NuScale Power™

LO-1216-52262

December 29, 2016

Docket: PROJ0769

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 Sixth Set of Human Factors Engineering Documentation for Design Certification Application

REFERENCES:
1. Letter from Thomas A. Bergman (NuScale) to U.S. Nuclear Regulatory Commission, "NuScale Power, LLC Submittal of Response to NRC's Letter, 'NuScale Control Room Configuration and Staffing Levels,' January 14, 2016," dated April 8, 2016 (ML16099A270)
2. NRC Table, "Human Factors Engineering Documentation for NuScale Design Certification Application Submittal," dated April 11, 2016 (ML16034A181)

In a letter dated April 8, 2016 (Reference 1), NuScale Power, LLC (NuScale) proposed, in part, the scope of human factors engineering (HFE) information that it planned to submit as part of NuScale's design certification application (DCA). The proposed documentation scope included a list of HFE results summary reports and revised implementation plans. The U.S. Nuclear Regulatory Commission (NRC) confirmed the documentation scope in a table dated April 11, 2016 (Reference 2). In addition to the implementation plans and results summary reports listed Reference 1, NuScale planned to submit, prior to or at the time of DCA submittal, documents describing the concept of operations, control room staffing plan validation methodology and results, and human-system interface style guide to support the DCA.

The purpose of this letter is to forward the following documents to the NRC as the sixth of six sets of submittals:

1) Proprietary and non-proprietary versions of Human-System Interface Style Guide, ES-0304-1381, Revision 1

Enclosure 1 contains the proprietary version of the above document. Enclosure 2 contains the non-proprietary version. 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.

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

Please feel free to contact Steve Mirsky at 240-833-3001 or at smirsky@nuscalepower.com if you have any questions.

Sincerely,

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

Distribution: Frank Akstulewicz, NRC, TWFN-6C20
Greg Cranston, NRC, TWFN-6E55
Omid Tabatabai, NRC, TWFN-6E55
Samuel Lee, NRC, TWFN-6C20

Enclosure 1: Human-System Interface Style Guide, ES-0304-1381-P, Revision 1, proprietary version
Enclosure 2: Human-System Interface Style Guide, ES-0304-1381-NP, Revision 1, non-proprietary version
Enclosure 3: Affidavit AF-1216-52263

Enclosure 1:

Human Factors Engineering Interface Style Guide, ES-0304-1381-P, Revision 1, proprietary version

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvallis, Oregon 97330 Office 541.360-0500 Fax 541.207.3928
www.nuscalepower.com

Enclosure 2:

Human Factors Engineering Interface Style Guide, ES-0304-1381-NP, Revision 1, non-proprietary version

NuScale Power, LLC
1100 NE Circle Blvd., Suite 200 Corvallis, Oregon 97330 Office 541.360-0500 Fax 541.207.3928
www.nuscalepower.com

Human-Systems Interface Style Guide

12/02/2016

Revision 1

Docket: PROJ0769

NuScale Power, LLC

1100 NE Circle Blvd., Suite 200

Corvallis, Oregon 97330

www.nuscalepower.com

Department of Energy Acknowledgement and Disclaimer

This material is based upon work supported by the Department of Energy under Award Number DE-NE0000633.

CONTENTS

TABLES

FIGURES

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.

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.

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

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.

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
COLA	combined operating license applicant
CWS	circulating water system
DAS	data acquisition system
DOORS	dynamic object oriented requirements system
ELV	low voltage ac electrical distribution system
EMI	electromagnetic interference
EOP	emergency operating procedure
EPRI	Electric Power Research Institute
FCC	Federal Communications Commission
FRA/FA	functional requirements analysis/function allocation
GVD	group view display

Acronym	Definition
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
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

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.

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.

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.

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 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..

1.6.3 Volume III

This volume will contain chapters comprised of specific information about a system, location, or concept in a NuScale plant. The information that may be presented in each chapter 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.

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

Upon 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.

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

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

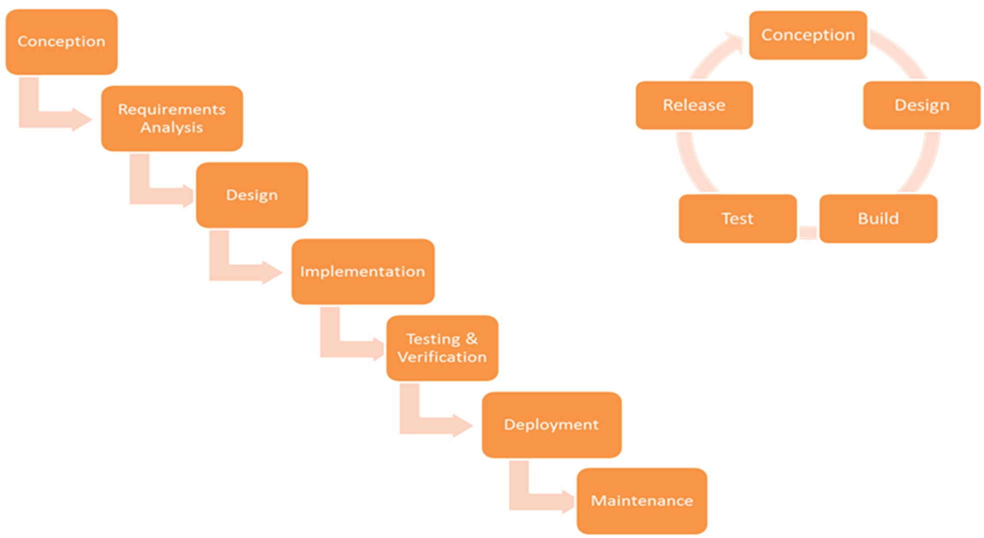


Figure 2-1. Comparison of Waterfall vs Agile Methodology

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 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.

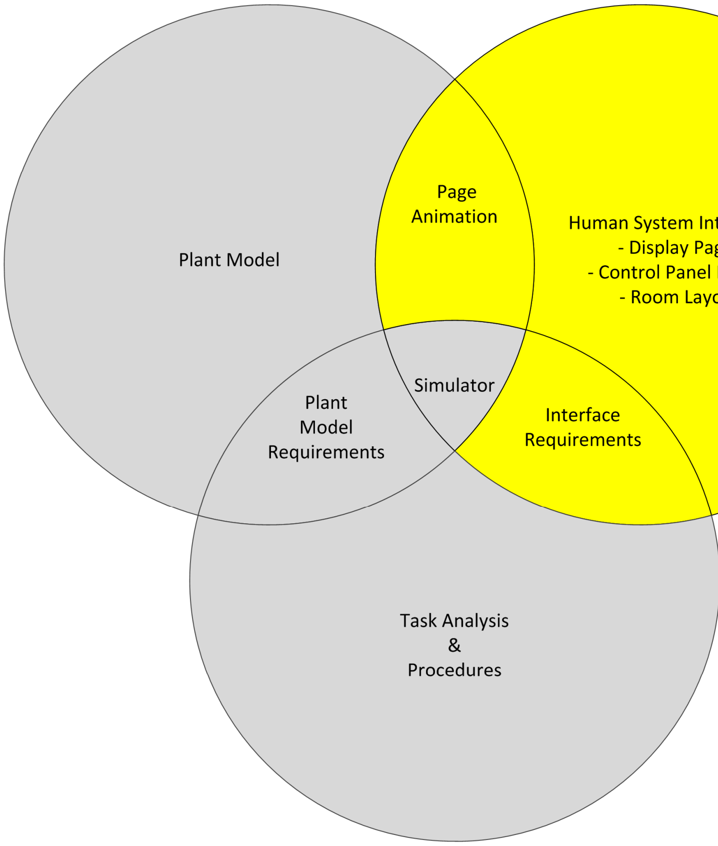


Figure 2-2. Simulator Venn diagram

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.

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 Definitions

2.8.1 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.

2.8.1.1 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.

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 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.

2.8.1.2 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 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.

2.8.2 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.

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.

2.8.3 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.

2.8.4 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.

2.8.4.1 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.

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.

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.

2.8.4.2 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.

2.8.4.3 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 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.

2.8.4.4 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.

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.

2.8.4.5 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.

2.8.5 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.

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.

2.8.6 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 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.

2.8.7 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.

2.8.8 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.

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

2.8.9 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 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.

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.

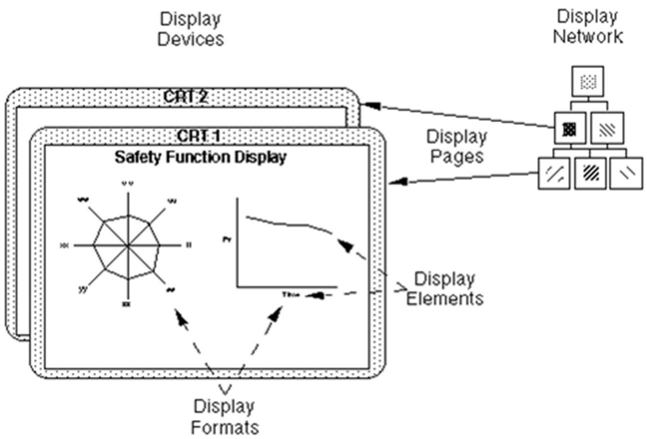


Figure 3-1. Information display characterization

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.

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 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 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 (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 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.

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.

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.

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.

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(Reference 1.5.1)

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.

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.

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.

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.

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

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.

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.

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.

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.

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, the Colors codes will be called out 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.

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.

HSI Design Criteria

Loss of indication failures with a device will turn that elements HSI display color to "WHITE" or dashes for parameters.

Loss of communications failures with a device will turn that elements HSI display color to "WHITE" with an additional lasso around the component.

Examples of this behavior are shown in Appendix C.

Text Size used for the parameters will be presented in Appendix A, the Colors codes will be called out 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

3.1.2.2.10 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

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.

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 H.

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.

HSI Design Criteria

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

All three independent networks will provide status condition notices, warnings and alarms via plant notifications 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-engergized.

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.

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

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 PI&D.

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.

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.

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-0304-1381-8026 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.

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

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.

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

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

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.

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

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

STEAM GENERATOR LEVEL	**SG# 1:**
	SG# 2:
	SG# 3:
	SG# 4:

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), 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).

Reference: NUREG-0700-1.2.4

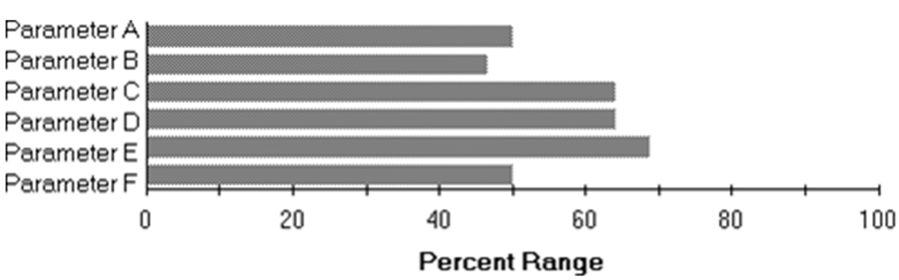


Figure 3-4. Example of a horizontal bar chart

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

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

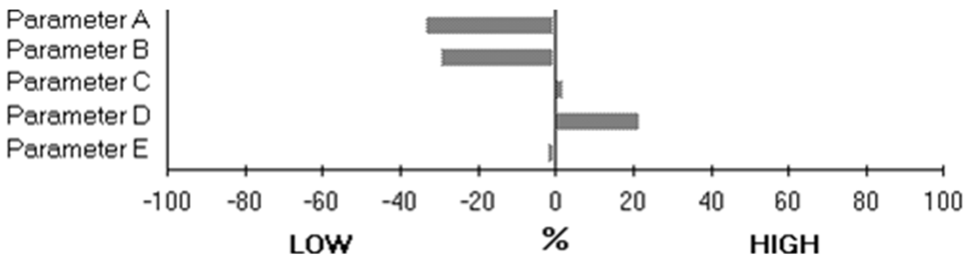


Figure 3-5. Example of a deviation bar chart

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

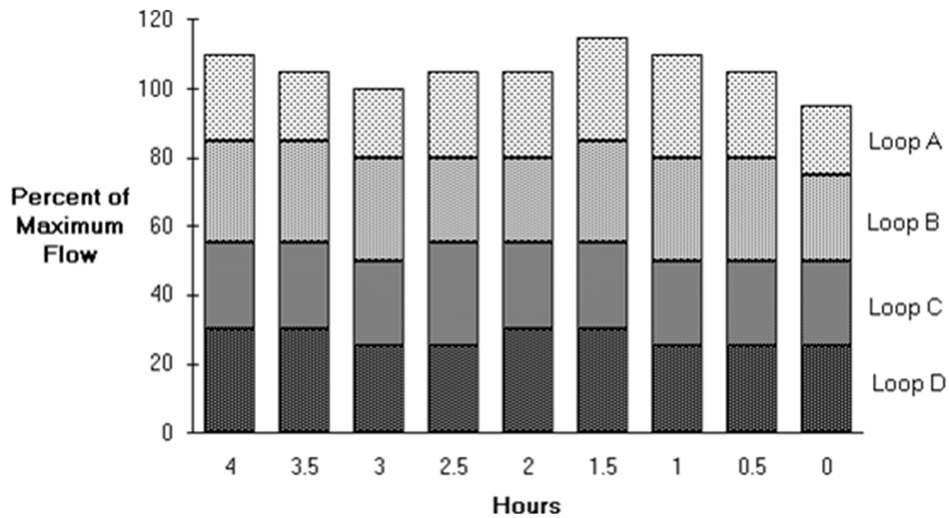


Figure 3-6. Example of a segmented bar chart

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.

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

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

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

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.

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

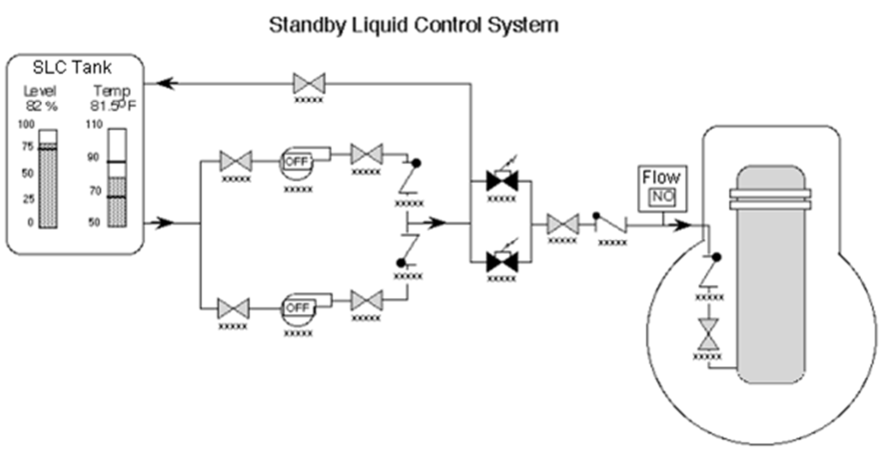


Figure 3-7. Example of a mimic display

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.

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.

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.

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.

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.

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.

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

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

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.

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).

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

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.

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

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

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

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.

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.

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.

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

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.

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

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

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

Alarms will be the only notification that has an auditory signal associated with it for clear distinction 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 signal 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.

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 H, 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 H, will cover the number of audible signals as well as their use.

Reference: NUREG-0700-1.3.11

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

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.

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

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.

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).

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

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.

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.

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.

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 12 modules and 12 function key templates on screen reminders are not needed.

Reference: NUREG-0700-2.2.2.1

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 10.

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.

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

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 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

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

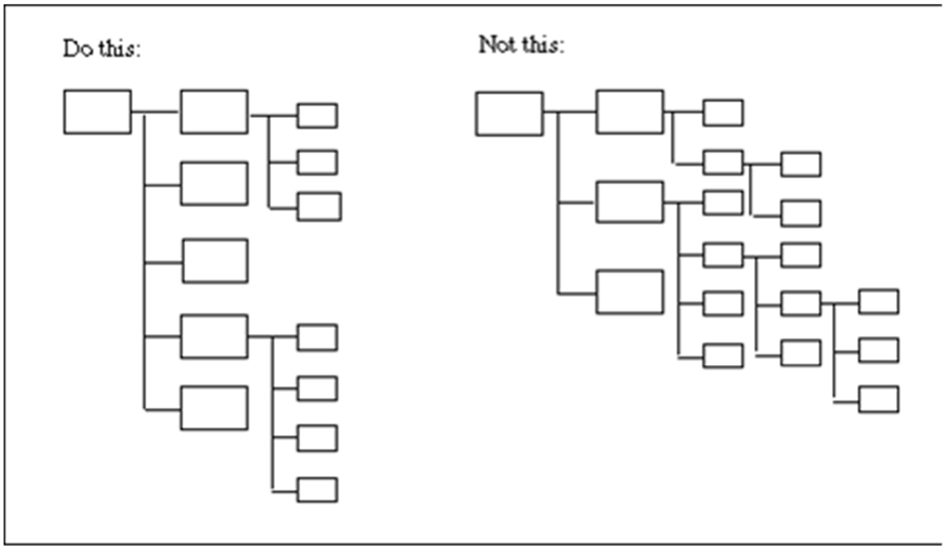


Figure 3-8. Examples of broad and shallow menu structures

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.

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

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.

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.

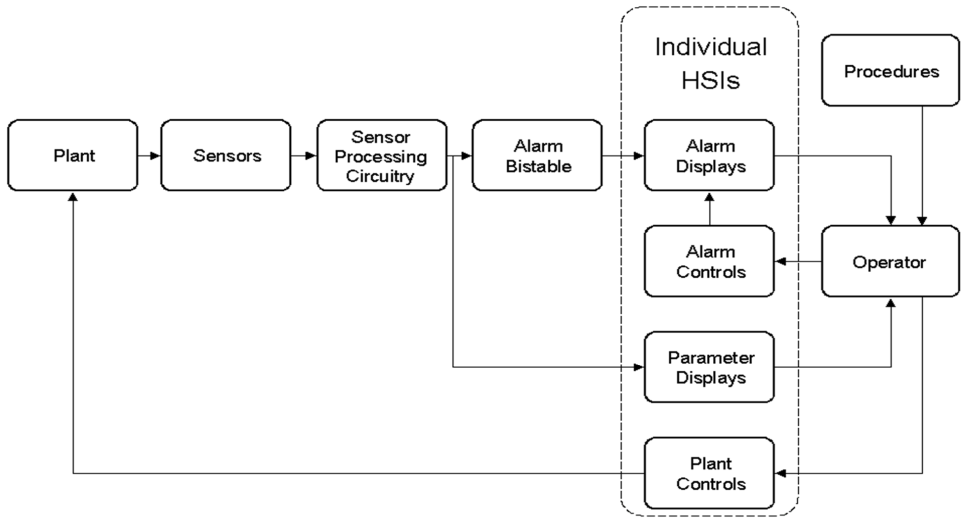


Figure 3-9. Conventional alarm system

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.

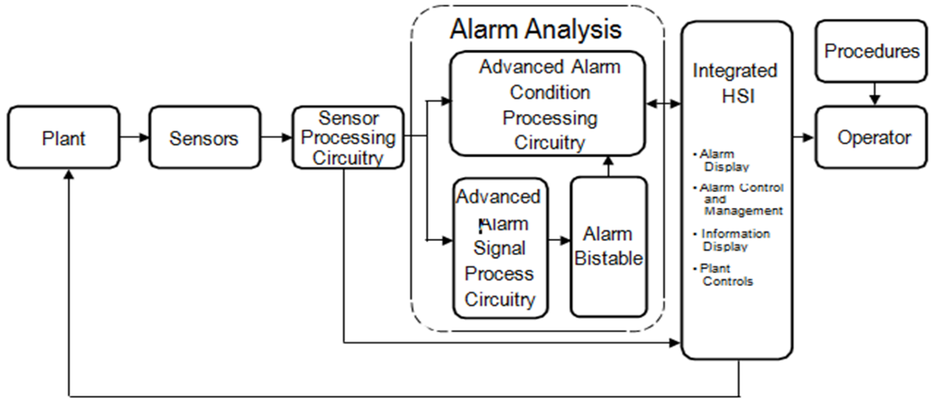


Figure 3-10. Advanced alarm system

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.

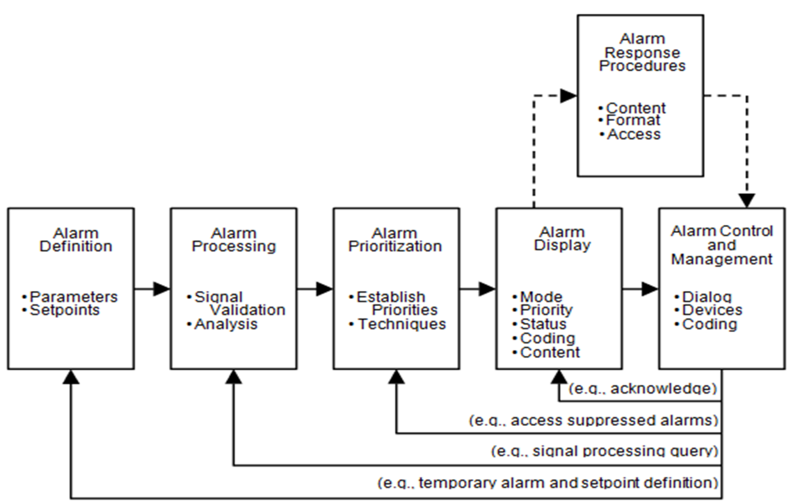


Figure 3-11. Alarm system functional elements

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 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).

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 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.

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.

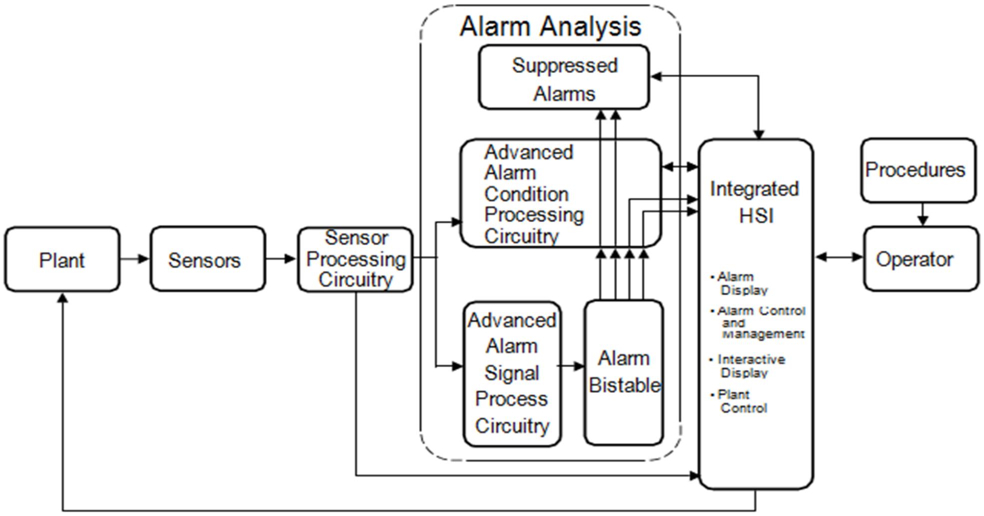


Figure 3-12. Alarm suppression

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
- 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.

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.

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
- 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.

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

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

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

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

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.

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

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

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.

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.

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);
- 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.

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.

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.

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

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.

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 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

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.

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.

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.

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

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.

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.

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.

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 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.

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 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

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.

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.

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

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 .15 to .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

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 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.

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.

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

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

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.

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 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

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 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.

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

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 HE, 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

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 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.

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).

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.

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

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.

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

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

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.

HSI Design Criteria

The NuScale HSI will provide access to ARP's.

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 ARP's.

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,
- 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 ARP's 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 ARP's 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 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 ARP's 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 (SDI) shall provide indication in the main control room (MCR) 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.

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 these systems are used in coordination with other display and control devices of the HSI to verify plant safety and support operators 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.

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.

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 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

3.3.2.1.8 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.

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

3.3.2.1.9 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 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

3.3.2.1.10 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 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

3.3.2.1.11 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 cover all modes of operation.

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

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 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

3.3.2.2.2 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 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 given for the SDI panel.

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.

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.

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 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-0700-5.3

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).

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 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-0700-5.3

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.

All NuScale HSI will be built with a common theme using the appendices A through H. The appendices will strive to make ALL plant parameters being displayed convenient and readily accessible to the users of the 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.

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

SDI panels will be labeled.

Reference: NUREG-0700-5.4

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, and NUREG-0800 contain general guidance for procedure maintenance and configuration control developed for PBPs.

The following characterization identifies 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 two types of procedures. The first type is the tradition “electronic” type of procedure that will be available on the computer networks such that they can be accessed by anyone on the network. The second type is the “embedded” procedure which 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 read those procedures.

To interface with the embedded 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.

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.

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

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 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.

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.

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.

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

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.

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.

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.

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.

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.

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.

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.

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.

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

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.

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 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.

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

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.

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

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.

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

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.

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.

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

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.

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.)

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.

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

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

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.

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

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.

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 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.

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

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

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.

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

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

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 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.

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

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.

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

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

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.

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

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

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

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.

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

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.

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.

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.

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.

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.

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 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

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.

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.

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.

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

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

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

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.

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.

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 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

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)
- 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.

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

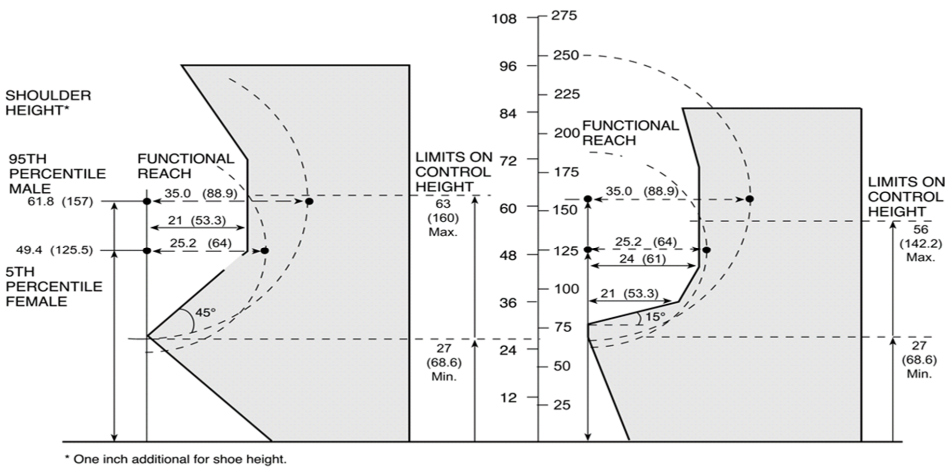


Figure 3-13. Reach capabilities and control height for two stand-up consoles

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.

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 Table 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**.**

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

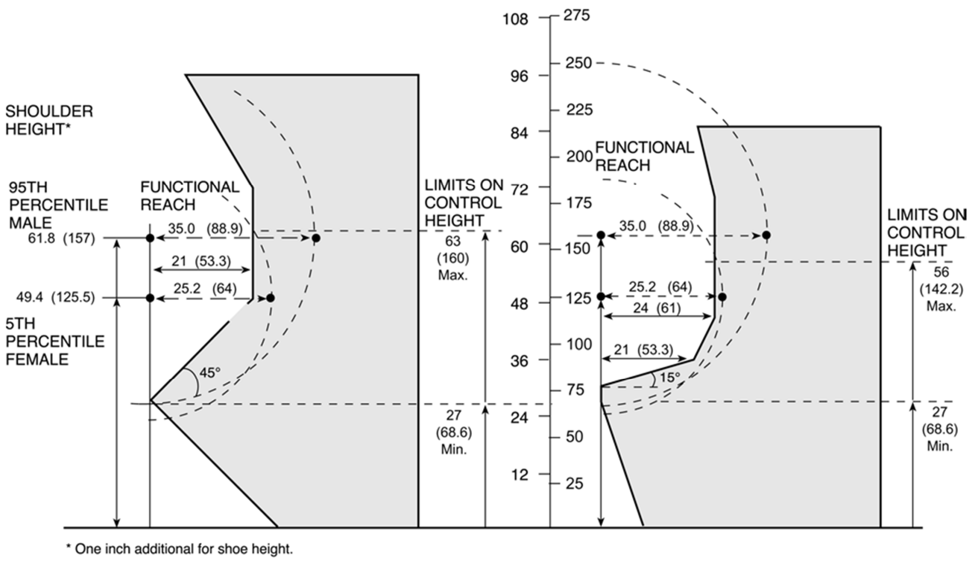


Figure 3-14. Display height and orientation relative to a standing user's line of sight

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

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 Table 3-15.

Additional Information: Measurements should be made using seated shoulder height with the shoulder 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

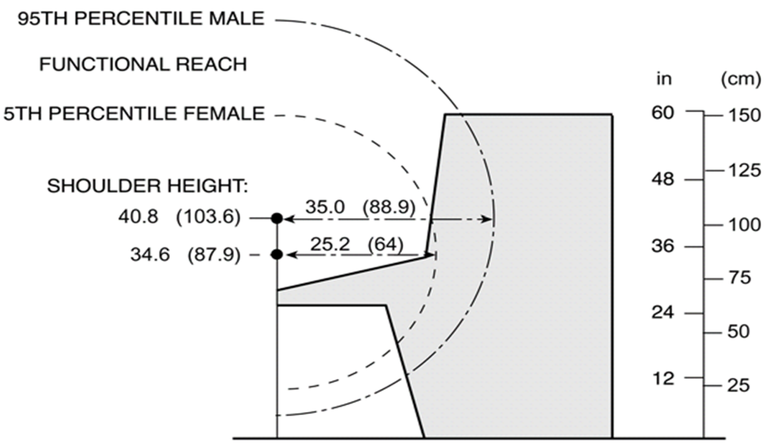


Figure 3-15. Reach capabilities for sit-down consoles

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 3-9and illustrated in Table 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

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 Table 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

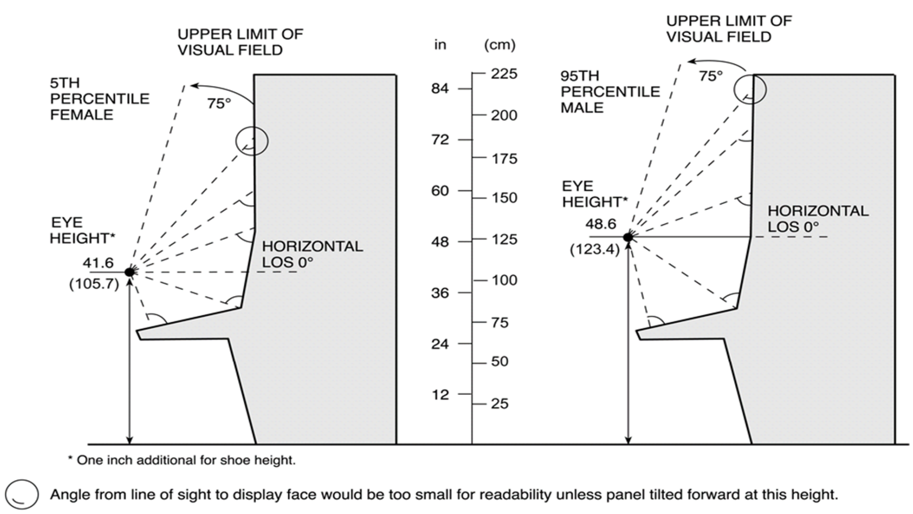


Figure 3-16. Display height and orientation relative to a seated user's line of sight

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.

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

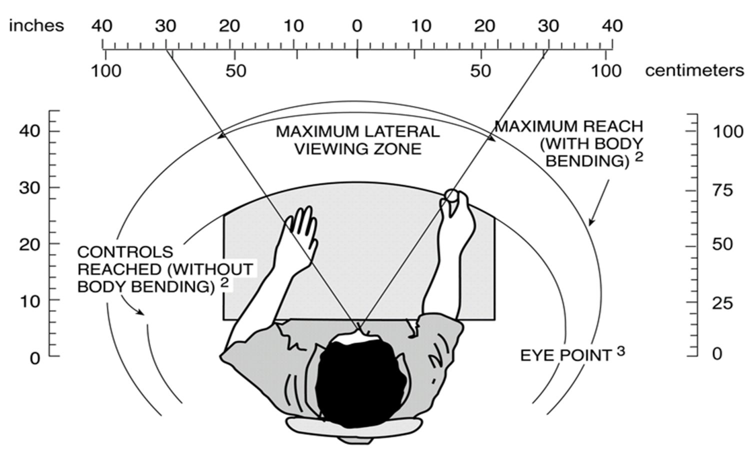
Guideline: All necessary controls and displays needed for critical or frequently performed activities should be within the maximum extended reach and viewing range of a seated user from a single reference point as shown in Table 3-9 and illustrated in Table 3-17.

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. Table 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



[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. Table 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

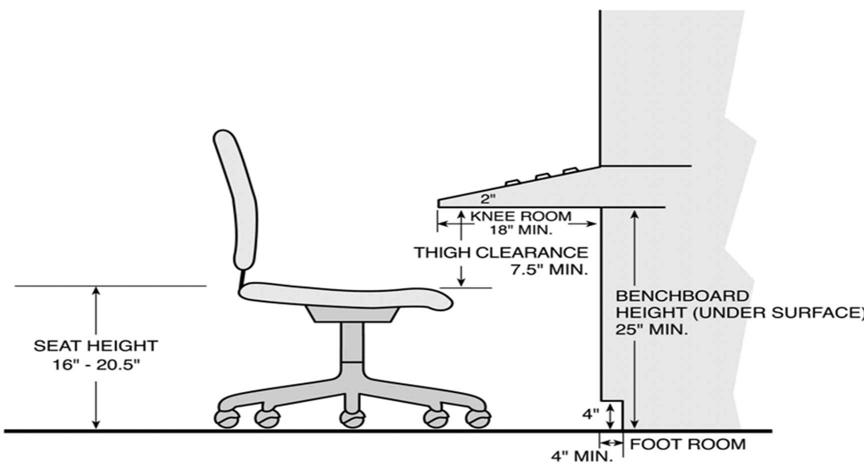


Figure 3-18. Leg- and foot-room dimensions

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.

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

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 Sit-Down workstations will incorporate this design standard.

Reference: NUREG-0700-11.1.4

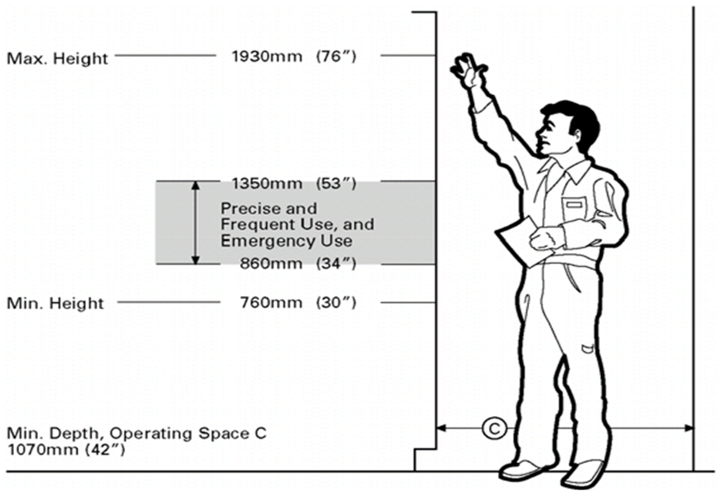


Figure 3-19. Control height

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

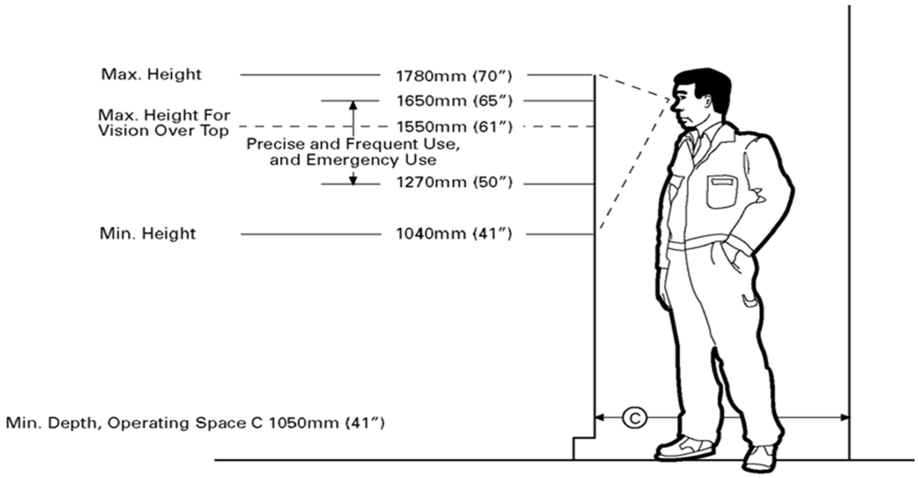


Figure 3-20. Display height

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

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

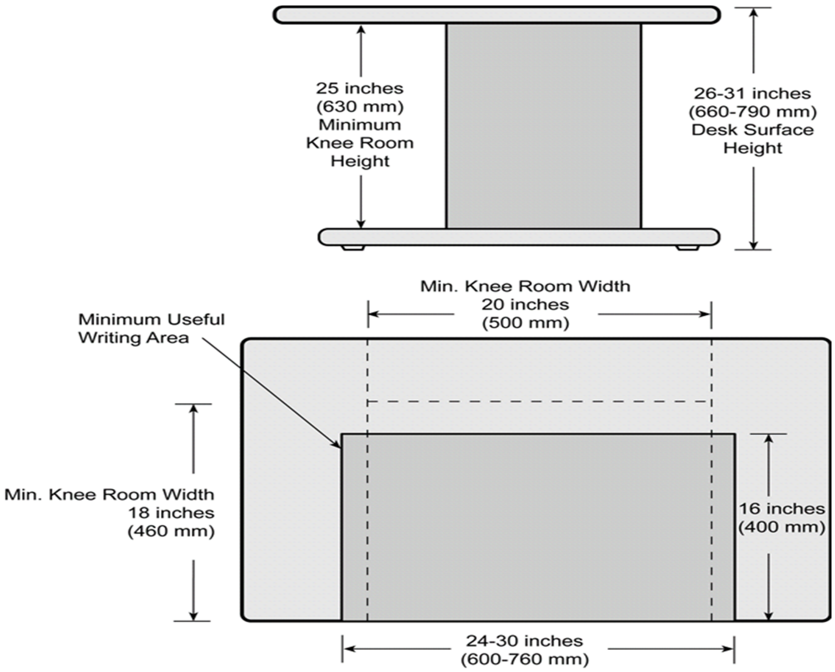


Figure 3-21. Recommended desk dimensions

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).

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.

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

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

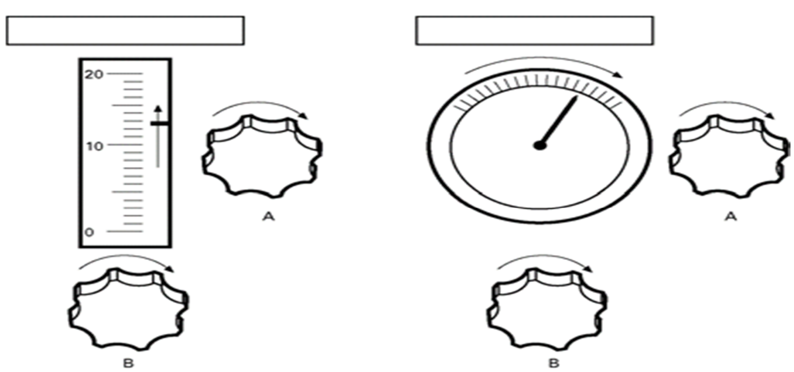


Figure 3-22. Position of control actuator and associated display

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

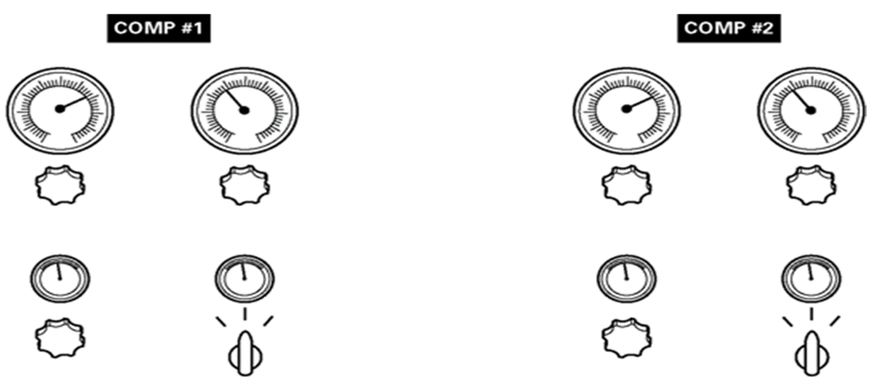


Figure 3-23. Association by grouping

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.

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

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.

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.

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

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

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

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.

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

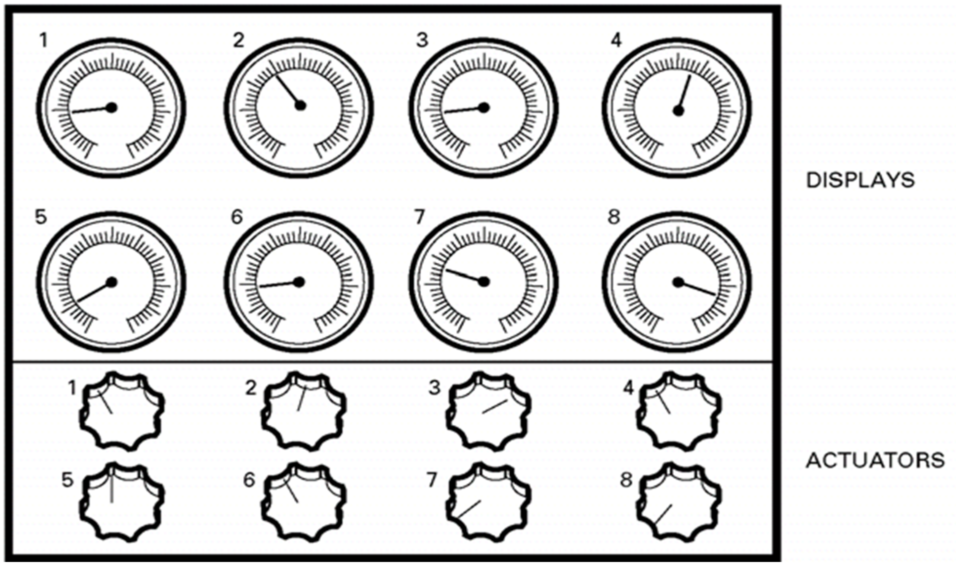


Figure 3-24. Controls and displays in rows

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

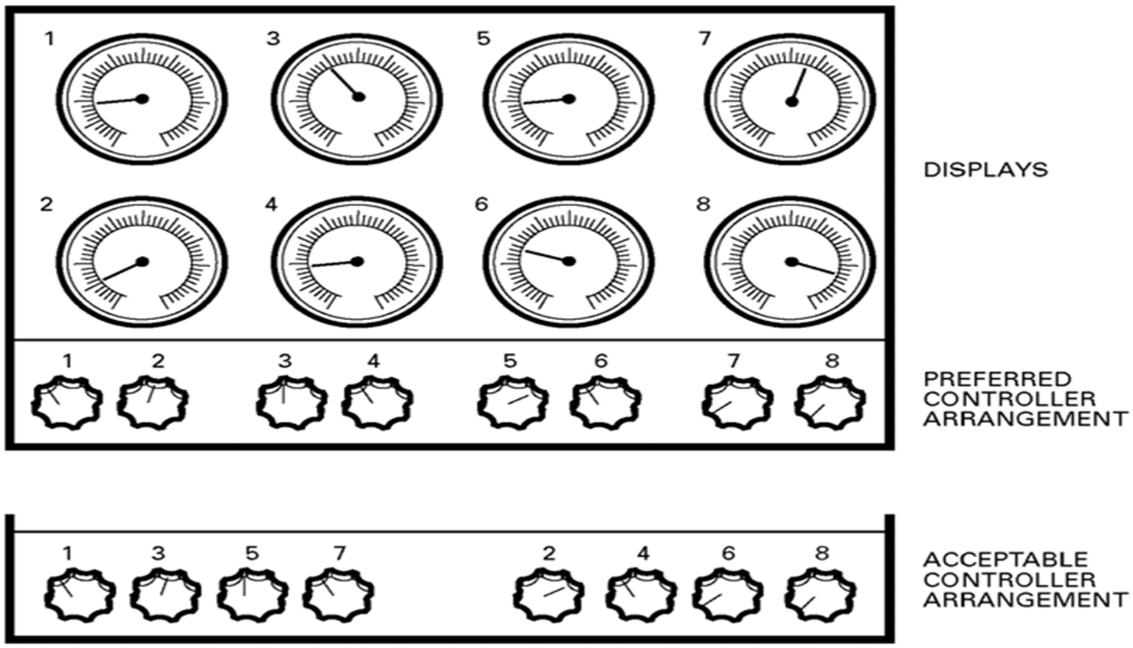


Figure 3-25. Two rows of displays with a single row of controls

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

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

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

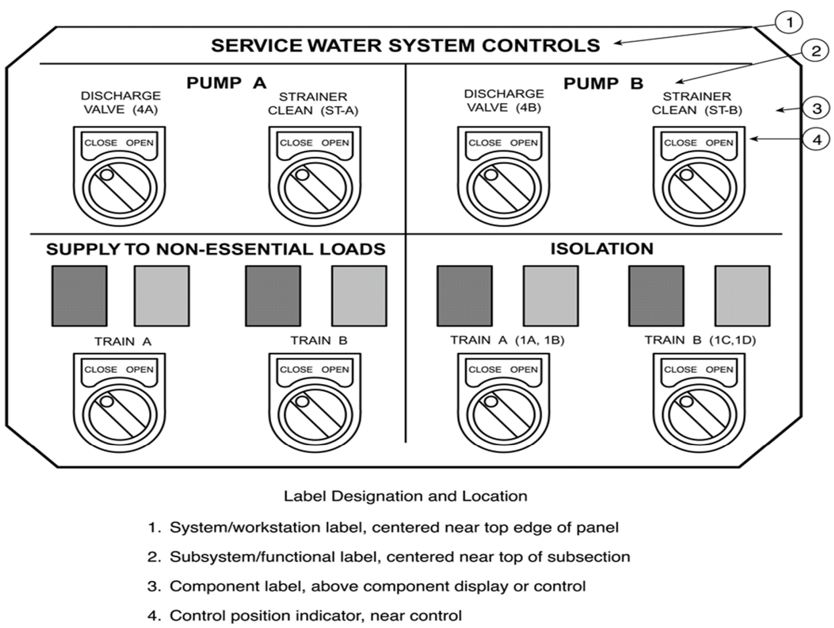


Figure 3-26. Example of good panel labeling

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.

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

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