Information: Users should be able to resolve all important display detail at the maximum viewing position. Application of this criterion should consider the types of information contained in the group-view display, the ways in which this information is used by individuals, and the locations of these individuals relative to the display. For example, supervisors may only need to read high-level indications from their workstations while operators may need to read more detailed information. Evaluations that use this criterion should consider the reading/viewing requirements of personnel who may be seated at the greatest distance from the large-screen display. Considerations include: (1) do the individuals need to resolve all details or merely be able to detect changes that require additional scrutiny, and (2) will some or all or the large-screen display information be available on separate displays located closer to these individuals.

HSI Design Criteria

Appendix A contains the sizing information for items displayed on the GVD.

Reference: NUREG-0700-6.3.2

3.8.5.2.42 Minimum Viewing Distance

ES-0304-1381-11104

Guideline: The display should not be closer to any observer than half the display width or height, whichever is greater.

HSI Design Criteria

Appendix A contains the sizing information for items displayed on the GVD.

Reference: NUREG-0700-6.3.2

3.8.5.2.43 Off-Centerline Viewing Angle

ES-0304-1381-11106

Guideline: The determination of the acceptability of off-centerline viewing should take into account both the spatial distortion of the image and the effect of the viewing angle upon screen characteristics such as brightness and color rendition.

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Additional Information: Individual viewers in a fixed location should be no more than 10 degrees off the centerline. For multiple viewers, it indicates a preferred limit of 20 degrees and an acceptable limit of 30 degrees off the centerline. This guideline addresses spatial distortion of the displayed image due to the viewing angle. However, off-centerline viewing of large-screen display devices may also result in (1) loss of general brightness for high-gain screens, and (2) loss of color rendition in projection-type devices due to the angles of reflection of the separate projection elements. Loss of general brightness for high-gain screens is usually not a problem until off-centerline viewing exceeds 25 degrees for beaded screens and 30 degrees for high-gain metallic screens. These effects may further reduce perceived resolution by reducing the effectiveness of color codes and image contrast. Thus, the combined effects of off-centerline viewing upon image distortion and screen characteristics should be considered.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.3.2

3.8.5.2.44 Viewing of Multiple Display Devices

ES-0304-1381-11108

Guideline: When multiple, large display devices are used, the normal work areas of each user should be within the acceptable off-centerline viewing area of each large display that each user must view.

Additional Information: If the large display devices are adjacent to each other, they should be angled toward each other so the acceptable off-centerline viewing areas of the displays overlap. If the operators' tasks require them to work at multiple locations in the control room, the acceptable viewing area should be maximized by angling the display surfaces toward each other so that the acceptable off-centerline viewing areas of each display device coincide to the greatest extent possible.

HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.3.2

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3.8.5.2.45 Unobstructed View

ES-0304-1381-11110

Guideline: Seating areas should be arranged to provide critical observers with unobstructed views of the display.

Additional Information: Large screen displays should be located relative to critical observers so that the view is not obscured by other people. There are two methods for achieving this: (1) laterally staggering (off-setting) personnel and consoles to maintain an unobstructed view and (2) elevating the line of sight of personnel (e.g., supervisors) who are located farther from the display so they may see over the heads of personnel located closer to the display. The line of sight may be elevated by using raised or inclined floors or by raising the height of the screen.

HSI Design Criteria

The MCR layout will be done in such a way as to not obstruct any users of the GVD's view.

Reference: NUREG-0700-6.3.2

3.8.5.2.46 Externally Illuminated Displays

ES-0304-1381-11112

Guideline: Externally illuminated displays should have adequate illumination.

Additional Information: Large displays that are primarily illuminated by external sources, such as static mimics, should satisfy the criteria for illumination, uniformity, task area illumination, shadowing, glare, reflectance, and color. The level of illumination should provide adequate contrast to allow users to resolve all important displayed details at the maximum viewing distance.

HSI Design Criteria

NuScale will not use externally illuminated displays.

Reference: NUREG-0700-6.3.2

3.8.5.2.47 Group-View Display Text Size

ES-0304-1381-11116

Requirement: The size of text for labels and detailed information should be based on analyses of the maximum viewing distances of personnel.

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Additional Information: The height of letters and numerals should typically not subtend less than 15 minutes of visual angle as measured at the maximum viewing distance. However, the maximum viewing distance may be different for different types of information in the display. For example, labels and high-level status indications may require larger viewing distances (e.g., across the control room) while individual parameter values may require shorter viewing distances (e.g., must be legible from panels that contain the corresponding controls). Therefore, the determination of acceptable text size should consider the type of information and the context in which it will be used.

HSI Design Criteria

All NuScale HSI Display Pages will follow the guidance found in Appendix A for the sizing of text.

Reference: NUREG-0700-6.3.2

3.8.5.2.48 Use of Labels

ES-0304-1381-11118

Requirement: The presence of labels should not cause excessive clutter or detract from detailed information.

HSI Design Criteria

All NuScale HSI Display Pages will follow the guidance found in Appendix A for the sizing of text.

Reference: NUREG-0700-6.3.2

3.8.5.2.49 Use of Information Displays Developed for Standard Video Display Units (VDUs)

ES-0304-1381-11120

Guideline: Displays developed for standard VDUs should not be presented on large-screen display systems without first being evaluated for acceptability.

Additional Information: Large-screen display devices tend to have lower brightness and resolution than standard VDUs and are susceptible to glare from ambient light sources. This may result in reduced legibility and reduced effectiveness of color coding schemes. Text, graphics, and color codes should be reviewed and adjusted to suit the characteristics of the particular display device.

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HSI Design Criteria

NuScale GVD's display page will supply all of the information needed by the operators in the same format used to design the support pages available on the MCR workstations and SDI panels.

Reference: NUREG-0700-6.3.2

3.8.6 System Response

3.8.6.1 Requirements and Guidelines

3.8.6.1.1 Prompting User Entries

ES-0304-1381-9546

Guideline: Users should be provided with clear and specific information to guide entries during logon/logoff or command or information entry.

Additional Information: Prompts may be incorporated in a display and/or provided in response to requests for HELP. Where six or fewer control options exist, they should be listed. Where more input options exist, an example of the type of entry that is required should be presented. If a default value has been defined for null entry, that value should be included in the prompting information.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

The HFE design team will also ensure that the system response of the individual control systems satisfies the operator's tasks by reviewing the system design document.

Reference: NUREG-0700-2.4.1

3.8.6.1.2 Response Time Consistent with Requirements

ES-0304-1381-9578

Guideline: System response times should be consistent with operational requirements.

Additional Information: Required user response times should be compatible with required system response time. Required user response times should be within the limits imposed by total user tasking expected in the operational environment.

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HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

The HFE design team will also ensure that the system response of the individual control systems satisfies the operator's tasks by reviewing the system design document.

Reference: NUREG-0700-2.4.3

3.8.6.1.3 Feedback During Data Entry

ES-0304-1381-9564

Guideline: Feedback should be displayed for all user actions during data entry; keyed entries should be displayed stroke by stroke.

Additional Information: For reasons of data protection, it may not be desirable to display passwords and other secure entries.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

The HFE design team will also ensure that the system response of the individual control systems satisfies the operator's tasks by reviewing the system design document.

Reference: NUREG-0700-2.4.2

3.8.6.1.4 Feedback for Completion of Data Entry

ES-0304-1381-9566

Guideline: The computer should acknowledge completion of a data entry transaction with a confirmation message if data entry was successful, or else with an error message.

Additional Information: Successful data entry should not be signaled merely by automatic erasure of entered data from the display, except possibly in the case of repetitive data entries. For single data entry transactions, it may be better if entered data is left on the display until the user takes an explicit action to clear the display.

HSI Design Criteria

NuScale will provide the appropriate guidance to the design team via the Appendices as needed.

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The HFE design team will also ensure that the system response of the individual control systems satisfies the operator's tasks by reviewing the system design document.

Reference: NUREG-0700-2.4.2.

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3.9 Automation

To balance the workload demands of operating 12 units in a single control room and to provide consistent, repeatable task performance, a large amount of automation is being considered for the NuScale design. There are benefits and pitfalls encountered when adding automation to processes that have been traditionally manual. Recognizing the potential pitfalls will provide the subject matter experts with the tools to appropriately determine if automation will be used and which level would best meet the desired goal.

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3.9.1 Definitions

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3.9.2 Requirements

3.9.2.1 Hierarchal Access to Information

Information should be presented hierarchally, enabling operators to determine the overall status of automation from top-level displays, and to access more detailed information on lower level displays.

Information hierarchies are a means whereby operators can monitor automation's status at a glance, and also obtain progressively more detailed information to support their situation assessment of automation and troubleshooting. The displays should contain navigation aids to enable users to quickly and easily move from higher-level displays to lower-level displays in the hierarchy.

Human-system Interfaces to Automation Systems: Review Guidance and Technical Basis, Part 2, 8.1.1-1, NUREG-0700, Section 2.5.1.

3.9.2.2 Use of Graphical Features for Status-at-a-glance Functionality

The detailed design of the HSIs to automation should ensure status-at-a-glance functionality.

Display features supporting status-at-a-glance functionality enable operators to assess automation's performance with minimal workload. This functionality is supported by display considerations, such as representational mapping, maximum use of integral- and configural-displays, and inclusion of graphical features, that required little interpretation.

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3.10 Plant Maintenance and Work Management

This section was added as a place holder for future efforts.

This is an area of coordination concern with in an operating plant that the NuScale NSIDE software may be able to help address through the Process Library or some other yet to be developed interface application.

3.10.1 Definitions

Some items to be defined here:

1. Work Requests
2. Workflow Efficiency
3. Work Orders
4. On-Time Work Completion
5. Work Progress
6. Improve Safety Procedures

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4.0 Volume III

4.1 Boron Addition System (BAS) - B011

4.1.1 System Function

The boron addition system mixes, stores, and supplies borated water to the CVCS and spent fuel pool cooling system.

The boron addition system major components include:

- Batch tank with mixer
- Transfer pump
- Storage tank
- Two supply pumps

4.1.2 Display Page

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Figure 4-1. 00-BAS-BAS-Overview

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4.2 Backup Power Supply System (BPSS) - D060

4.2.1 System Function

The principal function of the backup power supply system (BPSS) is to provide electrical power to the NuScale plant when AC power is not available from the normal operating sources, such as during a loss of offsite power (LOOP) concurrent with all turbine-generators tripped.

Two backup diesel generating sets, including all required support systems, are available to provide power to the alternate feed terminals of the B-6000 motor control centers (MCCs) in the low voltage ac electrical distribution system (ELV). This power is specifically provided for nonsafety-related, risk significant loads to use in the post-72 hour period of a station blackout (SBO), but may be available for use prior to the 72 hour point. The backup diesel generators (BDGs) will automatically start at the initiation of an SBO by sensing the loss of all 13.8 kV to the 13.8 KV and SWYD (EHV) system buses. This provides additional flexibility to the control room operators for responding to an SBO.

One auxiliary ac power source (AAPS), including all required support systems, is available to provide power to the 13.8 kV portion of the EHV system. The AAPS may be any type of ac power source as long as the sizing and capability requirements are met. The power provided will be used for nonsafety-related, not risk significant loads.

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Figure 4-2. 00-Electrical-BPSS-CTG

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4.3 Containment Flooding and Drain System (CFDS) - B191

4.3.1 System Function

The CFDS is a nonsafety system which is shared among multiple RXMs. For a 12-module plant there are two independent CFDS subsystems, 6A and 6B, each servicing six RXMs. The design consists of two 100% capacity pumps to service six RXMs. The CFDS is only used after shutdown and prior to startup of a RXM; therefore the system is designed to service only a single RXM at a given time.

4.3.2 Display Page

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Figure 4-3. YY-Containment-CFD-Overview

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4.4 Chemical and Volume Control System (CVCS) - B010

4.4.1 System Function

The CVC system consists of pumps, valves, heat exchangers, a mixing tank, demineralizers, filters, and a module startup heater. During normal operation, the CVCS recirculates a portion of the reactor coolant through demineralizers to maintain coolant cleanliness and chemistry. A portion of the recirculated coolant is used to supply pressurizer sprays to control reactor pressure.

Reactor coolant inventory is controlled by injection of additional water when reactor coolant levels are low or letdown of reactor coolant to the liquid radioactive waste system when coolant inventory is high. During the startup process, the CVCS will be used to add heat to the reactor coolant to establish natural circulation flow in the reactor coolant system.

Boron concentration in the reactor coolant system is controlled by a feed-and-bleed process. Injection pumps provide borated water or clean demineralized water that is delivered into the reactor vessel to maintain the desired boron concentration. The excess coolant is letdown to the radioactive waste system.

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4.4.2 Display Page

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Figure 4-4. Chemical and Volume Control-CVC-CVC Overview

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Figure 4-5. Chemical and Volume Control-CVC-CVC Demins

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4.5 Circulating Water System (CWS) - C090

4.5.1 System Function

The circulating water system (CWS) consists of two subsystems. Each subsystem includes three 33 percent capacity pumps supplying six condensers, a 14 cell cooling tower, 14 cooling tower fans, a cooling tower basin, a chemical injection system, makeup and blow-down piping and all associated CW piping, valves, and fittings. A 12 unit plant will have two CWS.

The principle function of the CWS is to condense turbine exhaust steam/turbine bypass steam and reject the heat to the environment.

During normal operation, the CWS provides a continuous supply of cooling water to the plant turbine condensers. Heat from up to six condensers in one turbine building is returned to a mechanical draft cooling tower. The cooled circulating water collects in a common basin where it supplies the circulating water pumps, returning the cooled water to the condensers.

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4.5.2 Display Page

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Figure 4-6. YY-CW-CW-Overview

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4.6 Highly Reliable DC Power System (EDS) - D040

4.6.1 System Function

The principal functions of the Highly reliable DC power system (EDS) is to provide continuous and reliable power to SSCs, specifically:

- Provide redundant and reliable power to loads for Engineered Safety Features and reactor trip.
- Provide redundant and reliable power for load needed for post-accident monitoring.

  EDS is comprised of two DC subsystems

  - the module-specific subsystem
  - the common plant subsystem

The module-specific subsystem contains four power channels for each module.

Power channels A and C are a part of EDS Division I, and power channels B and D are a part of EDS division II.

Each power channel contains two batteries, two battery chargers, and one DC bus.

Each power channel provides power to one module protection system (MPS) separation group, A, B, C, or D.

During normal operations, the EDS battery chargers receive power from the low voltage ac electrical distribution system (ELVS). One backup diesel generator from the backup power supply system (BPSS) provides power to power channels A and C battery chargers in Division I. A redundant backup diesel generator from BPSS provides power to power channels B and D battery chargers in division II.

Each power channel contains the ability to receive power from a portable generator should the batteries and the BPSS DGs fail.

The common plant subsystem contains two divisions; EDS Division I and EDS Division II.

Each common plant subsystem division contains two batteries, two battery chargers, and one DC bus.

During normal operations, the EDS common plant subsystem battery chargers receive power from the ELV. The backup diesel generator from BPSS provides power to division I battery chargers. A redundant backup diesel generator from BPSS system provides power to Division II battery chargers.

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Each power channel contains the ability to receive power from a portable generator should the batteries and the BPSS DGs fail.

4.6.2 Display Page

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Figure 4-7. 00-Electrical-EDS-Electrical Bus Overview

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4.7 Condensate and Feedwater (FW) System - C020

4.7.1 System Function

The condensate and feedwater system consists of a main condenser, a condensate polishing system, a gland steam condenser, condensate pumps, feedwater pumps, valves, and feedwater heaters.

During normal operation, the condensate and feedwater system collects the condensed exhaust steam of the turbine generator and delivers the water to the steam generators. The water is sent through the condensate demineralizers to purify the water and to the gland steam condenser. The water is then heated in the three feedwater heaters by turbine extraction steam.

The pressure of the water is increased by the feedwater pumps. Flow of water to the steam generators is controlled by the feedwater regulating valves at low power level, and feedwater pump speed at higher power level to maintain steam generator inventory.

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4.7.2 Display Page

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Figure 4-8. Condensate and Feed Water Display Page

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4.8 Main Steam (MS) System - C010

4.8.1 System Function

The Main Steam (MS) system consists of MSIVs, MSIV bypass valves, atmospheric dump valve (ADV), turbine bypass valves, turbine bypass valve desuperheater, extraction steam valves, extraction steam dump valves, and piping.

During normal operation, the main steam system is pressurized and supplies steam to the turbine-generator, atmospheric dump valve, turbine bypass valves, extraction steam to three feedwater heaters, turbine gland steam system, and secondary sampling system,. The MSIVs and MSIV bypass valves are containment isolation valves for the main steam system.

4.8.2 Display Page

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Figure 4-9. Steam-MS-Overview

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4.9 Reactor Component Cooling Water System (RCCWS) - B200

4.9.1 System Function

The RCCWS is a cooling system that removes heat from potentially radioactive nonsafety heat loads. The only safety function is to provide isolation of the system penetrations into the containment vessel.

There are two independent RCCWS subsystems, 6A and 6B, each servicing six modules. Each subsystem consists of three 50 percent capacity pumps and two 100 percent capacity heat exchangers to service six modules. During normal plant operation the system is continuously operating with two pumps and one heat exchanger in service. The remaining pump and heat exchanger are in standby.

4.9.2 Display Page

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Figure 4-10. XX-Unit RCCW-RCCW-Overview

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4.10 Reactor Module (RXM) System - A010

4.10.1 System Function

The reactor module (RXM) system is a collection of systems, sub-systems, and components that together constitute a modularized, moveable, nuclear steam supply system (NSSS).

The RXM system is made up of the containment system (CNT), reactor coolant system (RCS), and the reactor system (RXS).

The containment system (CNT) is comprised of the containment vessel (CNV) and containment isolation valves.

The reactor coolant system (RCS) is comprised of the reactor coolant, pressurizer (PZR), reactor safety valves (RSV), reactor coolant instrumentation, reactor vessel internals (RVI), steam generators (SG), and reactor pressure vessel (RPV).

The reactor system (RXS) consists of the reactor core (RXC) system and the control rod drive system (CRDS).

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4.10.2 Display Page

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Figure 4-11. Reactor Module (RXM) - A010

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4.11 Safety Display and Indication (SDI) System – E014

4.11.1 System Function

The information provided to the operator by the SDI consists of:

- MPS and PPS accident monitoring parameter values and set points
- MPS, PPS, and SDI equipment status
- MPS and PPS actuation device status

Each module has two independent displays for a total of 24 with two additional displays for the common plant systems.

The operator will use the SDI for validation that a protective action has gone to completion and that the modules are being maintained in a safe condition. Because the SDI does not perform any actions, the operators will use the SDI to aid in decision making regarding plant operations.

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4.11.2 Display Pages

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Figure 4-12. Safety Display and Indication (SDI) – E014

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4.12 Unit Group View Display (GVD)

4.12.1 Page Function

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4.12.2 Display Page

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Figure 4-13. Unit Group View Display (GVD)

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4.13 12 Unit Overview

4.13.1 Page Function

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4.13.2 Display Page

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Figure 4-14. 12 Unit Overview

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4.14 Safety Function Monitoring Page

4.14.1 Page Function

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4.14.2 Display Page

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Figure 4-15. Safety Function Monitoring Page

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4.15 12 Unit Navigation

4.15.1 Page Function

This page was developed to create a secondary method to quickly access any of the 12 unit's pages.

4.15.2 Display Page

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Figure 4-16. 12 Unit Navigation

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4.16 Plant Notifications Overview

4.16.1 Page Function

This page was developed to give the operators a single location to access plant wide notifications. The notifications can be sorted by plant and type. Notification functionality such as acknowledgement and silencing of alarms as well as directly accessing applicable alarm procedures can be performed on this display.

4.16.2 Display Page

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Figure 4-17. Plant Notifications Overview Page

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4.17 Plant Overview

4.17.1 Page Function

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4.17.2 Display Page

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Figure 4-18. Plant Overview Page

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4.18 Process Library

4.18.1 Page Function

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4.18.2 Display Page

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Figure 4-19. Process Library Page

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4.19 Single Unit Tile Navigation

4.19.1 Page Function

This page was developed to allow the operators a secondary means of navigating to a specific unit's display pages. It provides a single display of all the pages grouped by unit, common, or six unit shared systems.

4.19.2 Display Page

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Figure 4-20. Single Unit Tile Navigation Page

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5.0 HSI Design Appendices

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Appendix A. Language and Text

A.1 Purpose

This appendix contains the requirements and guidelines for display and entry of text and numeric information in NuScale HSIs. In this context, text refers to the main body of printed or written matter on a page or in a message. In word processing applications, text consists of alphanumeric character strings in linear arrays, making up words, sentences, and paragraphs. Text is often the most explicit way for an interface to convey information without user error. However, it is also one of the slowest ways to transmit information.

A.2 High Level Rules:

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Table A-1 Text size and color

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Table A-2 Font color examples

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Appendix B. Color Usage

B.1 Purpose

This appendix contains the requirements and guidelines for display and use of colors in NuScale HSIs. Colors may be used for multiple purposes provided they are not used to show diversely opposing visual cues (e.g. green for both on and off condition). Color is often used to enhance the way an interface conveys information due to its ability to quickly assess information.

B.2 High Level Rules:

1. Display pages are the interface between the operator and the control system. It is important to choose an appropriate color and design for control of the plant and even more crucial to choose the appropriate color schemes to convey images and messages.

2. Color is a central part of the display page design and as such its use needs to take into account the way operators react to different colors, tints, and shades. The HSI designers will incorporate color into the display page to capture the operators' attention and cause them to react based on the basic rules of color theory and the functions of color.

The HSI designers used the guidelines in Volume II to develop the color palette used in the NuScale HSI display pages as shown below.

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Table B-1 Color Chart

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Appendix C. User Interfaces

C.1 Purpose

This appendix contains the requirements and guidelines for the display of icons and other user interfaces in NuScale HSIs. In this context, user interfaces refers to elements on the HSI that the user interacts with either physically (via touch or mouse) or just visually (e.g. a chevron or bar graph). Icons are an extremely effective way for an interface to convey information without the use of text. However, when used in conjunction with text it is also one of the quickest ways to transmit information and prevent errors.

C.2 High Level Rules:

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NOTE: Icons that have to show a state such as pumps, valves and fans will use a common universally accepted symbol for consistency in look and feel and most importantly behavior.

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Figure C-1. Icon Library

NOTE II: The icons shown were developed exclusively for the NuScale HSI. Any use could result in copy right infringements

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Figure C-2. Chevron icon

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Figure C-3. Valve icon in various status conditions

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Figure C-4. Pump icon in ON and OFF status

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Figure C-5. Quick key icons located on the bottom of the window template

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Figure C-6. Alarm icon

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Figure C-7. Caution icon

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Figure C-8. Notice icon

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Figure C-9. RXM icon

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Figure C-10. Breadcrumb navigation icons

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Figure C-11. Heartbeat icon

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Appendix D. Display Page Design

D.1 Purpose

The NuScale HSI design incorporated pertinent design considerations based on accepted HFE principles and industry standards. In addition, the design incorporated high-level design considerations identified during preliminary analyses such as; maintaining situational awareness with a highly automated system and acceptable workload levels with multiple modules assigned to a single operator.

Within the HSI design process; there were common design elements that drove the entire architecture and usability of the user interface. The elements below are discussed in detail in subsequent subsections.

- Survey of state-of-the-art in HSI technologies
- Develop an HSI global layout and navigation schema
- Develop notification schema
- Develop procedures
- Develop automated process

D.2 High Level Rules:

Within the HSI design process, there were common design elements that drove the entire architecture and usability of the user interface.

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Figure D-1. Window template

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Appendix E. Plant Notifications

Plant notifications are a vital piece of this design. It aids the control room staff in understanding the current plant status without overwhelming or distracting the operators from performing their duties.

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E.1 Functional Specifications

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E.2 Tiered System

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Figure E-1. NuScale notification system alarm, caution and notice icons

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Figure E-2. Example of a NuScale icon status indicators

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Appendix F. Safety Display and Indication System

The NuScale HSI design addresses the 10 CFR 50.34(f)(2)(iv) requirement to provide a plant safety parameter display console that will display to operators a minimum set of parameters defining the safety status of the plant, capable of displaying a full range of important plant parameters and data trends on demand, and capable of indicating when process limits are being approached or exceeded as discussed below.

The NuScale PRA, Safety Analysis, and Plant Operations Groups considering the guidance of NUREG-1342 determined the critical safety functions. The selection of the variable type (A, B, C, D, or E) was performed. The minimum set of parameters chosen for display are available on the SDCV SDI display panel for each unit and Division in the MCR.

Note: There are no Type A variables in the NuScale plant design. There are no Type E variables shown on the SDI display page.

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Figure F-1. SDI display pages

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Note: The table below is a partial list of what appears on the SDI display page.

Table F-1 SDI partial display page inventory

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The HFE design team ensured that the HSI process and the resulting products addressed the following important MCR considerations:

1. Safety Display and Indication Console

   The NuScale PRA, Safety Analysis, and Plant Operations groups considering the guidance of NUREG-1342 determined the critical safety functions. The selection of the variable type (A, B, C, D, or E) was performed. The minimum set of parameters chosen for display are available on the SDCV SDI display panel for each unit in the MCR.

   Note: There are no Type A variables in the NuScale plant design or E variables shown on the SDI HSI.

   The NuScale HSI design addresses the 10 CFR 50.34(f)(2)(iv) requirement to provide a plant safety SDI console that will display to operators a minimum set of parameters defining the safety status of the plant, capable of displaying a full range of important plant parameters and data trends on demand, and capable of indicating when process limits are being approached or exceeded as discussed below.

   The SDI bank of SDCV video display units provides redundant, highly reliable indications of plant conditions provided by the MPS and PPS networks. Operators rely on these indications to give them the status of the plant during normal operations and for 72 hours after a loss of normal power. Additionally, the MPS and PPS provide information to the MCS and PCS, respectively, via unidirectional communication paths. The PCS and MCS communicate with each other via bi-directional communication paths.

   Each SDI VDU will provide one display page that covers all five modes of operation. This is appropriate based on the plant's simple, passive design where all required information can be displayed on a single HSI page. This approach allows for a more simplistic SDI implementation and provides the operators with consistent display page behavior across all SDI VDU's.

   The organization of information (e.g., grouping) of related data is important for supporting prompt recognition and comprehension of plant status. The information presented by the SDI includes parameters and indications of functions important to plant safety. Important presentation characteristics include the conciseness of the display format, the arrangement of information, the range of conditions displayed, the display system's response to transient and accident conditions, the data sampling rate, the display's accuracy, the continuous presentation of information, the visibility of displayed data, limit marks for variables, and the indication of magnitudes and trends for variables. Some of the more important SDI display page requirements are listed below:

   - The SDI display page parameters accuracy and update sampling rates will be consistent with the MPS/PPS system that drives them.

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- The SDI display page will provide visual cues for the initiation and completion of a safety function by highlighting a reserved area on the display page indicating the current status of that function. Each safety function has its own status area reserved on the display page.

- The SDI display page will utilize the trending feature to a set of predetermined parameters to help the operators maintain attention to slow and rapidly changing variables.

- The SDI display page trends will be appropriately scaled to the magnitudes of the variables in 5-10 divisions based on the parameter(s) being displayed. The trends will be designed to provide the adequate space for scaling. All trend areas will have a 30 min data display requirement with no auto-ranging capability.

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Figure F-2. SDI Panel

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Appendix G. HFE Design

When performing workplace or workstation design for control rooms or LCSs in a NuScale plant, the NuScale HFE design team should follow the guidance provided in Section 3.6 and 3.7 and provide any appropriate design considerations/decisions below.

This Appendix is meant to capture applicable HFE design considerations for NuScale designed location and is not meant to replace any system or detailed design documents needed by the owners of those locations.

G.1 Vendor provided LCSs and control room locations using the requirements and guidelines found in this document will be included below.Workstation Configuration

HSI elements are organized into workstations, where the operators perform their functions and tasks. Types of workstations include sit-stand workstations, stand-up consoles, sit-down consoles, vertical panels, and desks (e.g., used by personnel when performing tasks related to the operation and safety of the plant in the main control room). The operators' performance may be affected by design characteristics that affect reach, vision, and comfort. Unique considerations for these types of workstations include the following:

- workstation height (i.e., for workstations that the operator must see over)
- benchboard slope, angle, and depth for consoles and sit-stand workstations (i.e., accommodations for reach; provision of writing space)
- control device location (i.e., placement of highest and lowest controls; distance from front edge of workstation)
- display device location (i.e., placement of highest and lowest display devices, orientation relative to line of sight, viewing distance, position of frequently and infrequently monitored display devices)
- lateral spread of control and display devices at a console or workstation
- clearances for legs and feet

In addition, the workstation design includes the seating provided for personnel at the consoles or desks. Important considerations include mobility; rests for back, arms, and feet; seat adjustability, and cushioning. Review guidelines for workstation configuration are provided as follows: stand-up consoles in Section 3.6.2.1, sit-down consoles in Section 3.6.2.2, sit-stand workstations in Section 3.6.2.3, vertical panels in Section 3.6.2.4, desks in Section 3.6.2.5, and chairs in Section 3.6.2.6.

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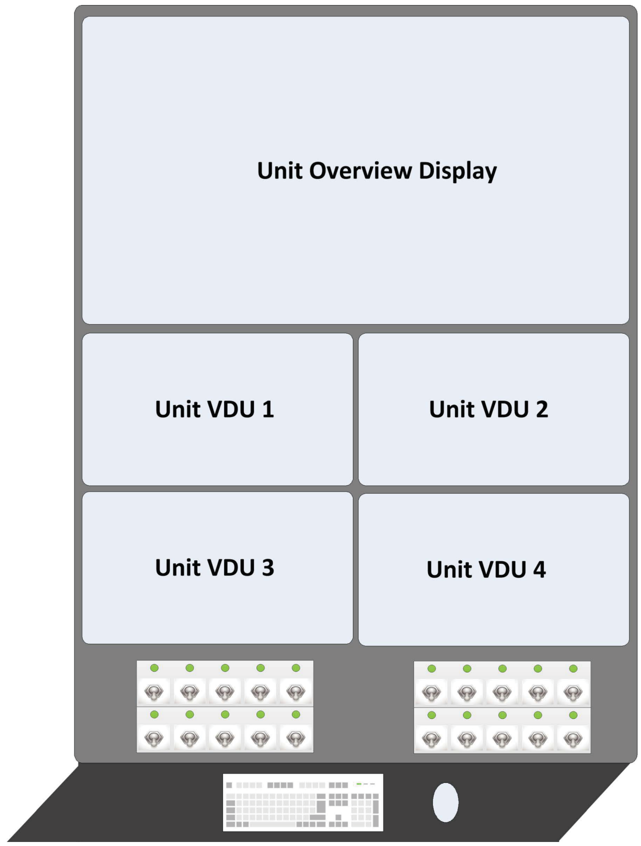

Figure G-1. Stand-up workstation

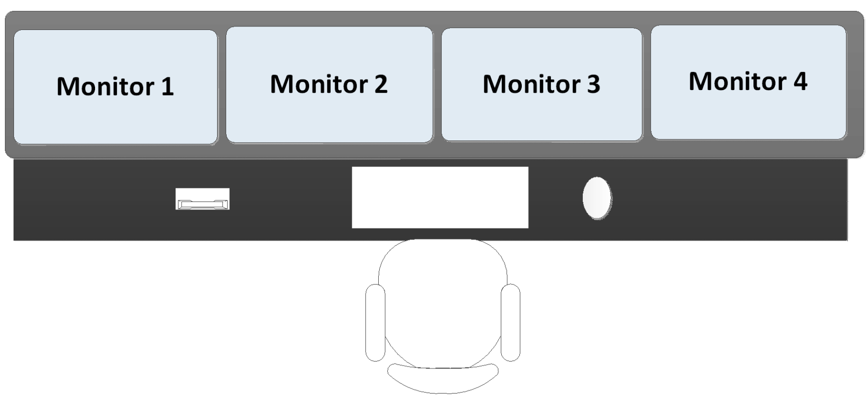

Figure G-2. Sit-down workstation

G.2 Control Room Configuration

Control room configuration refers to the overall layout and arrangement of the control room; it comprises the following factors.

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G.3 Accessibility of Instrumentation/Equipment

Accessibility refers to the ease with which control room personnel can gain access to needed instrumentation and equipment. Any instrumentation and equipment needed by control room personnel for detecting abnormal conditions and shutting down the plant, but which are not located inside the control room, should be identified. Similarly, the controls and displays required for continuous monitoring and the timing of control actions that are not located in the primary operating area of the control room should be identified. Review guidelines are provided in Section 3.7.2.1.

G.4 Consistency of Staffing with Equipment Layout

This refers to factors that may affect the adequacy of personnel staffing levels, including: the ability of control room personnel to monitor and operate all necessary controls, displays, and other equipment during all modes of plant operation (e.g., consistency of the control room layout with staffing levels and task assignments); the ability of additional onsite or offsite personnel to augment the normal crew complement under certain unusual conditions, such as refueling (e.g., consistency of control room layout with anticipated activities and task assignments); the ability to limit access and movement of nonessential but authorized personnel to prescribed areas within the control room (e.g., adequate designations of prescribed areas; doors, gates, and other physical barriers). Review guidelines are provided in Section 3.7.2.1.

G.5 Furniture, Instrumentation and Equipment Layout

The arrangement of furniture, instrumentation, and equipment in the control room that might affect the operators' requirements for viewing, communication, accessibility, and movement are provided in Section 3.7.2.1.

G.6 Document Organization and Storage

Review guidelines are provided in Section 3.7.2.2 for the availability, storage, and accessibility of procedures and other documents needed for ready reference.

G.7 Supervisor Access

The accessibility of the shift manager's office by walking and communication links is addressed by review guidelines in Section 3.7.2.4.

G.8 Multiunit Control Rooms

The characteristics of multi-unit control rooms that may affect personnel performance include whether or not the control room has a mirror-image design, design factors that distinguish the operating units, equipment layout that might affect personnel movement and communication. Review guidelines are provided in Section 3.7.2.5.

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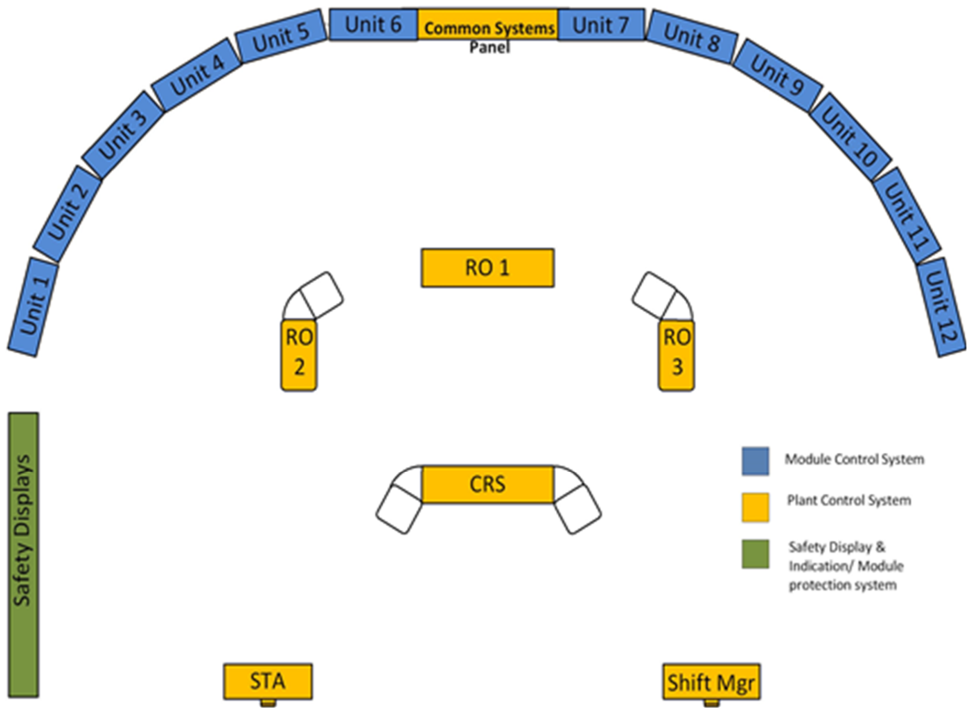

Figure G-3. MCR layout

G.9 Locations outside of the Main Control Room

The HSIs in the locations outside of the MCR (TSC, EOF, and the RSS) are all MCR derivatives (i.e., operated from the same platform and connected to the same I&C distributed control system). These HSIs are for information display only meaning no control functions are provided in any of the emergency response facilities.

G.10 Local Control Stations Design

The HSIs on the VDU-based LCSs are MCR derivatives. For vendor-supplied LCSs, the NuScale HFE program scope is limited to ensuring that those interfaces adhere as closely as possible to guidance provided in this document. Inputs from the vendor-supplied LCSs are replicated on the VDU-based HSI on an as-needed basis

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Appendix H. Automation and Computer-Based Procedures

The use of automation is a key component in aiding the operating crew in managing the workload of a NuScale plant operated from a single control room. The criteria and discussion presented here is meant to aid design in determining the correct level of automation and to provide standard rules by which the automation behaves.

A computer-based procedure system assists plant personnel by computerizing paper-based procedures. Their purpose is to guide operators' actions in performing their tasks in order to increase the likelihood that the goals of the tasks will be safely achieved. The NuScale CBP system will consist of three types of procedures.

- Type 1 (Electronic Procedure)
- Type 2 (Interactive Electronic Procedure)
- Type 3 (Embedded Procedure)

The interface difference between the types is depicted in Table H-1.

Table H-1 Computer Based Procedure Types

Capability	CBP		
	Type 1	Type 2	Type 3
Select and display procedure on computer screen.	Yes	Yes	Yes
Provide navigation links within or between procedures.	Yes	Yes	Yes
Display process data in the body of the procedure.	No	Yes	Yes
Process step logic and display results.	No	Yes	Yes
Provide access links to process displays and soft controls that reside on a separate system.	No	Yes	Yes
Provide embedded soft controls.	No	No	Yes
On operator command initiate procedure-based automation.	No	No	Yes

Computer-Based procedure platform

Procedures are provided to guide operators in all aspects of plant operations at a NuScale plant. Traditional paper-based procedures will be available. The use of computer-based procedures facilitates mobility and enhances operator use. NuScale computer-based procedures are designed in accordance with the guidance in Section 8 of Reference 1.5.2 and Section 1 of D I&C ISG-05 2008.

NuScale investigated several types of computer-based procedure techniques so that the unique need of the plant is satisfied. Complete electronic versions of the paper copies are available on a tablet via the computer-based procedure system. This will help operators outside of the MCR to have mobile versions of all the procedures. The operators inside of the MCR will also have access to this system via a tablet as well as paper-based procedures for back-up purposes.

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In addition to the guidance provided in Section 3.9 of this style guide the NuScale HSI developers should follow the additional guidance listed below.

H.1 Automation Interface

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Figure H-1. Process Library Automation page

H.2 Type 1 (Electronic Procedure)

Type 1 procedures represent procedure text documents for operational use on a computer-generated visual display. These types of procedures can be accessed by anyone on the “Plant Network” and may or may not contain live plant data.

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H.3 Type 2 (Interactive Electronic Procedure)

Type 2 procedures use dynamic process data for the display of live plant data, to evaluate conditions or procedure logic, or to monitor plant conditions during procedure-defined intervals of applicability.

Type 2 procedures reside on the “Control Networks” but typically cannot issue control commands, however they may provide access to soft control capabilities that exist outside of the control systems e.g. performing maintenance on the fire protection system.

H.4 {{

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Figure H-2. Process Library Procedure page

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Appendix I. Plant Maintenance and Work Management

I.1 Purpose

Unique regulatory and quality requirements of the nuclear industry are embedded throughout our applications, which enable support of safety and compliance objectives. This section will discuss how the HSI will aid in monitoring and performing plant maintenance and work management.

I.2 High Level Rules:

TBD

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Enclosure 3:

Affidavit of Thomas A. Bergman, AF-0219-64503

NuScale Power, LLC
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NuScale Power, LLC

AFFIDAVIT of Thomas A. Bergman

I, Thomas A. Bergman, state as follows:

(1) I am the Vice President of Regulatory Affairs of NuScale Power, LLC (NuScale), and as such, I have been specifically delegated the function of reviewing the information described in this Affidavit that NuScale seeks to have withheld from public disclosure, and am authorized to apply for its withholding on behalf of NuScale

(2) I am knowledgeable of the criteria and procedures used by NuScale in designating information as a trade secret, privileged, or as confidential commercial or financial information. This request to withhold information from public disclosure is driven by one or more of the following:

(a) The information requested to be withheld reveals distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by NuScale competitors, without a license from NuScale, would constitute a competitive economic disadvantage to NuScale.

(b) The information requested to be withheld consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), and the application of the data secures a competitive economic advantage, as described more fully in paragraph 3 of this Affidavit.

(c) Use by a competitor of the information requested to be withheld would reduce the competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

(d) The information requested to be withheld reveals cost or price information, production capabilities, budget levels, or commercial strategies of NuScale.

(e) The information requested to be withheld consists of patentable ideas.

(3) Public disclosure of the information sought to be withheld is likely to cause substantial harm to NuScale's competitive position and foreclose or reduce the availability of profit-making opportunities. The accompanying standard reveals distinguishing aspects about the method by which NuScale develops its human-system interface.

NuScale has performed significant research and evaluation to develop a basis for this method and has invested significant resources, including the expenditure of a considerable sum of money.

The precise financial value of the information is difficult to quantify, but it is a key element of the design basis for a NuScale plant and, therefore, has substantial value to NuScale.

If the information were disclosed to the public, NuScale's competitors would have access to the information without purchasing the right to use it or having been required to undertake a similar expenditure of resources. Such disclosure would constitute a misappropriation of NuScale's intellectual property, and would deprive NuScale of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

(4) The information sought to be withheld is in the enclosed standard entitled Human-Systems Interface Style Guide. The enclosure contains the designation "Proprietary" at the top of each page containing proprietary information. The information considered by NuScale to be proprietary is identified within double braces, "{{ }}" in the document.

(5) The basis for proposing that the information be withheld is that NuScale treats the information as a trade secret, privileged, or as confidential commercial or financial information. NuScale relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC §

552(b)(4), as well as exemptions applicable to the NRC under 10 CFR §§ 2.390(a)(4) and 9.17(a)(4).

(6) Pursuant to the provisions set forth in 10 CFR § 2.390(b)(4), the following is provided for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:

(a) The information sought to be withheld is owned and has been held in confidence by NuScale.

(b) The information is of a sort customarily held in confidence by NuScale and, to the best of my knowledge and belief, consistently has been held in confidence by NuScale. The procedure for approval of external release of such information typically requires review by the staff manager, project manager, chief technology officer or other equivalent authority, or the manager of the cognizant marketing function (or his delegate), for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside NuScale are limited to regulatory bodies, customers and potential customers and their agents, suppliers, licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or contractual agreements to maintain confidentiality.

(c) The information is being transmitted to and received by the NRC in confidence.

(d) No public disclosure of the information has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or contractual agreements that provide for maintenance of the information in confidence.

(e) Public disclosure of the information is likely to cause substantial harm to the competitive position of NuScale, taking into account the value of the information to NuScale, the amount of effort and money expended by NuScale in developing the information, and the difficulty others would have in acquiring or duplicating the information. The information sought to be withheld is part of NuScale's technology that provides NuScale with a competitive advantage over other firms in the industry. NuScale has invested significant human and financial capital in developing this technology and NuScale believes it would be difficult for others to duplicate the technology without access to the information sought to be withheld.

I declare under penalty of perjury that the foregoing is true and correct. Executed on May 10, 2019.

Thomas A. Bergman